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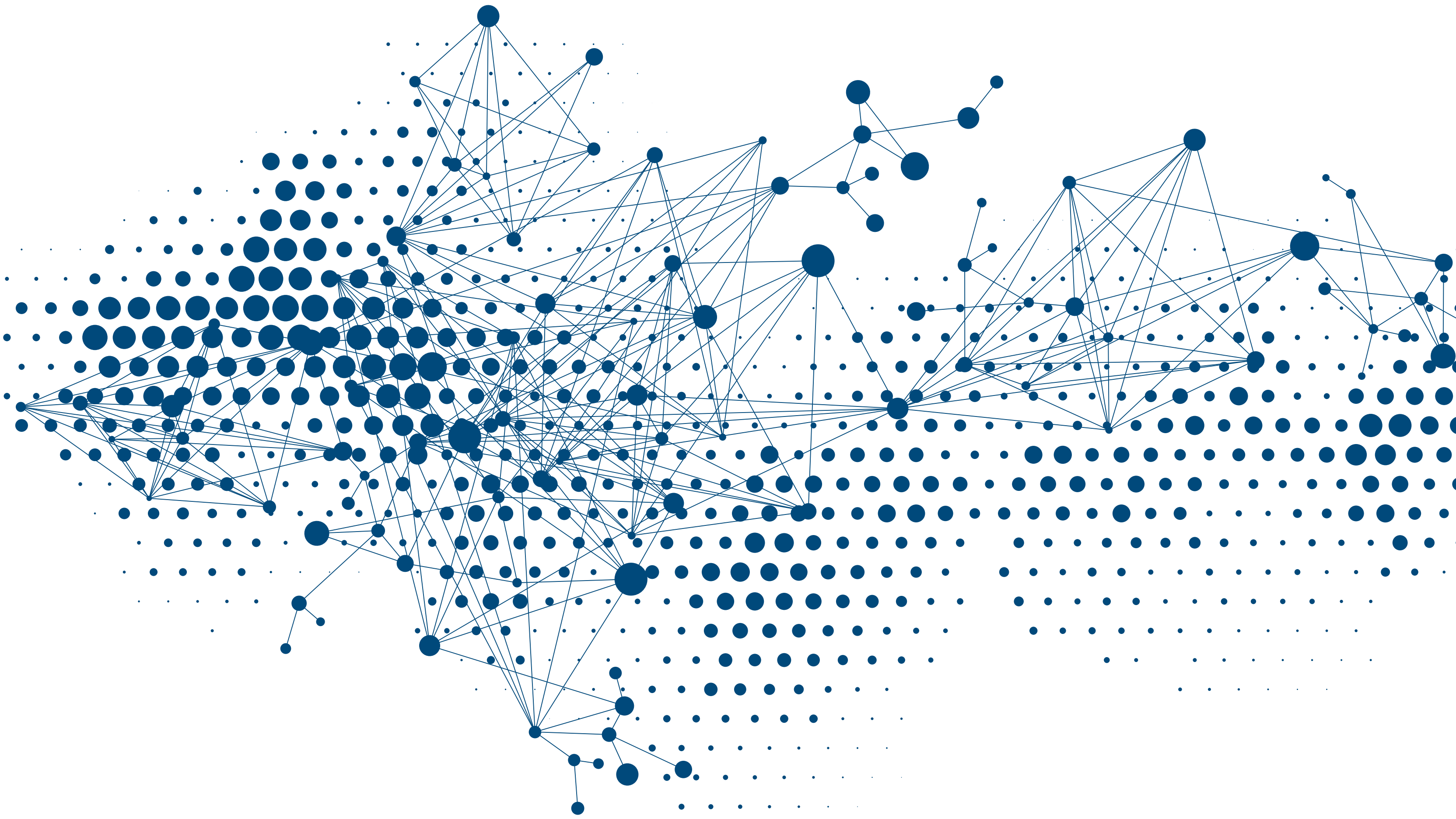
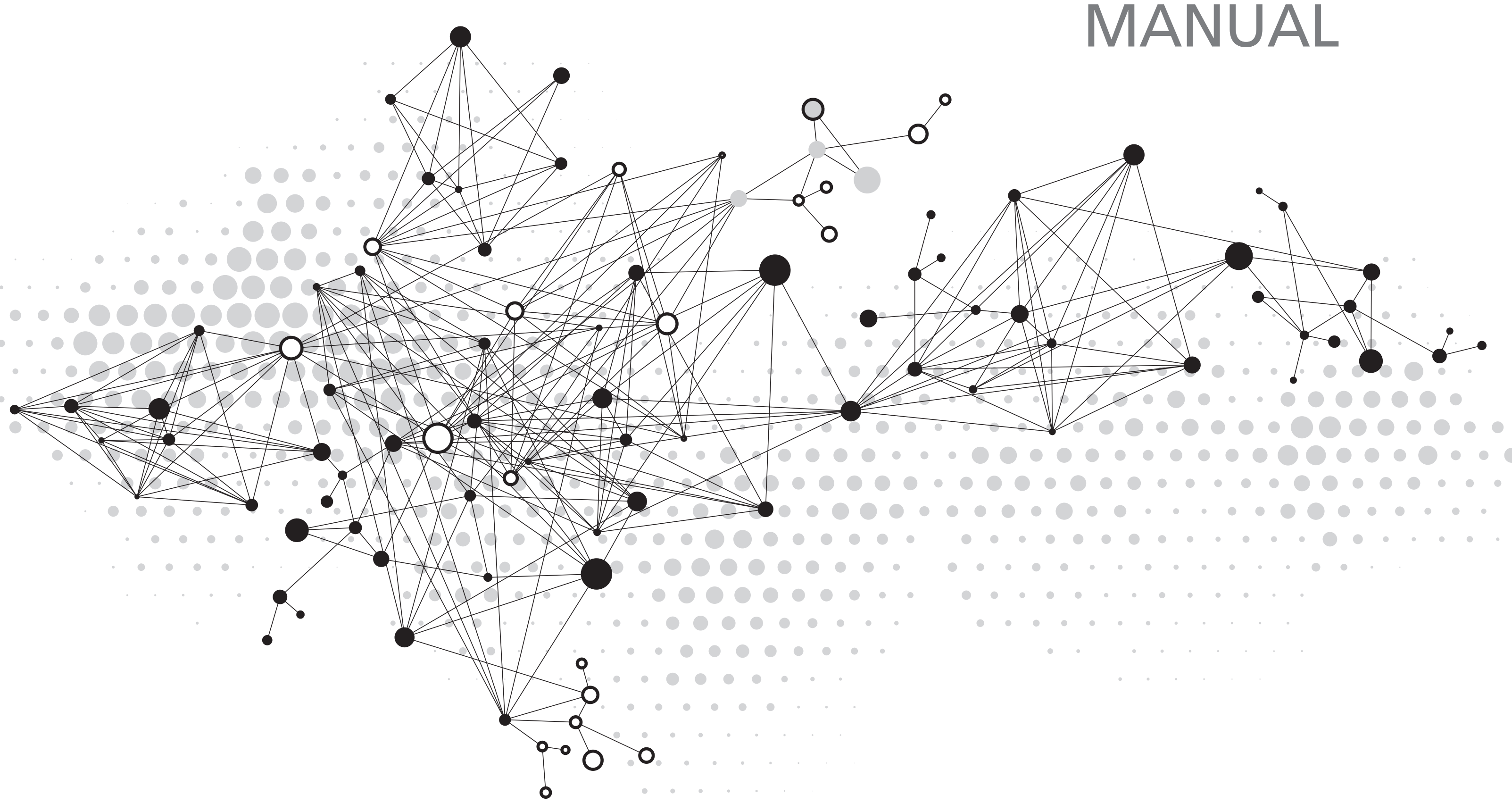


QUARTERLY NATIONAL ACCOUNTS MANUAL

2017 EDITION

INTERNATIONAL MONETARY FUND

MANUAL



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2017 EDITION

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Foreword

Traditional macroeconomic statistics will face significant challenges in the years to come. The digitalization of society has brought new players into the information market and a number of new sources with the potential to provide instantaneous measurement of social and economic life. Official statistics agencies are in the process of adapting and modernizing their products to remain relevant.

In this fast-changing data landscape, quarterly national accounts are well positioned to play a key role in combining high-frequency economic indicators with the integrated framework of national accounts statistics. This second edition of the *Quarterly National Accounts Manual* (the *Manual)* emphasizes the timeliness and reliability of quarterly national accounts estimates. Early estimates of GDP are needed by policymakers to promptly identify current developments in economic activity; however, the push toward timelier estimates comes at a cost of greater uncertainty in preliminary readings of data. The *Manual* provides guidance on how to produce quick estimates of quarterly GDP that can be trusted and offers solutions regarding how revisions should be reduced, controlled, and communicated to the users.

The *Manual* should be regarded as a companion guide to the *System of National Accounts 2008 (2008 SNA)* concerning the specifics of quarterly GDP compilation. The methodology and concepts described in the *Manual* are also harmonized with other major international statistical standards, the sixth edition of the *Balance of Payments and International Investment Position Manual (BPM6)*, the *Government Finance Statistics Manual 2014 (GFSM 2014),* and the *Monetary and Financial Statistics Manual and Compilation Guide*.

The *Manual* was prepared by the IMF Statistics Department in consultation with a range of experts from member countries and other international and regional organizations. I would like to thank all the experts involved for their indispensable assistance and for their collaborative spirit in sharing their experience.

In 2001, when the first edition of the *Manual* was published, quarterly national accounts were yet to be developed in the majority of IMF member countries. Seventeen years later, quarterly GDP estimates are regularly produced by 133 countries. I encourage member countries to continue developing and improving their systems of quarterly national accounts according to the guidelines in this *Manual.*

Christine Lagarde
Managing Director
International Monetary Fund

Preface

The *Quarterly National Accounts Manual* (the *Manual*) provides conceptual and practical guidance for compiling quarterly national accounts (QNA) statistics. The *Manual* offers a comprehensive review of data sources, statistical methods, and compilation techniques to derive official estimates of quarterly GDP. The new edition—which upgrades the first edition, published in 2001—improves and expands the previous content based on recent methodological advances, best country practices, and suggestions received from QNA compilers and experts. The *Manual* also benefits from technical assistance missions and training courses conducted by IMF staff and IMF Statistics Department experts in well over 100 countries since 2001.

The primary target audience of the *Manual* is compilers of QNA statistics. It is an essential guide for countries developing their QNA statistics for the first time. It is also a reference tool for countries that wish to improve the quality of their QNA systems. The *Manual* presents the main data sources for GDP and other components of the national accounts; provides guidance and recommendations on statistical methods used in the QNA compilation process, such as benchmarking, seasonal adjustment, and chain linking; and advises on specific compilation aspects of the QNA statistics, including early estimates and revisions. The *Manual* is also a valuable resource for users who wish to understand how quarterly GDP estimates are derived.

The *Manual* provides an internationally accepted framework for producing QNA data. It is fully consistent with the *System of National Accounts 2008 (2008 SNA)*. Countries should consider the *Manual* a companion guide to the *2008 SNA* regarding specific aspects of quarterly GDP compilation. The methodology and concepts described in the *Manual* are also consistent with those of other statistical manuals produced by the IMF Statistics Department, including the sixth edition of the *Balance of Payments and International Investment Position Manual*, the *Government Finance Statistics Manual 2014*, and the *Monetary and Financial Statistics Manual and Compilation Guide*.

We hope that this manual will contribute to increasing the number of countries with QNA systems. The IMF Statistics Department will continue to provide training and technical assistance to help countries develop and improve their QNA data in line with the *Manual*'s recommendations.

Acknowledgments

The update of the *Manual* was conducted by the Real Sector Division of the IMF Statistics Department.

The *Manual* has been authorized by Louis Marc Ducharme, Director of the Statistics Department. The work was supervised by Gabriel Quirós (Deputy Director), Claudia Dziobek (Chief, Real Sector Division), and Robert Dippelsman (Deputy Chief, Real Sector Division), all from the Statistics Department. Manik Shrestha (former Deputy Chief, Real Sector Division) initiated the update project. Marco Marini (Senior Economist, Real Sector Division, Statistics Department) was the primary drafter and also coordinated and edited contributions to the *Manual*. Other main drafters were Thomas Alexander and Michael Stanger (Senior Economists, Real Sector Division, Statistics Department). Other staff in the IMF Statistics Department contributed to the project; in particular, Michael Andrews, Levan Gogoberishvili, Brian Graf, Robert Heath, Chris Hinchcliffe, Kwangwon Lee, Maria Mantcheva, Margarida Martins, Silvia Matei, Niall O'Hanlon, Marshall Reinsdorf, Lisbeth Rivas, Mick Silver, Dan Smith, Louis Venter, and Kim Zieschang. We are grateful to our long-term advisors and short-term experts on the national accounts for their valuable feedback throughout the update project, in particular to Zia Abbasi, Pamela Audi, Segismundo Fassler, Russel Freeman, Donna Grcman, Pete Lee, Bent Thage, and Robin Youll.

The *Manual* has also benefited from feedback received by national accounts compilers and QNA experts. Three seminars were held to present preliminary versions of the *Manual* at the IMF regional training centers (Joint Vienna Institute in November 2014, Singapore Regional Training Institute in May 2015, and Brazil Training Center in May 2017). Comments and suggestions on initial drafts of each chapter were also received through a global consultation process launched on the IMF website. We wish to thank the following experts who provided extremely useful comments to improve our initial drafts: Svetlana Bachilo, Tigran Baghdasaryan, Dario Buono, Tommaso Di Fonzo, Lusya Khachatryan, Kristina Kiriliauskaitė, Arto Kokkinen, Stanimira Kosekova, Andreas Lorenz, Maria de Lourdes Mosqueda Gonzales, Andrej Mikus, Brent Moulton, Bruno Parmisani, Aurelienne Poissoiner, Cristian Martin Poveda, T. Rajeswari, Marcus Scheiblecker, Benson Sim, Shelly Smith, Karsten Webel, Wisnu Winardi, and Jorrit Zwijnenburg.

Louis Marc Ducharme
Chief Statistician and Data Officer, and Director
Statistics Department
International Monetary Fund

Acronyms and Abbreviations

ANA	Annual national accounts
AR	Autoregressive
ARIMA	Autoregressive integrated moving average
BI	Benchmark to indicator
BPM	*Balance of Payments and International Investment Position Manual*
CIF	Cost insurance and freight
COICOP	Classification of individual consumption according to purpose
CPI	Consumer price index
e-GDDS	Enhanced General Data Dissemination System
ESA	European System of National and Regional Accounts
FISIM	Financial intermediation services indirectly measured
FOB	Free on board
GDP	Gross domestic product
GDP-E	Gross domestic product by expenditure
GDP-P	Gross domestic product by production
GFSM	*Government Finance Statistics Manual*
GNI	Gross national income
GVA	Gross value added
IIP	International investment position
ILO	International Labour Organization
IMF	International Monetary Fund
IMTS	International Merchandise Trade Statistics
IO	Input output
IPI	Industrial production index
ISIC	International Standard Industrial Classification of All Economic Activities
NPISH	Nonprofit institution serving households
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary least squares
PIM	Perpetual inventory method
PPI	Producer price index
QNA	Quarterly national accounts
SDDS	Special Data Dissemination Standard
SDDS Plus	Special Data Dissemination Standard Plus
SNA	System of National Accounts
SUT	Supply and use tables
VAT	Value-added tax

1 Introduction

This chapter introduces the scope and role of quarterly national accounts (QNA) in the framework of macroeconomic statistics. It emphasizes the time-series nature of quarterly gross domestic product (GDP) data to analyze recent trends and business-cycle movements. The chapter also highlights the importance of temporal consistency between quarterly and annual accounts. Finally, the main changes to the 2001 edition are summarized.

Background

1.1 QNA constitute a system of integrated quarterly time series coordinated through an accounting framework. QNA adopt the same principles, definitions, and structure as the annual national accounts (ANA). In principle, QNA cover the entire sequence of accounts and balance sheets in the *System of National Accounts 2008 (2008 SNA).* In practice, the constraints of data availability, time, and resources mean that QNA are usually less complete than ANA. The coverage of the QNA system in a country usually evolves. In the initial stage of implementation, only estimates of GDP with a split by industry and/or type of expenditure may be derived. Gross national income (GNI), saving, and consolidated accounts for the economy can follow next. Extensions can be made as the use of the system becomes more established, data sources become available, and users become more familiar with the data. Additional breakdowns of GDP, institutional sector accounts and balance sheets, and supply and use reconciliation may be added.

1.2 This second edition of the *Quarterly National Accounts Manual* (hereafter, the manual) revisits and expands the first edition published in 2001. An update of the manual was required in view of the many developments in the compilation of QNA that have taken place since 2001, and also to make the manual fully consistent with the international statistical standards resulting from the adoption of the *2008 SNA*.

1.3 The manual is written for both beginning and advanced compilers. In addition, it will be of interest to sophisticated data users. Most of this manual addresses issues, concepts, and techniques that apply to the whole system of national accounts. The discussion on data sources in Chapter 3 focuses on components of GDP by production, by expenditure, and by income. Although this reflects the main interest of first-stage compilers, it should not be taken to mean that QNA should stop there. As shown in Chapter 4, GNI and saving for the total economy can be readily derived in most cases, and further extensions are also feasible. In particular, the quarterly expenditure and income components of GDP, in conjunction with balance of payments data, provide all items for the full sequence of consolidated accounts for the total economy.

1.4 Several countries with advanced QNA have expanded their systems to include a complete set of quarterly accounts by institutional sector. Other countries are currently aspiring to do so in the medium term. Most of the sources and methods discussed in this manual are also relevant for the compilation of quarterly sectoral accounts. However, this manual remains primarily oriented toward the compilation of GDP and other components for the total economy.

1.5 This manual is intended for readers who have a general knowledge of national accounts methodology. The manual aims at full consistency with the *2008 SNA*, and duplication of material presented in the latter is avoided as much as possible. Thus, for general national accounts issues, readers are referred to the *2008 SNA.*

1.6 This chapter discusses the main purposes of QNA and the position of QNA between ANA and short-term indicators. It also discusses some important aspects of QNA, such as their time-series character, the usefulness of seasonally adjusted QNA data, their relation to ANA, the importance of transparency, and the rise of early estimates for policymaking.

An outline of the manual is given. Finally, a brief summary of the changes to the 2001 edition is provided.

Purposes of Quarterly National Accounts

1.7 The main purpose of QNA is to provide a picture of current economic developments that is more timely than that provided by the ANA and more comprehensive than that provided by individual short-term indicators. To meet this goal, QNA should be timely, coherent, accurate, comprehensive, and reasonably detailed. If QNA fulfill these criteria, they can serve as a framework for assessing, analyzing, and monitoring current economic developments. Furthermore, by providing time series of quarterly data on macroeconomic aggregates in a coherent accounting framework, QNA allow analysis of the dynamic relationships between these aggregates (particularly, leads and lags). Thus, QNA provide the basic data for business-cycle analysis and for economic modeling purposes. Also, QNA have a particular role to play for accounting under high inflation, sharp changes in relative prices, and where annual source data are based on varying fiscal years. In addition, as with the annual accounts, QNA provide a coordinating conceptual framework for design and collection of economic source statistics and a framework for identifying major gaps in the range of available short-term statistics.

1.8 QNA can be seen as positioned between ANA and specific short-term indicators in many of these purposes. QNA are commonly compiled by combining ANA data with short-term source statistics and ANA estimates, thus providing a combination that is more timely than that of the ANA and that has increased information content and quality compared with short-term source statistics.

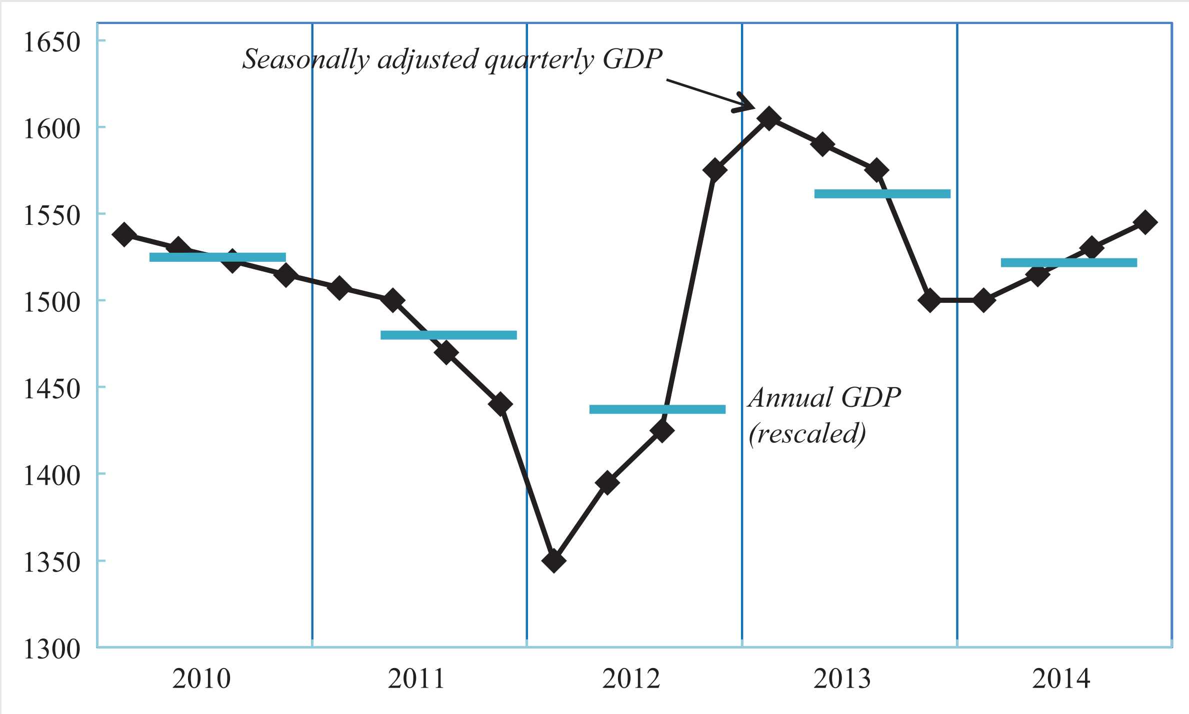
1.9 QNA should be available within three months after the end of the reference quarter. ANA, on the other hand, are produced with a considerable time lag. The initial ANA (accounts based on annual data as opposed to first estimates on the basis of the sum of the four quarters) are often available six months or more after the end of the year. Even if the ANA were as timely as the QNA, they would not provide timely information about the current economic situation since the information for, say, the first quarter would be delayed. Also, annual information is insufficient for monitoring of the business cycle, and the timing of economic policy aimed at affecting the business cycle, since it masks higher frequency developments. Within-the-year economic developments are not shown in the ANA. In addition, developments that started in one year and end in the next may not be visible in the ANA (see Example 1.1). The strength of the ANA is to provide information about the economic structure and long-term trends, rather than to provide data needed for monitoring the business cycle.

1.10 QNA are best positioned for forecasting purposes as they provide up-to-date information on the current economic situation. Furthermore, quarterly data more adequately reflect the dynamic relationships between economic variables (leads and lags in particular), and they provide four times as many observations, which is very helpful when using mathematical techniques such as regression analysis.

1.11 QNA are indispensable during times of high inflation or sharp changes in relative prices for at least two reasons. First, in these circumstances, one of the basic axioms of the ANA is violated: namely, the assumption of price homogeneity over time. Although this basic axiom never fully applies (unless there are no price changes), in times of low inflation, it does not affect the usefulness of the ANA. However, in situations of high inflation, adding up current price data over a year becomes meaningless because the prices vary so much within the year. QNA are much less affected by this situation (although under extreme circumstances the accounting period should even be shorter). Second, the problem of holding gains is much less severe for QNA than for ANA and can more easily be eliminated because changes in valuation are less frequent in a shorter accounting period.

1.12 QNA are less timely than short-term indicators, but they provide a more comprehensive picture of current economic developments organized in an integrated framework for analyzing the data. Short-term indicators such as price indices, labor market indicators, industrial production indices, and turnover data for retail trade are often available on a monthly basis shortly after the reference period. These short-term indicators provide valuable information on specific aspects of current economic developments. However, these indicators do not provide a coherent, comprehensive, and consistent picture of the different aspects of the current economic situation. This hampers tracing the causes of current problems and identifying potential future developments. For instance, for a country facing decreasing domestic output growth,

Example 1.1 Monitoring Business Cycles—Quarterly GDP Data (Seasonally Adjusted) versus Annual GDP Data



The chart shows quarterly and annual constant GDP price for a hypothetical economy and illustrates how annual data may mask the cyclical movements. In this example, the QNA data show that the economy was growing during 2012 and that the upturn from the preceding slump started around the first quarter of 2012. In contrast, the ANA data show that the economy contracted in 2012 compared with 2011. The growth during 2012 first emerges in the ANA when the annual estimates for 2013 become available.

The situation is further aggravated by the usual time lag of the ANA, with the first annual estimates for 2013 not available until 2014. While the QNA will show the upturn in the first quarter of 2012, the ANA will not show that upturn until 2014. By that time, the economy in this example has just gone through a second downturn. Thus, an upturn in economic activity would already have changed into a downturn while the ANA would still show positive growth.

in addition to identifying affected industries (as a detailed production index would allow), it would be helpful to identify causes such as decreasing domestic demand or falling exports and to further trace deeper causes such as income, saving, and investment patterns affecting demand categories. A key advantage of the QNA is that they assemble and integrate these indicators into the consistent analytical framework of the national accounts.

1.13 A criticism of QNA is that quarterly GDP is not a good business-cycle indicator, because GDP includes activities such as government and agriculture that do not necessarily respond to changes in the business cycle. For this reason, it is argued that a less comprehensive measure, such as a volume index for manufacturing industries, is preferable as a business-cycle indicator. However, the QNA should not be reduced to being a vehicle for compiling summary aggregates such as GDP. Quarterly GDP can be broken down into specific economic activities or expenditure components, which provides a view of economic activities that are deemed more relevant for business-cycle analyses. The QNA also provides an integrated framework for analyzing economic statistics, thus allowing the examination and analysis of developments and behavior.

Quarterly National Accounts as Time Series

1.14 QNA data should be presented in a time-series format. A time series is a collection of observations ordered in time. To be temporally comparable, a time series should present the following characteristics:

a. Observations of a time series should measure the same concept over time.

b. Measurement of the same concept should be consistent over time with respect to statistical standards and units of measurement.

c. Time periods should be in the same unit (e.g., months, quarters, etc.). Periods of different length are not comparable.

d. QNA should be compiled and disseminated in quarterly discrete form. Cumulative data do not constitute time series.[1] Observations of a cumulated series cannot be compared, because they measure periods of time with different length.

1.15 For time series recorded in a consistent manner over time, series of period-to-period changes (e.g., GDP quarter-to-quarter growth) or changes from the same period of the previous year (e.g., GDP growth between the third quarter of the current year and the third quarter of the previous year) are generally used to assess short-term movements or annual trends from quarterly data. However, these changes should be analyzed with caution, as the comparison between quarters may be influenced by changing seasonal and calendar effects, international standards, or methodological advances that intervened over time.

1.16 A time-series format of QNA data is essential for a number of uses: business and trend cycle analysis, identifying turning points, studying dynamic relationships between economic variables (in particular, leads and lags), and forecasting. Most of these analyses require long time series. In a situation where QNA have only recently been started, it is recommended to extend the series backward. As a rule of thumb, for purposes of regression analysis and seasonal adjustment, the time series should cover at least five years. A QNA series that is restricted to two consecutive years cannot be considered a time series, because such a presentation would not allow comparisons with preceding years. This requirement for a time-series character of the QNA has important implications for the design of QNA compilation techniques (as described in later chapters).

1.17 The importance of presenting monthly and quarterly data as time series for the purposes of analyzing trends and turning points is illustrated in Annex 1.1. The numerical example provided there shows that in measures of change from the same period of the previous year, turning points in the data can be seen with a systematic delay, which in most circumstances is substantial. The average delay is around half a year in discrete data and around three-quarters in cumulative data. As shown in Example 1.1, rates of change from the same period in the previous year can indicate that an economy is still in recession when it has actually been recovering for some time.

Seasonally Adjusted Data and Trend-Cycle Estimates

1.18 Seasonal adjustment[2] is the process of removing seasonal and calendar effects from a time series. The purpose of seasonal adjustment is to provide users with additional series where some of these components have been removed. In seasonally adjusted data, the effects of recurrent within-a-year patterns—the seasonal and calendar patterns—are removed, while in trend-cycle estimates the impact of irregular events are also adjusted for. Calendar-adjusted data remove only the impact of calendar effects from the original series.

1.19 Opinions differ among both users and compilers whether it is the role of statistics agencies to produce seasonally adjusted and trend-cycle estimates. Opinions differ on the usefulness of seasonally adjusted data and whether seasonal adjustment and trend-cycle estimation should be the responsibility of compilers of official statistics. Consequently, country practices in this respect differ. Some statistical offices do not publish any seasonally adjusted data or trend-cycle estimates at all, considering it to be part of users' analysis of the data. Others focus on seasonally adjusted data and trend-cycle estimates, and may not compile or publish unadjusted QNA estimates. Most publish seasonally adjusted data and trend-cycle estimates in addition to the unadjusted figures (at least for the main aggregates), and this practice is encouraged.

[1] For instance, data covering January–March, January–June, January–September, and so on. Annex 1.1 illustrates the disadvantage of cumulative data when identifying turning points.

[2] Well-established techniques are available for seasonal adjustment, such as the X-12/X-13 and TRAMO-SEATS methods (discussed in Chapter 7).

1.20 A basic principle of this manual is to compile QNA from unadjusted source data and to apply seasonal adjustment/trend-cycle estimation to the resulting estimates (or the short-term indicators used to derive them). The discussions on sources and methods in this manual, and in particular the discussions concerning benchmarking, are all based on this premise. This premise is derived from the need to serve different users' needs as well as from practical compilation considerations. As illustrated in Box 1.1, unadjusted data, seasonally adjusted data, and trend-cycle estimates are useful for different purposes. The unadjusted data describe what happened in each period, while the seasonally adjusted data and the trend-cycle estimates provide a perspective of the underlying movements in the series. Thus, users should have access to all three sets of data. While QNA estimates based on unadjusted data allow seasonal adjustment, the reverse—deriving unadjusted QNA estimates from seasonally adjusted data—is not possible. QNA compilation of adjusted and unadjusted data should ideally be derived using a coordinated and integrated process.

1.21 Seasonally adjusted data and trend-cycle estimates are needed to identify changes in the business cycle and turning points. Turning points in the business cycle may not be visible if seasonal patterns and one-time events in the data are not filtered out. Using growth rates from the corresponding quarter of the previous year is not an adequate solution for business-cycle analysis, as explained above (see Annex 1.1 for further explanation of this issue). Furthermore, growth rates from the corresponding quarter do not fully exclude seasonal elements (for instance, religious holidays may rotate and take place

Box 1.1 Seasonal Adjustment: Unadjusted Data, Seasonally Adjusted Data, Trend-Cycle Estimates—What Do Users Want?

Main Use of the Data	Components of Interest	Components of Less Relevance
Business-cycle analysis	Trend-cycle and irregular components	Unadjusted data
Turning point detection	Trend-cycle and irregular components	Unadjusted data
Short- and medium-term forecasts	Original unadjusted series and all its components (trend-cycle, irregular, seasonal factors, preadjustment factors, etc.)	
Short-term forecasts of stable but highly seasonal items (such as electricity consumption)	Seasonal factors plus the trend-cycle component	
Long-term forecasts	Annual data and possibly the trend-cycle component of monthly and quarterly data	Unadjusted monthly and quarterly data, seasonally adjusted data, and the irregular components
Analysis of the effect of particular events (such as a strike)	The irregular component and any preadjustment factors	
To determine what actually happened (e.g., how many people were unemployed in November)	Original unadjusted series	Seasonally adjusted and trend-cycle data
Policy formulations	Original unadjusted series and all its components (trend-cycle, irregular, seasonal factors, preadjustment factors, etc.)	
Macroeconomic model building	Could be unadjusted, adjusted, trend-cycle, or all components, depending on the main purpose of the model	
Estimation of behavioral relationships	Could be unadjusted, adjusted, trend-cycle, or all components, depending on the main use of the estimated relationships	
Data editing and reconciliation by statistical compilers	Original unadjusted series, seasonally adjusted data, irregular component, and trend-cycle component	

in different quarters, the number and type of working days in a quarter differ from year to year, etc.).

1.22 Unadjusted data and other components of the series are needed for other purposes, including various aspects of monitoring current economic developments. For short-term forecasting of highly seasonal series, all components may be needed, particularly the seasonal component. Economic policy formulation may also require information on all components of the series; for analysis of the effects of particular events, identification of the irregular component may be most important. Unadjusted data are also required for purposes such as econometric modeling, where the information contained in the seasonal component of the series may play a particular role in determining the dynamic relationship among the variables.[3] Also, for the most recent data in the series, seasonally adjusted data and trend-cycle estimates are subject to additional revisions compared with the unadjusted series.

1.23 Some users may prefer the unadjusted data because they may want to seasonally adjust the data themselves by applying their own seasonal adjustment procedures. Some aspects of seasonal adjustment remain controversial, partly reflecting the many subjective and somewhat arbitrary choices involved in seasonal adjustment, including the choice of method (e.g., X13-ARIMA versus TRAMO-SEATS), the model decomposition (additive or multiplicative), the treatment of outliers, and the choice of filters.[4] For these and other reasons, it has been argued that statistical offices "should produce the raw data and the users can then use their own software for treating seasonal data in the way they want and in which their analysis calls for."[5] However, the statistical office may have particular information about special events impacting on the series. A key advantage in carrying out seasonal adjustment is to provide a single and consistently estimated official GDP to all users.

1.24 Seasonal adjustment may also assist compilers in detecting abnormalities in the data and allow better checks on plausibility of data (in particular, growth rates). Thus, it may be easier to identify some types of errors or discrepancies and their causes with adjusted data than with unadjusted data. On the other hand, the adjustments may obscure discrepancies and abnormalities in the unadjusted data that do not relate to seasonality. Also, it is more difficult to interpret discrepancies in the adjusted data, because it is uncertain to what extent the discrepancies were already implicit in the unadjusted data.

1.25 Although seasonal adjustment removes the identifiable regular repeated influences on the series, it does not and should not remove the impact of irregular events. Consequently, if the impact of irregular events is strong, seasonally adjusted series may not represent a smooth and easily interpretable series. To further highlight the underlying trend-cycle, most standard seasonal adjustment packages also calculate a smoothed trend-cycle series, representing an estimate of the combined long-term trend and the business-cycle movements in the series. Several countries include these estimates in their publications, and this practice enhances transparency and credibility of the seasonal adjustment results. However, the presentation should highlight the lower reliability of the trend-cycle estimates for the latest observations (as explained in Chapter 7).

Consistency Between Quarterly and Annual Accounts

1.26 To avoid confusion about interpreting economic developments, it is essential that the QNA are consistent with the ANA.[6] Differences in growth rates between QNA and ANA cause confusion in the users and uncertainty about the reliability of the actual measurements. Consistency means that the sums (or averages if the system is based on index numbers) of the estimates for the four quarters of the year should be equal to the annual estimates. In a situation where the ANA or ANA components are built up from the QNA, consistency is achieved by construction. ANA are more commonly based, however, on different sources than the quarterly estimates, and therefore, differences are expected. To overcome this issue, the QNA data should be aligned with the annual data; the process to achieve this is known as "benchmarking." One advantage of benchmarking is that incorporating the usually more accurate annual information into

[3] See, for instance, Bell and Hillmer (1984), pp. 291–320.
[4] See, for instance, Chapter 5 of Alterman, Diewert, and Feenestra (1999) for a discussion of many of these controversial issues.
[5] Hyllenberg (1998), pp. 167–168.

[6] Consistency is a strict requirement for nonseasonally adjusted QNA. For seasonally adjusted data, inconsistencies with ANA may derive from the application of seasonal adjustment procedures.

the quarterly estimates increases the accuracy of the quarterly time series. Benchmarking also ensures an optimal use of the quarterly and annual source data in a time-series context.

1.27 Benchmarking deals with the problem of combining a time series of high-frequency data (e.g., quarterly data) with less frequent but more accurate data (e.g., annual or less frequent data). Benchmarking also arises when the annual estimates are anchored to more comprehensive and detailed surveys and censuses that are performed only every few years. The same basic principle applies to quarterly and annual benchmarking; however, as shown through the technical discussion in Chapter 6, quarterly benchmarking is technically more complicated.

1.28 Benchmarking has two main aspects, which in the QNA context are commonly looked upon as two different topics: (a) *quarterly distribution*[7] of annual data to construct time series of historical QNA estimates ("back series") and to revise preliminary QNA estimates to align them to new annual data when they become available, and (b) *extrapolation* to update the QNA series by linking in the quarterly source data (the indicators) for the most current period ("forward series").

1.29 The general objective of benchmarking is to preserve as much as possible the short-term movements in the source data under the restrictions provided by the annual data and, at the same time, ensure that the sum of the four extrapolated quarters is as close as possible to the unknown future annual data. Preserving the short-term movements in the source data is important, since the indicator provides the only available explicit information to estimate QNA components. The optimal preservation of the short-term movements in the data is one of the basic premises of this manual. Therefore, the core problem of benchmarking in a quarterly context is how to align a quarterly indicator time series to annual data while maintaining the quarterly pattern and without introducing artificial discontinuities from the last quarter of one year to the first quarter of the next year. This problem is known as the "step problem." To avoid the step problem, several mathematical techniques have been developed. Chapter 6 presents two techniques: (a) the proportional Denton method, which is optimal under the general benchmarking objective stated above, and (b) the proportional Cholette–Dagum method with autoregressive errors, which under certain conditions may improve accuracy when extrapolating quarterly estimates beyond the available annual benchmarks.

1.30 To be consistent, QNA and ANA should use the same concepts. As mentioned, the manual seeks full consistency with the *2008 SNA* and aims to avoid any unnecessary duplication. Nevertheless, some conceptual issues have a stronger incidence and more substantial consequences on a quarterly than on an annual basis, which necessitates some further discussion. The most important conceptual issue in this respect is the time of recording, particularly in two cases: (a) long-production cycles and (b) low-frequency payments. Long-production cycles (or production cycles that are longer than one accounting period) mainly concern construction, manufacturing of durable goods, and agriculture and forestry. The problems involved can be very substantial for QNA compilation and are discussed in Chapter 11. Low-frequency payments are payments made on an annual basis or in infrequent installments over the year. Examples of such payments are dividends, end-of-year or vacation bonuses, and taxes on the use of fixed assets and other taxes on production. These issues are discussed in Chapter 4.

Transparency in Quarterly National Accounts

1.31 Transparency is a fundamental requirement of QNA for users, particularly when it comes to revisions. To achieve transparency, it is important to provide users with documentation regarding the source data used and the way they are adjusted. As well, documentation should be provided on the compilation process. This will enable users to make their own judgments on the accuracy and reliability of the QNA and will preempt possible criticism of arbitrary data manipulation. In addition, users should be informed about release dates according to a preannounced advance release calendar to avoid any impression of manipulative timing of publication. To avoid misperceptions, it is advisable that the compiling agency takes a proactive approach to educate users.

1.32 Revisions are undertaken to provide users with data that are as timely and accurate as possible. Resource

[7] It encompasses the techniques of interpolation for stock data and temporal distribution for flow data. For more on this, see Chapter 6.

constraints and respondent burden can cause tension between timeliness of published data, on the one hand, and reliability, accuracy, and comprehensiveness on the other. To balance these factors, preliminary data are compiled and later revised when more and better source data become available. Revisions provide the possibility to incorporate new and more accurate information into the estimates, and thus to improve their accuracy, without introducing breaks in the time series.

1.33 Although revisions sometimes may be perceived as reflecting negatively on the trustworthiness of official statistics, delaying the implementation of revisions may increase the size of later revisions (e.g., if they are in same direction, because they are cumulative). Experience has shown that more sophisticated users understand that publishing large revisions, especially when supported by improvements in source data and methods, is a sign of integrity. Not incorporating known revisions actually reduces the trustworthiness of data, because the data do not reflect the best available information, and the public may know this or find out (for instance, the public may wonder why a revision in the monthly production index is not reflected in the QNA). In a time-series-oriented compilation system, suppression of revised information can also be cumbersome and costly, and can cause estimation errors.

1.34 To minimize the number of revisions needed without suppressing information, it is advisable to coordinate statistical activities. The revision schedule should be largely driven by arrival of source data, and coordinating their arrival would help reduce the number of revisions needed.

1.35 Transparent publication and revision policies help address any concerns users may have about revisions. In addition, users need to be clearly informed about the causes of revisions and how these revisions are incorporated in the QNA estimates. Countries have adopted different approaches to revisions in response to their own circumstances. However, some important elements that constitute best practice are (a) candid and easily available documentation of sources and methods, (b) easily available documentation of the size and causes of revisions, and (c) release and revision dates that are well known and published through an advance release calendar. These practices are all required or encouraged by the IMF's data dissemination standards.[8] In addition, electronic release of the complete time series, not only the data for the most recent periods, will make it easier for users to update their databases. These issues are further discussed in Chapter 12.

1.36 It is advisable to take a proactive approach to educate users. Educating users, while valuable for most statistical areas, is particularly important for QNA because of their policy relevance and technical complexity. This introductory chapter has not only emphasized the usefulness of QNA, but also has pointed out inherent weaknesses. Compilers must be candid about these issues with the public and pursue transparency of sources and methods for compiling QNA. For instance, experience has shown that a proactive approach can help reduce complaints about revisions. Also, compilers should educate users about the analytical possibilities and other benefits of the QNA data. Enhanced contact with users may also help compilers detect weaknesses in the estimates or their presentation. In addition, users sometimes have their own economic information that could be helpful to compilers.

1.37 Users should be informed about the meaning of the data and the limitations, and inappropriate uses should be discouraged. Given the likelihood of future revisions, users should be cautioned about the lower relative robustness of the most recent release. To achieve a prudent appraisal of developments, users should be advised to also consider the trend in the data over several quarters in addition to the latest quarter alone. As well, if QNA data are presented in an annualized format, either as compounded growth rates or as levels multiplied by four, it is important to explain that this presentation magnifies the irregularity and uncertainty of QNA data. Similarly, using growth rates with more than one digit behind the decimal point gives the impression that the data are significantly more precise than they generally are.

1.38 Several approaches can be taken to educate users. Seminars could be conducted for specific audiences, such as specialized journalists, interested parliamentarians, and users within the central bank, government agencies such as the Ministry of Finance

[8] Current data dissemination standards of the IMF include Special Data Dissemination Standard Plus (SDDS Plus), Special Data Dissemination Standard (SDDS), and the enhanced General Data Dissemination System (e-GDDS).

or the Department of Commerce, or with the academic community. Direct inquiries by users are good occasions for compilers to explain specific issues. For the general public, the occasion of new releases, which often brings the QNA to public attention, can be used to highlight points of interest. In particular, attention should be given to revisions and their causes. Also, in presenting the data, care should be taken to exemplify proper use, as indicated above. The best way to go about this is to provide press releases tailored to the style of the media, ready to print.

Early Estimates

1.39 In some countries, early estimates of QNA are released fairly shortly after the reference period.[9] The terminology is designed to emphasize that shortcuts have been taken and that, consequently, the data are particularly subject to revision. The shortcuts usually include use of data for only one or two months of the quarter for some or all components, with the missing month(s) estimated by extrapolation using mechanical methods such as those discussed in Chapter 10. Another common shortcut is the use of data with less complete response rates than the data used for subsequent QNA estimates. Early estimates only differ from subsequent QNA estimates in that they use a higher proportion of such methods. Consequently, early estimates do not raise additional conceptual issues, although the practical concerns about informing users of their limitations and assessing the record of revisions for QNA are even more crucial. Early estimates may be more limited in coverage of the *2008 SNA* variables (for instance, they may cover variables from the production account only) or be published in a more aggregated form. Publication of less detail is a recognition that the statistical noise is greater in disaggregated data and will emphasize the limitations of the estimates to users. Preferably, the level of compilation would be the same as for subsequent estimates, because a different level of compilation requiring the use of different methods may cause unnecessary revisions.

Outline of the Manual

1.40 This manual comprises four parts. The first part (Chapters 1 and 2) introduces the basic principles and concepts of QNA and lays out strategic issues for their implementation. It is intended to be of particular interest to those setting up a new system. In addition, it will also be useful to those reviewing existing systems. Chapter 1 defines the scope and role of QNA and discusses the links between QNA, annual accounts, and short-term statistics. Chapter 2 deals with managerial and organizational issues and suggests main steps in establishing and maintaining a QNA system.

1.41 The second part (Chapters 3 and 4) deals with data sources. Chapter 3 reviews the commonly used data sources that are used by countries to compile quarterly GDP by industry, by type of expenditure, and by income category. Chapter 4 discusses the main sources to compile a complete sequence of accounts, possibly by institutional sectors. There is increasing interest in measuring the economy "beyond GDP" on a quarterly basis.

1.42 The third part (Chapters 5–8) illustrates the basic methodology for QNA compilation. Chapter 5 is an overarching chapter that discusses how to resolve specific QNA compilation issues such as time of recording issues and seasonal effects. Chapters 6–8 discuss in detail specific methods required for compiling QNA. Chapter 6 deals with benchmarking and reconciliation techniques. These techniques are essential in all countries where annual sources are of higher quality and more comprehensive than quarterly sources, and there is a need to make QNA estimates consistent with ANA benchmarks. Basic principles of seasonal adjustment are discussed in Chapter 7. The chapter is intended particularly for those starting a new system as well as those with existing systems that do not yet have seasonally adjusted data. Finally, Chapter 8 deals with specific QNA issues related to price and volume measurement. The problem of aggregation over time is relevant to all compilers, while the issues associated with chain-linking pertain to more advanced systems.[10]

[9] Early estimates of quarterly GDP are also referred to as advance, flash, or preliminary estimates.

[10] The term "volume" is used for measures that exclude the effects of changes in prices of the components that make up the item. The exclusion of the effect of price changes means that changes in a time series of volume measures are driven by quantity and quality changes. Volume can be contrasted with quantity, which is limited to data that can be expressed in physical units. Accordingly, quantity measures do not take into account quality change and are not applicable for unquantifiable items or aggregates of different items. Volume can also be contrasted with estimates in *real* terms which refer (in precise national accounts terminology)

1.43 The fourth part (Chapters 9–12) discusses advanced methods for improving the accuracy, reliability, and timeliness of the quarterly estimates. Chapter 9 provides a framework for validating estimates of quarterly GDP and other main quarterly aggregates. A quarterly supply and use model is proposed to integrate QNA compilation with available annual supply and use tables (SUT). Chapter 10 illustrates best practices to fill data gaps for calculating early estimates of quarterly GDP. Chapter 11 explains how to measure unfinished output as work-in-progress in the QNA. Finally, Chapter 12 emphasizes the importance of setting up a sound and coordinated revision policy of QNA data and explains ways to monitor the reliability of GDP estimates using revisions analysis.

Main Changes to the 2001 Edition

1.44 The second edition of the manual broadly maintains the structure of the 2001 edition. The new edition contains one additional chapter on specific QNA compilation issues. Two chapters are redrafted: Chapter 9 on editing procedures and Chapter 10 on early estimates. The remaining nine chapters are updated versions of the existing chapters with improved and additional content.

1.45 The manual realigns with the main changes made by the *2008 SNA*, in particular those related to the scope of transactions and the production boundary (*2008 SNA*, Annex 3.C) and those related to the extension of the concept of assets and capital formation (*2008 SNA*, Annex 3.D). Chapters 3 and 4 on data sources have been amended accordingly.

1.46 The updated manual adds a number of improvements based on best practices and country experience in the compilation of QNA. The most substantial additions refer to four areas of the QNA methodology: (i) reconciliation procedures, (ii) a supply and use model for validating quarterly GDP estimates, (iii) early estimates of quarterly GDP, and (iv) real-time database and revisions analysis of QNA data.

to measures of the purchasing power of an item (i.e., in reference to prices of other items). In common usage, “real” is often used for purchasing power as well as volume measures. While constant price estimates are a common form of volume measure, the term also includes fixed-base and chain-linked volume indices.

1.47 Chapter 6 on benchmarking is expanded to cover the problem of reconciling QNA series subject to both annual benchmarks and quarterly contemporaneous constraints. An optimal simultaneous procedure based on the Denton method is identified and recommended. A two-step reconciliation procedure is also recommended when the dimension of the problem is too large to be resolved simultaneously. These procedures may be relevant to reconcile discrepancies between ANA, QNA, and quarterly accounts by institutional sectors.

1.48 Drawing on recent country experience, Chapter 9 introduces a quarterly supply and use model as a validation tool to assess the coherence of independently derived quarterly estimates of GDP by production and by expenditure. When annual SUT are available, a quarterly supply and use model is proposed to transform aggregate GDP discrepancies into detailed product imbalances. A detailed view can facilitate the identification of the most critical areas of intervention for improving the quality of the quarterly GDP data.

1.49 Chapter 10 provides methodological guidelines and practical advice on how to calculate early estimates of quarterly GDP in the broader context of QNA, how to assess their quality, and how to communicate these estimates to the users. This chapter is intended to help statistics agencies to develop early estimates of quarterly GDP.

1.50 Chapter 12 proposes statistical measures to analyze revisions of QNA data. Following a well-established Organisation for Economic Co-operation and Development (OECD) methodology, the manual proposes that a real-time database of QNA estimates is created and maintained over time, from which descriptive statistics of revisions can be calculated to quantify and summarize revisions made to preliminary estimates at different stages. From this analysis, compilers can derive valuable information on the magnitude and directions of GDP revisions, identify weaknesses in the compilation process, and implement the necessary improvements.

1.51 Other relevant changes have been incorporated in the areas of benchmarking, seasonal adjustment, and chain-linking. A variant of the Cholette–Dagum benchmarking method is now suggested as an alternative to the Denton method for extrapolation (Chapter 6). Guidelines on seasonal adjustment are aligned with recent developments and best practices, including the treatment for calendar effects (Chapter 7). Finally, new advances in the calculation of quarterly chain-linked estimates are accounted for in Chapter 8 (e.g., the formula to calculate additive contributions to quarterly GDP growth from chain-linked components).

1.52 Finally, the new edition updates and incorporates the relevant content of chapters "V. Editing and Reconciliation" and "VII. Mechanical Projections" of the 2001 edition into "Editing Procedures" (Chapter 9) and "Early Estimates of Quarterly GDP" (Chapter 10), respectively.

Annex 1.1 Identification of Turning Points

A1.1 This annex provides a numerical example illustrating the importance of presenting monthly and quarterly economic information as time series and the derived rates of change in the time series on a period-to-period basis, for the purposes of analyzing trends and turning points in the data (as emphasized in Chapters 1 and 7). In the absence of seasonally adjusted time series and trend-cycle estimates, it is common practice to present changes from the same period in the previous year, instead of period-to-period changes. As shown in Example A1.1, rates of change from the same period of the previous year can be inadequate in identifying the current trend in economic activity, indicating, for example, that an economy is still in recession when it has actually been recovering for some time. If changes from the same period of the previous year are used, turning points in the data show up with some delay, which in some circumstances can be substantial. The average delay can be shown to be around half a year in discrete data and around three-quarters of a year in cumulative data.

A1.2 In addition to delaying identification of turning points, changes from the same period of the previous year do not fully exclude all seasonal elements (e.g., religious holidays rotate and take place in different quarters, or the number of working days of a quarter

Example A1.1 Identification of Turning Points

Quarter	Discrete Data	Cumulative Data	Rates of Change: Quarter-to-Quarter	Rates of Change: Changes from the Same Quarter of the Previous Year (Discrete Data)	Rates of Change: Changes from the Same Quarter of the Previous Year (Cumulative Data)
q1 2010	1,537.9	1,537.9			
q2 2010	1,530.2	3,068.1	–0.5%		
q3 2010	1,522.6	4,590.7	–0.5%		
q4 2010	1,515.0	6,105.8	–0.5%		
q1 2011	1,507.5	1,507.5	–0.5%	–2.0%	–2.0%
q2 2011	1,500.0	3,007.5	–0.5%	–2.0%	–2.0%
q3 2011	1,470.0	4,477.5	–2.0%	–3.5%	–2.5%
q4 2011	1,440.0	5,917.5	–2.0%	–5.0%	–3.1%
q1 2012	**1,350.0**	1,350.0	–6.3%	–10.4%	–10.4%
q2 2012	1,395.0	2,745.0	**3.3%**	–7.0%	–8.7%
q3 2012	1,425.0	4,170.0	2.2%	–3.1%	–6.9%
q4 2012	1,575.0	5,745.0	10.5%	**9.4%**	–2.9%
q1 2013	**1,605.0**	1,605.0	1.9%	18.9%	**18.9%**
q2 2013	1,590.0	3,195.0	**–0.9%**	14.0%	16.4%
q3 2013	1,575.0	4,770.0	–0.9%	10.5%	14.4%
q4 2013	**1,500.0**	6,270.0	–4.8%	**–4.8%**	9.1%
q1 2014	1,500.0	1,500.0	**0.0%**	–6.5%	**–6.5%**
q2 2014	1,515.0	3,015.0	1.0%	–4.7%	–5.6%
q3 2014	1,530.0	4,545.0	1.0%	–2.9%	–4.7%
q4 2014	1,545.0	6,090.0	1.0%	**3.0%**	–2.9%

Note: Bold type indicates turning points.

Example A1.1 Identification of Turning Points (continued)

may differ from year to year). Moreover, in addition to any irregular events affecting the current period, these year-to-year rates of change will reflect any irregular events affecting the data for the same period of the previous year.

A1.3 Consequently, year-to-year rates of change are not suitable for business-cycle analysis, and analyzing the economy only on the basis of these rates of change can have an adverse impact on the soundness of macroeconomic policy.

A1.4 If the changes from the same period in the previous year are based on cumulative data (e.g., data that cover January–March, January–June, etc.), which has been the tradition in some countries, the delays in determining the turning points are even longer.

A1.5 The numerical example presented in Example A1.1 is based on a time series of hypothetical data, starting in the first quarter of 2010, that can be viewed as representing tons of steel produced in each quarter, or alternatively, quarterly GDP at constant prices. It contains three turning points. The first turning point occurs in quarter 1 of 2012, the second occurs in quarter 1 of 2013, and the third in quarter 4 of 2013.

A1.6 From the discrete quarterly data presented in the first column of Example A1.1, these three turning points are easily seen as the series turns from

(a) decreasing to increasing in quarter 1 of 2012, (b) increasing to decreasing in quarter 1 of 2013, and (c) decreasing to increasing in quarter 4 of 2013.

A1.7 Similarly, from the quarter-to-quarter rates of change presented in the third column of Example A1.1, the first turning point is indicated by the shift in quarterly rates of change from a negative rate in quarter 1 of 2012 to a positive rate in quarter 2 of 2012, the second turning point by the shift from a positive to a negative rate of change from quarter 1 to quarter 2 of 2013, and the third turning point by the change from a negative to a positive rate of change from quarter 4 of 2013 to quarter 1 of 2014.

A1.8 When using changes from the same period of the previous year (e.g., comparing quarter 1 of 2011 with quarter 1 of 2010) instead of quarter-to-quarter changes, the delays in identifying the turning points can be substantial. In the example, the changes from the same quarter of the previous year are presented in the fourth column and show the third turning point as having taken place in quarter 1 of 2014 (i.e., three quarters after it actually occurred).

A1.9 If the changes from the same quarter in the previous year are based on cumulative data (as shown in the final column), the analysis gives the impression that the turning point took place even one quarter later.

Bibliography

Alterman, W.F., E. Diewert, and R. Feenestra (1999), "Time Series Approaches to the Problem of Seasonal Commodities," in ed. W.F. Alterman, E. Diewert, and R. Feenestra, *International Trade Price Indexes and Seasonal Commodities*, Washington, DC: U.S. Bureau of Labor Statistics.

Bell, W.R., and S.C. Hillmer (1984), "Issues Involved with the Seasonal Adjustment of Time Series," *Journal of Business and Economic Statistics*, 2 (October): 291–349.

Hylleberg, S., ed., (1992), *Modelling Seasonality*, Oxford: Oxford University Press.

United Nations, European Commission, International Monetary Fund, and Organization for Economic Co-operation and Development (2008), *The System of National Accounts, 2008*, New York: United Nations.

2 Strategic Issues in Quarterly National Accounts

This chapter highlights some key statistical and administrative issues that compilers should consider when establishing or operating a quarterly national accounts (QNA) compilation system. It seeks to ensure that the compilation system is built on sound statistical standards and that good management practices are employed to facilitate the efficient operation of the system. There is no single best way of organizing a QNA compilation system and countries develop their system based on their needs and circumstances. This chapter should not be considered prescriptive or exhaustive. The issues and suggestions presented should be of benefit not only to agencies that are setting up a compilation system for the first time but also to agencies seeking to improve the efficiency of the compilation system and the overall quality of the QNA statistics.

Introduction

2.1 Compilers must address strategic statistical and organizational issues to facilitate an efficient operation of the QNA compilation system. These issues arise when a QNA compilation system is being set up and should be revisited from time to time during the operational phase. The most important statistical issues to be considered are as follows: (i) coverage of the QNA and (ii) assessment of quarterly source data and the compilation process. Key organizational aspects are resource requirements, the compilation schedule, and the release cycle.

2.2 The overall process involves two phases: a development phase and an operational phase. In the development phase, the compiler should develop and assess the compilation approach, select source data, and establish a back series of QNA data. An important first step in this phase is to consult with potential users to determine how they may use the QNA data. User needs evolve over time and users may have a better understanding of their needs after new data become available; therefore, consultation with users should proceed on an ongoing basis. The main steps in establishing and maintaining QNA are summarized in Box 2.1. In the operational phase, estimates are compiled for the reference quarter and estimates for previous quarters may be revised when new quarterly and annual information becomes available. The data sources, statistical techniques, and compilation system used for establishing the back series in the development phase and for updating the series in the operational phase should be identical, as far as possible.

Statistical Issues

Coverage of the QNA

General Issues

2.3 When establishing the QNA, one of the first decisions that the compiler has to make is which parts of the *2008 SNA* should be implemented. The choice will depend on availability of quarterly source data, the ANA system in place, resource availability, and user needs. As mentioned in the introduction to this chapter, an important first step is to consult with potential users to see what kind of use they could make of QNA data. This implies assessing what level of detail users would find desirable.

2.4 The annual national accounts (ANA)—along with supporting source data—are usually already in place when the QNA compilation system is being established. Therefore, the next step in designing a QNA compilation system is to take an inventory of available source data to determine which parts of the ANA can be implemented on a quarterly basis. The initial design of QNA should be based on the ANA as much as possible, although it is usually simpler and more aggregated.

Box 2.1 Main Steps to Establish and Maintain Quarterly National Accounts

To Establish QNA

1. **Consult potential users**
   - Concerning possible uses
   - Concerning required coverage, detail, and so on
2. **Take inventory**
   - Of annual compilation methods
   - Of available quarterly and annual source data
3. **Design compilation methods and procedures**
   - Consider relationship to sources and methods used in the annual accounts
   - Decide coverage of QNA, including which parts of the *2008 SNA* are to be implemented
   - Determine compilation level
   - Choose integrated or separate ANA and QNA compilation system
   - Design compilation schedule, including timeliness of first estimates and revision policy
4. **Review the quality of source data and compilation procedures**
   - Study correlation between annual and quarterly source data
   - Study revisions to main aggregates based on historic data (historic simulation of the compilation system)
     - ➢ Revisions to the quarterly compilation system
5. **Generate time series of QNA data for past years ("back series")**
   - Benchmark the time series of quarterly source data to the time series of annual data (using methods such as the enhanced proportional Denton method or the Cholette–Dagum method)
     - ➢ To be done for a sufficiently long time series
     - ➢ To be done at the most detailed compilation level
6. **Perform real-time test runs and update the quarterly time series with estimates for the quarters of the current year (year *y*)**
   - Link monthly and quarterly source data for the current quarters with estimates for the back series
     - ➢ Extrapolation with indicators—benchmark the same series of quarterly source data to the series of annual data (using methods such as the proportional Denton method or the Cholette–Dagum method)
   - Fill information gaps
7. **First release**

To Maintain QNA

1. **Revise the quarterly estimates for the current year when new quarterly data become available**
   - Link monthly and quarterly source data for the current quarters with estimates for the back series
     - ➢ Extrapolation with indicators—benchmark the same series of quarterly source data to the series of annual data (using methods such as the enhanced proportional Denton method or the Cholette–Dagum method)
2. **Revise the quarterly estimates when new annual data become available**
   - Revise the quarterly estimates for year *y* (and preceding years) to incorporate new benchmark data without introducing steps in the series
     - ➢ Benchmark the time series of quarterly source data to the time series of annual data
     - ➢ To be done at the most detailed compilation level
3. **Update the quarterly time series with estimates for the next current year (year $y + 1$)**
   - Compile quarterly estimates for year $y + 1$ by linking monthly and quarterly source data for the quarters of year $y + 1$ with the revised and benchmarked QNA estimates for year 1 to year *y*
     - ➢ Extrapolation with indicators—benchmark the time series of quarterly source data to the series of annual data
     - ➢ To be done at the most detailed compilation level

2.5 In the initial stage of implementation, only estimates of value added or expenditure on gross domestic product (GDP) may be estimated. In some countries, it is desirable to start off with a limited system: for example, just volumes by industry expressed in index form without seasonal adjustment, initially labeled as experimental and only circulated to major economic policy agencies. While this system would not meet Special Data Dissemination Standard requirements, it would be a practical first step. The techniques would resemble those for flash estimates of GDP (as discussed in Chapter 10): that is, with less detail and more gaps. As users recognize the usefulness of quarterly data and the compilers gain experience, the country can move on to second or third phase extensions, such as improving data sources and adding current prices.

2.6 Since the QNA should be anchored to the ANA, the coverage of the QNA should then be consistent with the coverage of the ANA. This means that the coverage should either be the same as the ANA or constitute a subset of the ANA. For instance, if the ANA covers only compilation of value added, then the initial coverage of the QNA should be restricted to compilation of value added.

2.7 Developing a system of QNA requires additional resources, as current resources used for ANA compilation will need to continue. If additional resources are not forthcoming, the agency may consider efficiency gains or reprioritizing the ANA or other statistics tasks. However, it may not be possible to realize efficiency gains because the available resources being used for the statistics compilation may already be stretched to their limits. Further, the agency may already be compiling only the basic ANA aggregates and reprioritizing may therefore not be an option.

Measuring GDP and Its Components

2.8 QNA are almost always compiled at a lesser level of detail than the annual estimates, but it is not easy to draw the line on the level of detail required. Occasionally, the same data are available quarterly and annually: for example, merchandise trade statistics, government accounts, and selected financial statistics. In these cases, it is best to use the same level of detail as the ANA. The estimates should maintain separate data for items that are large, of interest to users, or behave in atypical ways. Less detail does not always mean making the compilation process simpler, faster, and less resource demanding, because sometimes a more detailed level of compilation makes it easier to eliminate differences between indicators. For instance, when balancing the supply and use of vehicles, having more detail about different types of vehicles (such as trucks and passenger cars) makes balancing of supply and use easier (the use of trucks is mostly for fixed capital formation, while use of passenger cars can be both for fixed capital formation and for household consumption). Also, in automated compilation processes, more detail need not make much of a difference in compilation speed and resource needs.

2.9 Measurement of GDP constitutes a core part of the national accounts system. Traditionally, a distinction is made among three approaches to GDP measurement: (a) the production approach, (b) the expenditure approach, and (c) the income approach. This distinction is somewhat artificial because these three approaches often use the same source data. For instance, government output and government consumption estimates are often based on the same source data; the estimates of fixed capital formation for the expenditure approach are partly based on output estimates of construction and production of machinery, which are also used in the production approach; and the wages and salaries estimates used in the income approach are often derived from the same statistics that provide the data on industry output and value added that are used in the production approach. However, the various approaches also use specific source data and allow a distinct perspective on development and level of GDP. Although, as argued, these approaches are not fully independent, applying various approaches facilitates cross-checking of data. Therefore, this manual recommends that countries estimate GDP using at least two of the three approaches. Because of their relative strengths, the production and expenditure approaches are preferred in the QNA.

2.10 Another important reason to apply at least the production and expenditure approaches is that they provide different breakdowns of GDP. To the extent that demand is driving short-term changes in the economy, the expenditure split provides particularly useful data for business-cycle and macroeconomic policy analysis and for forecasting. The production approach is widely used for measuring quarterly GDP, in part because of a traditional focus in many countries on short-term statistics on indicators of production. This approach involves calculating output, intermediate consumption, and value added at current prices as well as in volume terms by kind of economic activity. In most countries, output data are reasonably well covered for manufacturing, but the coverage of construction and services is usually less comprehensive. Components missing from output, intermediate consumption, and value added are estimated using ratios that reflect fixed input–output coefficients. Single-indicator-based estimates will be biased to the extent that the ratios vary with factors such as seasonal effects, capacity utilization, input composition, technological change, and productivity trends.

2.11 The production approach is used more widely to compile QNA relative to the expenditure approach. This is because of problems in availability, timing, valuation, and coverage in expenditure source data. The expenditure approach usually has two strong pillars of quarterly data: namely, merchandise trade and government consumption. The other categories—in particular, household final consumption—are often less well covered. The major components of external transactions are usually available from the balance of payments and through merchandise trade statistics that often have a strong basis in comprehensive data collection for customs purposes. Data on government consumption can be derived from government administrative data, but directly observed data on fixed capital formation and changes in inventories may be lacking.

2.12 Nevertheless, it may still be possible to derive a useful split of GDP by categories of expenditure. For example, if GDP is estimated using the production approach and the compiler can estimate key expenditure components using available source, then the missing components may be presented as a residual. One such missing component may be changes in inventories, because the source data are usually incomplete or inadequate. Although not an independent check of the GDP estimates, incomplete estimates of GDP by categories of expenditure (i.e., with some components derived as a residual) are useful for analysis in addition to providing some plausibility checks of GDP.

2.13 The expenditure split is, in some ways, the most practical to measure in constant price or volume terms because there is a relatively clear concept of price and valuation for each demand category. In contrast, the price and volume dimensions of value added are more complex because value added cannot be directly observed. The income approach is not suited for price and volume measures, although some analysts may be interested in deriving estimates of real income. As mentioned, the expenditure split also provides particularly useful data for business-cycle and macroeconomic policy analysis and for forecasting. Also, this split is most useful for policy reasons because, over the short term, demand can be more easily influenced than supply.

2.14 The income approach is the least commonly used of the three approaches but is potentially useful as an alternative measure of GDP. The income approach avoids some of the problems that may arise in using the production and expenditure approaches, such as the reliance on fixed input–output ratios in production data. However, it requires that businesses have quarterly data on profits and some expenses.

2.15 The income approach may have a sound underpinning in wage statistics or in administrative data on wages (for instance, for social security purposes), but quarterly observations of operating surplus/mixed income are often unavailable although the increasing use of business accounting software is leading to the wider availability of income data on a quarterly basis, even for many small businesses in the formal sector.

2.16 Even if income data are incomplete, it may still be possible to derive an income split where one of the categories (usually gross operating surplus) is derived as a residual. The distribution of income from GDP provides a useful alternative perspective on economic development. For a country interested in issues such as profitability and wage bargaining, this could be an important economic statistic. It also shows the link between business accounting and the national accounts, particularly if a bridge table from profits to operating surplus/mixed income is provided.

2.17 The weaknesses of the various methods for compiling GDP can be mitigated by combining production and expenditure data using the commodity flow method. This method is based on the fundamental national accounting identity shown in the goods and services account and supply and use tables (SUT): namely, that total supply (by-product) must equal total use. The commodity flow method can be applied on different levels: for instance, for groups of commodities or for individual commodities. The more detailed the level at which the method is applied, the more accurate the result (detailed information requires fewer assumptions on origin and use). This method is particularly strong if applied in supply and use framework, even one of limited dimensions. Production and income data can be checked if both are classified by industry, which is particularly meaningful if the value-added data for industries can be broken down into compensation of employees, operating surplus, and mixed income. Chapter 9 provides further details on how to use SUT in the compilation and validation of QNA.

2.18 In measuring GDP, compilers of QNA should ensure that the informal economy is covered and well represented. A common assumption in the QNA is that informal activities move together with formal ones. This assumption is not always plausible across time, particularly in countries with large shares of informality undergoing rapid changes in the economy. Box 2.2 provides some general principles on how to cover the informal economy in the QNA.

Box 2.2 Covering Informal Activity in the Quarterly National Accounts

Covering the informal economy is an essential step to improve the comprehensiveness of the GDP data. For countries with a significant share of informal activity, not including an estimate of informal activities will lead to an understatement of the GDP levels. Further, it may increase uncertainty in the analysis of trends when activities in the informal sector evolve with a different pattern from the formal sector. International comparability of country data also call for an estimate of the informal economy in the official GDP data.

Measuring the informal economy in the QNA is particularly challenging due to the scarcity of direct information on informal activities on a monthly or quarterly basis. Country practices are diverse and adapt to the specific circumstances faced by each country. Nonetheless, some general principles can be useful to guide countries that are planning to include (or have implemented) estimates of the informal sector in the QNA:

1. Prior to developing quarterly estimates, benchmark estimates of informal activities should be compiled as part of the annual compilation process or at the time of a major rebasing/benchmarking exercise. These benchmark estimates should be based on direct measurement of informal activities. Surveys of informal activity, with samples designed for this purpose, usually provide accurate results. However, new surveys are resource intensive. Alternatively, ad hoc modules on the informal economy can be added to regular household surveys (e.g., labor force survey, household income, and expenditure survey) or business surveys. Mixed household business surveys may also be conducted. Tax data can be used to complement regular survey data for uncovered units.
2. Countries with significant shares of informal activity should develop a QNA system where informal activities are distinguished from formal activity and are extrapolated using specific indicators. The identification of suitable proxy indicators for informal activities is of great importance. The need for formal/informal breakdown should be based on the share of informality by economic activity, usually available from the annual GDP compilation by production. The breakdown should be consistent with the annual accounts. When formal and informal activities present similar evolutions, the informal economy can be estimated based on the quarterly evolution observed in the corresponding formal activity (or the use of fixed ratios between formal and informal production). However, these assumptions can produce inaccurate results when the share of informal activity in the economy is expected to deviate from the share of formal activity during upturns or downturns in the economy.
3. Short-term indicators of informal activity should be derived indirectly, as observed data are usually not available quarterly. The indirect methods generally rely on comparisons between household surveys (e.g., labor force surveys) and establishment surveys at a disaggregated level. Regression models can also be developed to estimate informal activity based on proxy indicators and behavioral assumptions relative to formal activity. However, such models should be used with caution as strong assumptions are needed and the estimated coefficients may no longer be valid during sudden changes in the economy. For countries with quarterly household surveys, specific modules on the informal activity may be incorporated on an experimental basis to allow for a direct measurement of informal activities in the QNA.

References on the concepts and measurement of informal activities:

European Commission, IMF, Organisation for Economic Co-operation and Development, United Nations, and World Bank, 2008, *The System of National Accounts, 2008*, Chapter 25, New York: United Nations.

Organisation for Economic Co-operation and Development, 2002, *Measuring the Non-Observed Economy: A Handbook*, Paris: Organisation for Economic Co-operation and Development.

International Labour Organization, 2013, *Measuring Informality: A Statistical Manual on the Informal Sector and Informal Employment*, Geneva: International Labour Organization.

Assessing Source Data and the Compilation System

2.19 Before compiling the QNA estimates, the quality of both source data and the proposed compilation procedures must be reviewed going back as many years as feasible to produce a long time series. The main purpose of the review is to identify weaknesses in the quarterly compilation system and possibilities for improvements to minimize future revisions of the main aggregates. It is important to establish whether the source data properly indicate the direction and overall size of changes and whether they enable the identification of turning points. The review also gives an indication of the quality of the estimates and the degree of revisions that can be expected in the future. However, revisions are inevitable because of resource constraints, and accurate and detailed source data will be generated on a continuous basis. Thus, when the first quarterly estimates are released, users should be well informed of the accuracy and the reliability of the estimates and the possibility of revisions to the estimates.

2.20 When assessing the quality of statistics, "accuracy" is used to mean "closeness to the truth," while "reliability" is used to mean "degree of revisions to which the series is subjected." The QNA estimates are anchored to the ANA; therefore, the accuracy of the ANA sets a ceiling on the accuracy of the QNA; the reliability of the QNA is also thus determined because the extent of revisions depends on the closeness of the initial QNA estimates to the ANA estimates and the extent of revisions to the ANA estimates (for a more comprehensive discussion of revisions, see Chapter 12).

2.21 The use of sources and methods should be well documented. The documentation is useful for compilers when problems arise or when there is staff turnover or absence. It also provides the basis for documentation for users, who often wish to know more about the data.

2.22 The compiler should conduct the following tracking exercises to assess the source data and the compilation system:

a. assess how the quarterly source data for individual series track the annual estimates,

b. assess how preliminary quarterly source data for the individual series track the final quarterly source data, and

c. assess how the overall compilation system track the annual estimates for major aggregates.

The overall tracking exercise will also provide a measure of the reliability of the QNA. Assessing the source data and the compilation system should be seen as a continuing process that should also be conducted regularly during the operational phase.

Assessing Individual Source Data

2.23 Source data should be assessed for accuracy, reliability, and timeliness. Such an assessment is important because of the following reasons: (i) it will reveal whether a specific series of source data is suitable for QNA purposes; (ii) where more than one data source is available for a particular variable, it will aid in choosing among them; (iii) when source data are conflicting, it will facilitate a choice on where to adjust; (iv) it will help to identify areas for improvement; and (v) it will facilitate informing users about the quality of the estimates and expected future revisions. In many cases, the compilers will not have options among different data sources; however, it is still necessary to assess indicators that could possibly be used. These assessments should be discussed with the data providers, who may be able to give additional background information.

2.24 The main criterion for assessing the accuracy of quarterly source data is the extent to which these data track annual movements. This criterion follows from the need to keep QNA consistent with ANA and the assumed higher quality of the annual source data. The accuracy of the short-term source statistics as indicators for the annual movements depends on definitions and specification of the variables and on issues such as coverage, units, and classifications.

2.25 The ability of the quarterly source data to track the annual estimates should be assessed by comparing the growth rates in the annual sum of the quarterly source data with growth rates in the corresponding ANA estimates. Large differences in the rates of change indicate inconsistencies between the quarterly and annual source data for that series and potential weaknesses in the quality of either the quarterly or the annual source data. Large differences in the annual rates of change in the quarterly and annual source data for the back series also indicate that large revisions can be expected in the future as additional source data become available. Mathematical techniques can be used to more formally study the correlation between annual and quarterly data and to identify and remove any systematic errors (i.e., bias) in the quarterly source data's long-term movements.

2.26 Specific problems may arise if annual reporting is on a fiscal year basis rather than a calendar year basis. The main problem is that in annual statistics, respondents with a nonstandard reporting year (i.e., a reporting year that differs from the rest of the industry) are usually included in the statistics for the year that has the largest overlap, which will then create a mismatch with the sum of the quarters. A solution to this problem with the annual data could be found if the annual source statistics use the information from the quarterly source statistics to allocate the data of an individual respondent to the standard accounting period using the benchmarking techniques presented in Chapter 6.

2.27 The reliability of the quarterly source data has important implications for how early sufficiently reliable initial QNA estimates can be prepared. Often the first estimates will have to be based on preliminary versions of source data that are still open to revisions. One important reason for such revisions to the source data is that early response rates are lower, and estimates may change as response increases. These changes may follow a consistent pattern, which implies a "bias" in the preliminary estimates, or the changes may be irregular, which implies "noise." A bias in early estimates of an indicator may be caused by selectivity in the response. The reliability of the quarterly source data can be assessed by comparing period-to-period rates of change in the preliminary versions with the corresponding rates of change in the final versions of the series. This can only be done if the preliminary versions of the data have been retained in the databases rather than being continually overwritten. These results will also help identify where new data sources may be needed. From time to time in national accounts compilation, assumptions and methods that appear plausible turn out to be unsuitable, while others are initially suitable but later are not because of changing economic circumstances.

2.28 The timeliness of the quarterly source data also has important implications for how early sufficiently reliable initial QNA estimates can be prepared. Often the first estimates will have to be based on an incomplete set of source data. For some series, data may only be available for two months of the reference quarter, while data for other series may be unavailable altogether. To fill these source data gaps, provisional estimates will have to be made based on simple trend extrapolation or on alternative indicators that are more timely but less accurate. For each individual variable, the impact of these provisional estimates on the reliability of the first estimates can be assessed by constructing provisional estimates for the past years as if one were in the past and comparing the period-to-period rate of change in those estimates with corresponding rates of change in the final quarterly source data for that variable. In some countries, less reliable early data are published but labeled as "flash estimates" to highlight the lower level of reliability (see Chapter 10).

2.29 The assessment of possible source data will determine what source data are suitable for QNA purposes and, from there, which parts of the *2008 SNA* can be implemented. Sometimes, the assessment will lead to the conclusion that biases and noise are too substantial for a particular set of data to be used to compile QNA data. This can imply that the QNA compilers have no other choice other than to not use these data, but it would be important to discuss with the compilers of the source data whether improvements can be made (see paragraph 2.31). While the decision not to use a certain dataset might mean that the system cannot be fully implemented—until a later stage when a new data source is introduced—this is likely to be preferable to the use of data that can result in misleading results.

2.30 If alternative indicators are available for the same variable, it is important to have some knowledge of their accuracy and reliability to choose between them. The lesser quality data may still be useful as a check on the preferred series. QNA compilers may need to adjust the source data in the QNA compilation process. Inconsistencies in the data may be revealed through a SUT balancing or in a commodity flow equation, and in such cases, knowledge about the accuracy and reliability of the data will provide guidance on how much leeway there is for adjusting the data.

2.31 Assessment of the source data may also help identify areas that need improvement, both for the

QNA and the ANA. Necessary improvements may concern coverage, definitions, units, and so on. Obviously, it will be easier for QNA compilers to request improvement of statistics collected by the same agency, but even data from other agencies may be improved. Agencies collecting data for their own use that do not fit well into the QNA compilation might adapt their questionnaires to allow use in the QNA context rather than having their respondents exposed to a new survey.

2.32 In setting priorities for improvements, the relative importance of an indicator should be one of the considerations. For some components, the basic data may be so poor that refinement of methods would be of doubtful benefit. There are also likely to be components of little economic significance that have poor data. National accountants need to be careful about expending too much effort on numerous, trivial items at the expense of large, important items. Of course, the fact that an item is small cannot be an excuse for deliberately choosing a poor method when a better one is available, and compilers should be able to explain and defend the methods used to derive the estimates of even the smallest components. Further, it should be noted that some small items can have a substantial effect on the estimates of growth (e.g., changes in inventories).

2.33 In some cases, the development of QNA methods also leads to improvements in the ANA. The process of review often brings to light outdated or unrealistic assumptions in annual estimation, as well as faulty annual compilation practices. In a few cases, the quarterly data may be superior and so may be used to replace the annual data. QNA can also contribute to an improved allocation of fiscal year data to calendar years in cases where the two do not coincide.

Assessing the Overall Compilation System

2.34 Before QNA estimates are published, an aggregate tracking exercise should be undertaken to assess the overall consistency of the quarterly and annual source data and compilation systems with respect to annual rates of change for major aggregates. Errors in the individual series may go in opposite directions and, thus, may not give a good indication of the degree of future revisions of the main aggregates that can be expected. To undertake an aggregate tracking exercise, the entire compilation process needs to be simulated on historic data to produce time series of non-benchmarked estimates for the major aggregates. The QNA compilation system should be used to produce estimates of QNA aggregates for the past years as if one were in the past and producing the first preliminary sum of four quarter estimates for those years without later annual benchmarks. If feasible, it is preferable to perform the aggregate tracking exercise based on the incomplete set of source data that would actually have been available when the first sum of four quarter estimates would have been produced.

2.35 Later, in the operational phase, the aggregate tracking exercise should be repeated by comparing the various releases of annual data from the QNA system with the eventual ANA data. As emphasized in Chapter 12 and in the IMF's Data Quality Assessment Framework, best practice also involves periodically conducting and publishing studies of long-term trends in the revision patterns. Summaries of these studies may accompany the regular quarterly release of data to remind users that data are subject to revisions and to provide some indication of the potential range.

2.36 It is advisable to also perform test runs in real time before going public with the QNA. Only experience from such test runs can sufficiently ensure the robustness of a QNA system and its ability to cope with unexpected problems. QNA compilers should endeavor to schedule sufficient time to run one or two real-time test runs in the establishment phase.

2.37 The tracking exercise on the aggregate level can be used to remove weaknesses in the system overall. For instance, the exercise may indicate that estimates from the production approach are more robust than the estimates from the expenditure approach, which would provide guidance to adjustments in the course of the compilation process.

Statistical Processing

2.38 Statistical processing encompasses the assembly of data, benchmarking, deflation, seasonal adjustment, aggregation, and other calculations. In designing a processing system, it is useful to anticipate the differences and links between the preparatory and operational phases of QNA compilation so that different needs can be satisfied using the same processing system. In general, the processes for compiling data in the preparatory and operational phases will be the same. However, the operational phase has some extra complexities that may not be evident in the preparatory phase.

2.39 In the QNA preparatory phase, the objective is to compile data on past years (back series). Compilation of QNA data for a single quarter or year is of little value. The back series of historical data provide greater perspective on economic developments and, for that reason, should go as far back as feasible. Long back series also allow compilers setting up a new system to check the data, gain experience in the behavior of the series, and support seasonal adjustment.

2.40 In the operational phase, the objective is to update the time series with data for the current quarters as well as revising the data for past years. The operational phase differs from the preparatory phase in several respects. These differences arise because, in the preparatory phase, compilation was done after the fact with existing ANA totals as benchmarks, which would not be available for the most recent quarters. Other differences are that in the operational phase, the data will be less complete for the most recent quarters, data source revisions will be an issue, and the timing of data supply in a proper sequence becomes much more important. Only running the quarterly compilation system in real time will reveal all the implications. A trial run of a quarter or two before the official release (as recommended above) will allow these problems to be identified and resolved without delays that the public may notice.

2.41 For the operational phase, the forward or extrapolation part of the series presents its own difficulties because there will be no annual benchmarks for that part of the series. The challenge is to extend the series beyond the end of the last benchmark, tracking the likely future ANA estimates so that future revisions are minimized while preserving the short-term movements in the quarterly source data (to the extent possible).

2.42 Finally, during the operational phase, there are continuing cycles of revisions to quarterly indicators, revisions to annual benchmarks, and the receipt of annual benchmarks for the most recent years. This new information needs to be incorporated in the QNA estimates as it becomes available.

2.43 The calculations applied to the data are diverse and depend on the characteristics of the series. Some data will be received in a form ready to use without adjustment, but more commonly there will be the straightforward manipulations familiar in annual compilation—addition, subtraction, multiplication (whether called scaling, grossing up, or quantity revaluation), and division (e.g., deflation). However, the mathematical techniques used to produce QNA estimates by combining a quarterly indicator and an annual benchmark series are more complex. Inevitably, the movements in any two nonidentical quarterly and annual series will differ. The challenge is to align the QNA estimate to the ANA estimate while preserving the time-series properties of the data. This process—called benchmarking—is not an easy matter because simple methods such as pro rata distribution of the annual total introduce a discontinuity in the series between years—the "step problem." Benchmarking improves the quarterly data by taking into account the superior annual information.

2.44 It should be emphasized that in the case of incorporation of revised or new benchmarks, the calculations should be based on the original quarterly indicator, not on the preliminary QNA estimates that have already been adjusted. Otherwise, the compilation process risks deteriorating into an unorganized data hashing, in which the compilers lose track of the original data, the effects of benchmarking, and the effects of other adjustments.

2.45 To avoid introducing distortions in the series, incorporation of new annual data for one year will generally require previously published quarterly data for the past several years to be revised. This is a basic feature of all acceptable benchmarking methods. As explained in Chapter 12, the compiler may have to revise the quarterly estimates for the year for which new annual data are to be incorporated as well as the quarterly data for one or several preceding and following years. In principle, QNA estimates for all preceding and following years may have to be adjusted to preserve the short-term movements in the indicator if the errors in the indicator are large. However, in practice, the impact of new annual data will gradually diminish until it no longer has any impact on sufficiently distant past years.

Relationship Between QNA and Source Data

2.46 As a consequence of benchmarking and calculations in the QNA compilation process, the QNA data may differ from the source statistics. Subjecting data to a balancing process in a commodity flow or SUT framework will also generate differences with the source data. Users may find these differences puzzling and the compiler should make every effort to explain these differences. However, if the variables in the QNA are basically identical to those in the source statistics, then consistency should be pursued. This consistency should be pursued through adjustments in the source statistics. For instance, a monthly or quarterly production index should be benchmarked to the same annual or less frequent census data as used in the QNA. At the very minimum, causes for differences should be explored, and they should be documented in a way that facilitates access by users.

2.47 Initially, working the differences resulting from the benchmarks used in the QNA compilation process back into the source statistics may appear cumbersome. However, adjusting their statistics to the benchmarks used in the QNA is beneficial to the consistency of the statistical system and to the quality of their own statistics. One important effect of adjustment may be an increased awareness among the compilers of source statistics of the need to ensure consistency between data from high-frequency statistics (monthly and quarterly data) and annual data; these compilers may also be encouraged to apply benchmarking procedures. Discussions with the compilers of source statistics about the differences will most likely increase their involvement in the way their data are used in the QNA compilation process. For instance, they may develop an interest in participating in the deliberations during the balancing process, for which they could provide valuable input. Obviously, the adjustment process of the QNA source statistics will be easier to establish if a similar process is in place for the ANA. If this is not the case, starting a QNA system is a good opportunity to initiate an adjustment process for the ANA source statistics as well.

Dissemination

2.48 Dissemination of QNA has much in common with dissemination of other statistics. The IMF's dissemination standards provide some general guidance on the coverage, frequency, and timeliness considerations for the dissemination of the QNA estimates. In addition, the Data Quality Assessment Framework provides guidance on good dissemination practices.

2.49 This section focuses on some QNA-specific dissemination issues, especially concerning release and presentation. With regard to release, owing to the nature of QNA and their importance for decision making, the predominant condition is that the release should be timely. The statistical agency should establish and publicize a release calendar with a release schedule that meets or exceeds the timeliness requirements established in the IMF's dissemination standards (where relevant) and every effort should be made to release the data according to the preannounced schedule.

2.50 The first release of the QNA statistics may be a rather limited one, focusing on the most important data. For instance, the focus could be on GDP growth in current prices and in volume terms (both seasonally adjusted and nonadjusted) as well as on trend estimates. As a further extension, it could include breakdowns by expenditure categories and type of activity. Also, it is important to mention the most important revisions concerning earlier releases.

2.51 The quickest ways to release these data are simultaneously through a press release, via social media, and on the agency's website. The press release text should be short and ready for use without rewriting. These conditions promote acceptance by the media and also prevent misrepresentation by less knowledgeable media staff. Media often mention the source of press releases, which may generate the perception that the published article reflects the view of the statistical agency. Press releases should have a catchy heading; if they do not have one, the media will make one up that might be more creative than statisticians would like. Furthermore, it is advisable to support the press release with a small table containing the most important data. For easy recognition by the public, it makes sense to standardize such a table and to consult with media staff about its content. Publication through the internet should be simultaneous with the press release and preferably using the same text. Preparation of the releases should start as early as possible and need not wait until all the publishable data are ready; usually an impression of the important news can be developed on the basis of the data that become available in the last phases of the compilation process.

2.52 Many countries also publish a more comprehensive quarterly statistical publication dedicated to the QNA. These publications provide a more thorough analysis of the data, supported by charts depicting the economic developments in various ways, such as contributions to GDP growth from demand categories or from industries are often used. The extent to which statisticians comment on the data differs among countries. In some countries, statistical offices basically provide only the data with technical explanations as needed, some countries identify the highlights, and in others, statistical organizations see it as their task to interpret economic developments. Either way, national accountants should keep close to the facts to avoid giving the impression that the statistical agency wishes to influence public opinion by taking a position on economic and political issues.

Organizational Issues

General

2.53 Management of QNA differs from ANA because of the greater intensity of work and tighter deadlines. Also, compilation of QNA requires more assumptions and the greater use of indirect indicators. In addition, because of the more intensive use of mathematical techniques, some staff with a background in time series and regression analysis may be useful. The pattern of workload peaks is quite different for QNA than for ANA. A statistical office that produces only annual estimates is accustomed to a production cycle spread over a year. The annual estimation may often have some clustering of tasks toward the end of the cycle and there may be tight deadlines to be met.

2.54 For both ANA and QNA compilation, data from a wide range of sources are brought together. In many cases, the compilers are responsible for data collection, but typically, data may come from other parts of the same agency or from other agencies. The sequencing and timing of QNA compilation are complex because the QNA should be built around the arrival of the results from numerous collections and suppliers.

2.55 An important organizational issue to be dealt with at an early stage concerns the release cycle—the timing of the first release of the data for the reference quarter and of subsequent revised versions of the data. The release cycle will also depend on the release cycle of the ANA. After the first release, revisions are usually needed, depending on, among other things, the arrival of new or revised source data and, eventually, the arrival of annual data. The release cycle derives directly from the revision policy, which is discussed in Chapter 12.

Timing of the Compilation Process

Structuring the Compilation Process

2.56 Sequential and "big bang" processing are alternative ways to structure the compilation process. The sequential approach involves processing in stages (data entry, basic checks, aggregation at lower levels, deflation, seasonal adjustment, and overall aggregation). In contrast, with the big bang approach, the data are entered and the whole system is run simultaneously; the results are then viewed in detail in the context of the aggregate trends. This may be done iteratively several times as new data arrive and adjustments are made. In practice, there may be some blending of these two approaches. Some of the considerations to be taken into account in designing the processing system are whether the source data arrive within a short period of time or over several weeks, how much checking of source data is necessary, and the nature of the computer system being used. The big bang approach lends itself to SUT methods because it emphasizes interrelationships between different data.

Planning Workloads

2.57 QNA compilers are subject to short and tight deadlines. QNA compilation is also particularly vulnerable to delays in major data inputs or bugs in computing systems. To deal with timing problems, a quarterly work schedule should be drawn up. The schedule should take account of the release calendar, the expected availability of required source data, the period required to carry out each process, and the flow of data from one stage to the next. In this way, it is possible to predict when the results will be ready for publication. It will also help in identifying the sequence of tasks and calculating the effects of delays. The work schedule should identify the following:

- the data inputs and when they are expected to arrive;
- the tasks of the national accounts compilers, including how long each task is expected to take and the order in which they are carried out; and
- the delineation of responsibility for each task.

2.58 The work schedule should account for unforeseen delays. As required by the IMF's data dissemination standards, release dates should be preannounced. However, unforeseen problems may occur and failure to release the estimates as announced may create suspicion of manipulation for political reasons. When compilers first start compiling QNA, there is a greater potential for unforeseen problems. Therefore, countries might initially provide for a longer compilation period and greater margin for delay and gradually improve timeliness as they gain QNA compilation experience.

Methods of Speeding Compilation

2.59 Compilation is concentrated in a short period because source data are often released only after the end of the quarter and QNA are produced quickly. This situation makes accelerating tasks particularly important. The compilation process can be speeded in two important ways.

2.60 First is by reducing peaks in processing workloads. One way to reduce the burden during the peak processing period is to do as much work as possible in advance. For example, monthly data for the first one or two months of the quarter can be processed as soon as they are received or before the end of the quarter. Similarly, it may be possible to implement revisions made to data for earlier quarters before compilation for the new quarter begins. Some problems in data can be foreseen and dealt with in advance. For example, if a series will be rebased or its coverage changed, it may be possible to set up a program that splices together the old and new series before the data become available.

2.61 Second is by improving the arrangements for the supply of source data. Data suppliers may be able to provide preliminary or unprocessed data. The compiling agency may then be able to select and process the relevant data from a larger database, instead of waiting to have the complete dataset processed. This may require the development of special data sharing arrangements with the relevant agencies that would allow the compiling agency to access the unprocessed data.

Organizing Staff

2.62 The most common situation is for all national accounts data, including QNA, to be compiled in the national statistics agency. In a few cases, compilation of quarterly accounts is done in the central bank and the ANA by the statistics agency. It is generally undesirable to have different organizations involved because of the potential problems of inconsistent data and methods as well as the loss of synergies between the annual and quarterly systems.

2.63 The organization of national accounting divisions varies. In a small agency, there may be no division. In a larger organization, units can be divided in one or more of the following ways:

- detailed sources/integrating data and working on aggregates,
- quarterly data/annual data,
- industries/expenditure components/income components,
- current price data/constant price data,
- orientation on process/orientation on product, and
- development and analyses/operational work.

2.64 Some of the considerations regarding allocation of staff are balancing peaks and troughs in workloads, linking common subject matters and techniques, and having teams that are easy to manage (too large makes communication harder, too small means fewer skills and more vulnerability to absences and departures). When different teams address related issues, there is a risk of duplication or conflicting opinions about methods.

2.65 An important organizational choice to be made is whether there should be a unit focused specifically on QNA or whether QNA or ANA should be compiled within the same unit by the same staff. The pattern of workload peaks is quite different, so peaks in the annual compilation may not crowd out activities in QNA (and vice versa). An advantage of combining both functions is that harmonization between QNA and ANA is more likely if the same staff are working on both.

2.66 When setting up a new QNA system, it is often desirable to identify a separate QNA team. Otherwise, the developmental work may be hampered if staff are continually being called to other, more urgent tasks. The development of a new system requires a high level of conceptual ability, so the staff should have a good knowledge of the *2008 SNA* and the annual compilation system. QNA compilation uses some specialized approaches and techniques not used in ANA, so assigning ANA compilers for each component to develop the corresponding QNA component will be less efficient in taking advantage of the synergies of QNA techniques that could be achieved with a specialized QNA team. Some staff with good background knowledge on monthly and quarterly surveys may complement the knowledge of ANA compilers.

Organizing Data Supply

2.67 Coordination with data suppliers is one of the important tasks of the QNA compilers as the timing of QNA compilation is typically more critical than the timing of ANA. Compilers need to be in close contact with their suppliers so that both sides understand the other's needs. Data sources can have changes in coverage, definitions, procedures, and classifications that need to be identified in advance and well before the compilation process is initiated. Data suppliers can also provide information on what is happening in the economy, shortcomings of the data, and how to deal with problems such as breaks in the series.

2.68 It is also a good idea to keep the data supplier informed of how the data are being used and how the estimates may be used in policy analysis. This would help data suppliers appreciate the usefulness of their data. The compiling agency may provide this information through discussions with data suppliers or through special brochures that are sent out to suppliers.

2.69 In some countries, a memorandum of understanding is established with each data supplier, stating aspects of the relationship such as data specifications, timetables, notification of changes, and regular meetings. Such a process should be considered, though some countries find that informal procedures may also be effective.

3 Sources for GDP and Its Components

This chapter describes the process of identifying and assessing the data sources for compiling quarterly estimates of gross domestic product (GDP). It is not possible to identify a limited, standard set of sources that could be applied across all countries because of differences in the production structure of economic activities and the degree of sophistication of the data collection systems. Therefore, this chapter highlights examples of acceptable data sources that are used to compile estimates of quarterly GDP in various countries and some of the factors that need to be taken into account when considering these sources.

Introduction

3.1 Ideally, the same data sources used for the annual estimates of GDP should be used for the quarterly estimates. However, this may not be possible because the data are not available on a quarterly basis, and even if they are, the higher frequency data may be less accurate and reliable. Compilers therefore must choose among a range of alternative data sources, with varying degrees of accuracy and reliability, and hence suitability. This chapter addresses issues that are specific, or are of greater importance, to quarterly GDP compilation relative to annual GDP compilation. Therefore, it will not provide a broad description of sources because, in general, the same principles for designing sources and methods apply to both annual and quarterly GDP.

3.2 The chapter first presents an overview of the data sources and issues relating to the compilation of quarterly GDP. These issues may apply to more than one component of GDP. The remainder of the chapter covers issues relating to the components of the production, expenditure, and income approaches to measuring GDP. The production approach is presented by type of indicator. A presentation by type of economic activity would be repetitive because some issues are relevant across various types of economic activity and a presentation arranged by output and intermediate consumption would not show the links among the compilation of these items.

3.3 The expenditure and income approaches are discussed by component because the indicators used to derive the estimates for each component tend to be more specific to that component. Some indicators may be used in more than one approach because of the relationships between the components or activities. One example is the use of the same construction indicators for construction in the production approach and for gross fixed capital formation on dwellings, buildings, and other structures in the expenditure approach. In these cases, specific issues for such indicators are discussed under the heading of expenditure. Even if expenditure or income data are incomplete, it may still be possible to derive a useful split of GDP by type of expenditure or income, as noted in paragraph 3.80.

Overview of Data Sources

General Issues

3.4 Quarterly GDP data sources are generally more limited in detail and coverage than those available for the annual estimates. Quarterly GDP data sources are also expected to be timelier than the data for the annual estimates, a factor that could affect data availability and may increase data collection costs. As a result, GDP compilation may rely on indicators that best capture the movements in the target variable in the past and in the future. Therefore, the basic principle in selecting and developing sources is to obtain indicators that best reflect the economic activity being measured. In some cases, source data are available in a form ready for use in compiling quarterly GDP with little or no adjustment. In other cases, the source data may differ substantially from the ideal and will need to be adjusted. These adjustments may typically be established for one or a few main benchmark years for which additional data sources—such as the results of more comprehensive and detailed surveys or censuses—may be available. In these cases, the annual and quarterly time series are anchored to these main benchmark years and the regular source data are used as indicators to update the benchmark estimates (extrapolation or, equivalently, forward carrying of the benchmark adjustments). As the annual GDP provide the benchmarks for quarterly GDP, they should be the starting point in selecting and developing quarterly sources. In some cases, the same sources that are used for the annual estimates or for the benchmark estimates may also be available on a quarterly basis. The most common among these are merchandise trade statistics and accounts of government operations.

The Choice of a Suitable Indicator

3.5 The choice of a suitable indicator is based on the assumption that it is able to reflect the changes in the target variable. However, these indicators should be reviewed on a regular basis because the economic conditions (production relationships or price relationships of the variable) may have changed over time. For example, the use of the number of visitors as an indicator of accommodation should take into account that over time (and even based on the quarter), the length of stay per visitor and the ratio of visitors using paid accommodation is likely to vary.

3.6 The indicator being chosen may either be a primary item of a data collection system or a by-product of the system. For example, the number of employees in a given industry would be a primary item of a survey of employment but a by-product of a business income tax system. If the indicator is a by-product, then factors such as the sampling procedures, representativeness, and classification systems could affect accuracy because the by-product would have been collected using survey procedures and data collection systems that were not specifically designed to collect these data.

3.7 The suitability of an indicator must first be assessed qualitatively by examining the similarities and differences with the target variable in terms of scope, definitions, frequency, coverage, and so forth. There is a range of possibilities for the closeness of the indicator and the target variable. The most desirable indicators differ only slightly from those used in the annual GDP, for example, by being based on a sound sample but with less detailed data. Less satisfactory are indicators that cover only a part of the total, such as the key products or a subset of producers in an industry. Even less satisfactory are indicators that measure a variable related to the process or population of the target variable, but less directly, such as labor inputs as an indicator of the output of services.

3.8 Indicators that apply past trends or measure a variable that is connected to the target variable only by a behavioral relationship or statistical correlation should be avoided because the underlying relationships can be expected to be less stable than is the case of an indicator with a direct intrinsic relationship to the target variable.

3.9 The indicator and the assumptions behind its use can also be assessed quantitatively by comparing the rate of change in the annual sum of the quarterly indicator with growth rates in the corresponding annual GDP estimate. Equivalently, the ratio of the annual benchmark to the sum of the quarterly indicators for the four quarters shows the relationship between the two series as a single figure, which in this manual is called the benchmark–indicator ratio.

3.10 A stable benchmark–indicator ratio shows that the indicator represents the movements in the target variable well. Changes in the ratio may point to problems and help identify ways to improve the indicator in the future. The benchmark–indicator ratio does not necessarily have to oscillate around one, as differences between the levels of the annual estimate and the quarterly indicator can easily be solved by multiplication. For example, a quarterly indicator in the form of an index can readily be converted to a monetary value. This lack of emphasis on levels is an important difference in focus between quarterly GDP and annual GDP compilation: while establishing correct levels is essential in annual GDP compilation, levels in quarterly GDP can be derived from the annual GDP. The essential task in quarterly GDP is to obtain the data sources that provide the best indication of quarterly movements.

3.11 Even with careful selection of the most suitable indicators and improvements to data sources, benchmark–indicator ratios will vary over time, because indicators are generally not fully representative of the target variable. It is possible to identify multiple indicators for one target variable or to decompose that one variable into various subcomponents, with each subcomponent having a separate indicator.

3.12 Multiple indicators may be available for the same item either in terms of being alternative indicators of the overall activity or representing different aspects of the activity under consideration. For example, air transport indicators may include total passenger movements, sales of aviation fuel, or visitor arrivals by air. In this case, the indicator that is most representative in terms of concept and best tracks annual movements should be adopted. In some cases, the indicators may represent different parts of the item. In cases where the indicators represent different aspects of the activity, the best solution is to split the annual data into each component and benchmark each indicator and component separately. If this is not possible, the components should be added or weighted together to form a single indicator before benchmarking.

Surveys of Businesses and Households[1]

3.13 This section addresses issues relating to the collection of data for statistical purposes and therefore covers issues relating to both sample surveys and censuses.

3.14 The timeliness of surveys for compiling quarterly GDP is a common challenge because of the limited time available for data collection processing. In this regard, surveys of businesses may be limited to covering large enterprises and establishments in some major activities. A common problem for surveys of businesses is the outdated nature of the survey frame because of delays in including new businesses and deleting nonoperating (dead or dormant) businesses as well as reclassifying the businesses that change economic activity. This problem is more serious for quarterly GDP than for annual GDP because of the more limited collection time for the quarterly source data and because the information needed to update the survey frames may be more limited on a quarterly basis. The continuing process of births and deaths of establishments and enterprises occurs for all activities but may be more prominent in those with a large number of small-scale, short-lived establishments, such as retail and personal services. Births and deaths of establishments and enterprises are important factors in changes in the overall trends. In fact, an increase in the number of producing units is usually an indicator of growth in output. Further, as the structure of the economy changes or as new products become more popular, it is possible to see a growth in producers engaged in a given kind of activity and a decline in others.

3.15 Moreover, new businesses are particularly likely to have higher rates of growth and high levels of capital formation (particularly in the start-up quarter), as well as being more likely to be established during economic upturns. Closed businesses are included in the scope of surveys but may be misclassified as nonresponse. Because of these factors, quarterly business surveys should be designed to reflect changes in the population of businesses or they will tend to understate growth for a booming economy and understate declines for an economy in recession.

3.16 In many countries, the business register may be based on enterprises rather than establishments, as the former may be the legal requirement for registration. However, the latter is preferred if the compiler is to derive an accurate breakdown of economic activity.

3.17 For survey results to reflect changes in the population, the following considerations need to be taken into account when designing surveys of business:

- The register needs to be updated on a continuous basis to ensure complete coverage of the entire population of businesses in the frame. New businesses should be incorporated in the survey as soon as they start, either by drawing supplementary samples of new businesses or redrawing the sample for the whole population.
- Deceased business units should be distinguished from nonresponding units. The contribution of deceased businesses to their industry should be recorded as nil; for nonresponding businesses, values should be estimated.
- For each economic activity, the original sample and the supplementary samples should be stratified by size (preferably revenues or sales instead of number of employees), location, age, and other dimensions that may explain major variations in the level and growth rates of the target variable for each business for which corresponding population-wide information is available in

[1] A specific discussion on the use of data from household income and expenditure surveys is included in paragraphs 3.83–3.84.

the frame. Different stratification principles may have to be used for new and continuing businesses in cases where the available population-wide information differs for the two subgroups.

- Many surveys collect information on a range of variables. Statistical agencies adopt this approach to reduce response burden and the cost of data collection. Survey design and sample selection is usually determined by the primary variables being covered in the survey often to the detriment of the other variables. In this regard, the accuracy and reliability of secondary variables should be considered against the primary objectives of the survey.

3.18 The problem of survey nonresponse may be more acute for quarterly surveys because of the time constraints posed by having to complete the survey in a shorter period compared to an annual survey. Survey nonresponse should be monitored closely because differences between respondents and nonrespondents could lead to bias in the estimates for the population. There are various factors that the statistical agency may consider to mitigate nonresponse and achieve an acceptable response rate. For quarterly data collection, it may be useful to focus on the following:

- complexity of the questionnaire (it is necessary to focus on that level of detail for quarterly data),
- questionnaire follow-up and data collection methods,
- respondent burden, and
- survey timing.

3.19 Monthly or quarterly labor force surveys can be an important data source for quarterly GDP, particularly in cases where there may be undercoverage of business surveys. If new businesses cannot be incorporated in the survey as soon as they start or there is a large informal economy, household labor force surveys may provide information that can be used to adjust incomplete coverage of business surveys. However, the coverage, timeliness, and frequency of the labor force survey could be a challenge.

3.20 The comparison of labor force and business survey results could give adjustment factors for undercoverage in business surveys and to cover the nonobserved economy. The adjustments, or grossing-up procedures, should be conducted at a detailed industry level with stratification by dimensions that explain variations in the ratio between the target variable and the grossing-up factor. Infrequent changes in survey frames or other changes in survey methodology can lead to distortions in the time-series qualities of the quarterly GDP. Movements in the indicator will be misleading if caused by changes in survey methods or coverage, rather than underlying economic events. Therefore, it is essential to determine and isolate the causes of the movements. It may be possible to identify and separate the effects of changes in sampling frame and methods from changes due to economic events.

Administrative Data

3.21 Administrative data are records that are compiled by government agencies or other organizations for administration, regulation, and monitoring, and not specifically for statistical purposes. However, in some cases, the needs of statistics compilers may be taken into account when the information gathering system is being developed. Administrative data are relatively cheaper to obtain compared with survey data—since they do not require specific collection protocols—and may be more timely. As a result, administrative data may be more widely used in quarterly GDP than in annual GDP compilation. However, there may be limitations in the data sources that may undermine their suitability for national accounts compilation in terms of the consistency of definitions, coverage, scope, timing differences, and so forth. Timing differences, in particular, may constitute a major drawback to using administrative data in estimating quarterly GDP, because these differences may be magnified in the quarterly context. For example, an administrative system that collects data every two weeks could result in some quarters having six two-week periods and others having seven. Taxation records—in particular, value-added tax (VAT) data—and merchandise trade statistics collected through customs records represent the two most widely used forms of administrative data. Quarterly income tax records for large enterprises and quarterly income and financial statements of the enterprises that list shares in the stock exchange, if available, may be useful to compile quarterly GDP and quarterly sectoral accounts.

Value-Added Tax Data

3.22 Tax collection systems represent an important type of administrative data for national accounts compilation. These systems are established to monitor income taxes, VATs, sales taxes, or other product taxes. VAT systems have gained in prominence as a source of data for national accounts as more and more countries have implemented VAT over the past two decades. These systems cover a broad range of goods and services that are sold by both producers and distributors, and they collect monthly and quarterly data as part of the tax collection process.

3.23 However, as with other administrative data sources, tax systems are not designed to meet statistical objectives. Therefore, there may be inconsistencies between framework used by the tax authorities to collect the information and the conceptual framework of the national accounts. These inconsistencies may result from the classification of units, the coverage of units at each point in time, the classification of transactions, the residency criteria used for transactions, and the time of recording of transactions. For example, the VAT system may most likely record transactions on a cash basis, whereas national accounts transactions should be recorded on an accrual basis. Further, VAT information may be presented on the basis of the legal entity, which may be engaged in various types of economic activity, rather than on the basis of type of activity. Therefore, the requisite level of detail may be lacking. VAT data for the legal entity could be supplemented by a survey of multi-industry enterprises. If such a survey is not possible, data by industry of enterprise could be used as an indicator of data by industry of establishment. There may also need to be extensive communication with the tax collection authorities to understand the data, to produce tabulations in a form suitable for national accounts compilation, and to make adjustments to tax forms and procedures to better meet statistical objectives. Other product tax systems may also provide data on the underlying flows of taxable products, such as alcohol and petroleum.

3.24 In using VAT data to estimate value added by type of economic activity, it should be noted that the data do not take into account changes in inventories because the data cover sales (not output) and purchases (not intermediate consumption). Also, purchases of goods and services that are deductible for VAT usually include both capital formation and intermediate consumption. For national accounts indicators, it is highly desirable to separate these two components. Otherwise, the purchases data would not be usable as an indicator of intermediate consumption as gross fixed capital formation is usually large, lumpy, or both.

International Merchandise Trade Statistics

3.25 International Merchandise Trade Statistics (IMTS) represent one form of administrative data that includes specific requirements for statistical purposes. The guidelines used to compile the IMTS are outlined in the United Nations' *International Merchandise Trade Statistics: Concepts and Definitions 2010* (*IMTS 2010*). These statistics are relatively cheap to compile, comprehensive, and timely; therefore, they are particularly useful in countries with weak data sources. The IMTS could be used for a range of compilation purposes; for example, imports statistics may be used to derive commodity flow estimates and exports may be used to estimate production of some key industries. If imports data are used, the usefulness of the data is enhanced when domestic production of the goods under consideration is low. Likewise, if exports data are used, the usefulness is enhanced if domestic consumption of the goods under consideration is low.

3.26 One major drawback of using the IMTS is that the dataset lacks the requisite product detail that will allow the differentiation of products by quality, and in some cases, end use. Merchandise trade statistics are classified according to *product groups* and not according to specific products.[2,3] Therefore, it is not always possible to get accurate, reliable product price information based on the quantity and value information in the merchandise trade statistics. The quantity and value information produce unit values, which reflect the value of a group of products. In addition, merchandise trade statistics may be prone to

[2] For example, in terms of quality, the commodity group HS3-87059 (*Special purp. motor vehicles, other than those principally designed for the transport of persons/goods, n.e.s. in 87.05*) may include vehicles of varying make, model, and hence quality.

[3] For example, in terms of end use, the commodity group HS3-170199 (*Cane/beet sugar & chemically pure sucrose, in solid form, not containing added flavoring/coloring matter)* does not specify whether the goods will be used as intermediate inputs or final consumption.

classification errors, incorrect values, and incorrect quantity measures.

3.27 The IMTS also pose numerous timing issues for compilers. The data are recorded when the goods cross the customs frontier (entered in the records of the customs) and not when they are produced or used in production. Therefore, it is not possible to separate imports entering inventories from imports for other uses (intermediate consumption, final consumption, capital goods, etc.). Thus, if imports data are used to estimate the supply of goods in production or for consumption based on commodity flow methods, then some of the goods used to estimate supply may actually be entering inventories. Likewise, if exports data for a given period are used to estimate domestic production in that period, then it is likely that some of the goods may be inventories produced in a previous period and some of the goods produced in the current period may be exported in a following period.

3.28 Major products, such as ships and aircraft, may be excluded from the IMTS. Information on these imports may be obtained through government registration or licensing records or through supplementary surveys of airline and shipping companies. The balance of payments compilers may also compile data on imports and exports not recorded by customs, including goods under merchanting.

3.29 The IMTS include goods for processing that enter or leave the economy without a change of ownership. These goods should be excluded from the imports and exports statistics. The balance of payments compilers may undertake the necessary adjustments (see compilation guide on balance of payments; IMF 2014).

Other Data Sources

3.30 Compilers may also consult industry associations, industry experts, or the leading enterprises in a specific industry to derive quarterly indicators, if survey or administrative data are not available or are inadequate. Ideally, there should be only a few gaps that represent a small proportion of the total. Compilers should make every effort to fill the data gaps to ensure comprehensiveness of the measurement of economic activity; however, the use of information obtained through these consultations should be temporary and the data gaps should be closed as soon as is feasible using more conventional data sources.

3.31 If no quarterly indicators are available from the consultations, compilers may consider some additional alternatives. Some of the alternatives include the following:

- a related item as an indicator,
- a range of other items as an indicator,
- the overall economy (excluding the target components) as an indicator, or
- mathematical methods based on distribution of annual data and extrapolation of past annual trends.

The suitability of these methods is discussed in Chapter 10.

3.32 In choosing among alternatives, past patterns in the annual data for that variable can be used as a guide. If a series is volatile and related to the economic cycle, growth rates of the rest of the economy could be a suitable indicator. If the annual series does not relate to fluctuations in the rest of the economy, a growth rate based on past trends may be suitable. Extrapolation on the basis of past trends is generally not desirable, as it tends to hide the actual data on current trends. If there is no suitable indicator, a simple method that is transparent may be more appropriate than something that is time consuming and complicated but not necessarily any better.

GDP by Type of Economic Activity

General Issues

3.33 Estimates of GDP by type of economic activity show the contribution of each activity to economic growth and therefore provide a useful perspective on economic performance. In many countries, these estimates may be based on more reliable source data and more rigorous compilation procedures compared to the expenditure and income approaches. Therefore, estimates by type of economic activity may be considered to be the most accurate and therefore the official quarterly GDP estimates in these countries.

3.34 The general principles for deriving current price and volume estimates are the same for quarterly and annual GDP. The production approach involves calculating output and intermediate consumption, and deriving value added as the difference.

3.35 Observed data on both output and intermediate consumption at current prices may be available quarterly in some cases; in these cases, the double indicator method for value added can be used. For example, in some countries, government-owned enterprises may dominate or have a monopoly in some industries such as petroleum, air transport, electricity, water, or telecommunications and the units may be able to provide the detailed data required.

3.36 However, the data required for the production approach may be incomplete on a quarterly basis. Because compiling the production accounts at current prices and in volume terms requires detailed accounting information on output and inputs current expenses, the required data may not be available quarterly or may not be collected with the timeliness needed to compile quarterly GDP estimates. The missing data must then be estimated by using another series as an indicator. Most often, output data are available, while data on intermediate consumption are not. In cases where data on intermediate consumption are not available, data on some key components of intermediate consumption (e.g., fuel for transportation services), labor inputs, or capital inputs may be available as indicators of intermediate consumption, assuming a fixed relationship. Likewise, if no data on intermediate inputs are available, then the estimation process could assume a fixed relationship between output and value added.

3.37 Relationships between inputs and outputs may change as a result of technological changes, differences in the seasonal patterns of outputs and inputs, or variations in capacity utilization caused by changes in the business cycle. The impact of technological change may not be significant in the short term and can be handled through the benchmarking process if they happen gradually over a longer period. As discussed in Chapter 6, it is preferable to use benchmarking rather than fixed ratios. The reliance on fixed coefficients is particularly unsatisfactory for calculations at current prices because of the additional factor of changes in relative prices.

3.38 In some countries, value added is derived directly, without explicitly calculating output and intermediate consumption. This practice is undesirable for several reasons. Since value added is not directly observable, this method encourages the use of inappropriate calculation methods. Further, it is not consistent with the *2008 SNA* presentation of the production account or with supply and use tables, and does not support comparison of quarterly estimates with subsequent annual output data. As an example, compiling the full production account by type of economic activity makes explicit the assumptions about input–output (IO) ratios that might otherwise be implicit or ignored. An assumption of fixed IO ratios at both current prices and in volume terms might be highlighted in implausible implicit price deflator movements, or deflating value added by an output price index might result in unacceptable changes in IO ratios.

3.39 Deflating value added by output price indices assumes that prices of inputs and output change by the same proportions. Relative prices may be quite volatile because of various factors that may cause the price of inputs to deviate from the price of the output. For example, units engaged in road or air transport may not be able to transfer sudden changes in the price fuels to the output as these changes occur, and this could lead to deviations between output and intermediate consumption over a short period.

3.40 The preferred method of deriving value added in volume terms is similar to deriving value added at current prices—as the difference between output in volume terms and intermediate consumption in volume terms. Thus, the current values of output and intermediate consumption are each deflated by appropriate price indices. This method, double deflation, while conceptually sound, requires a large amount of data that may not be available on a quarterly basis and in a timely manner. Double deflation may also be prone to measurement errors of both output and intermediate consumption.[4]

3.41 As a result, compilers may opt to use a single indicator method. One widely used method is to extrapolate value added based on the volume index of output. Another, but less satisfactory single indicator method is to extrapolate value added using a volume index of inputs. These may be total inputs, intermediate inputs, or one major input, such as fuel or labor. However, it may be difficult to derive a volume index of total inputs or intermediate inputs for quarterly

[4]On the merits of using double deflation techniques in the national accounts, see Alexander and others (2017).

data, and one major input may be used. The use of volume indices for inputs may be more common or necessary for nonmarket activities where information on output volumes may not be available.

3.42 If data on intermediate consumption at current prices are not available, one option is to first derive an estimate of intermediate consumption in volume terms using output in volume terms as an indicator. This method assumes a stable relationship between output and intermediate consumption. Intermediate consumption at current prices is then derived by reflating the volume estimate using price indices that reflect the product composition of intermediate inputs in volume terms. A composite price index of intermediate consumption may be constructed by weighting the relevant price index components of published indices such as the consumer price index (CPI), producer price index (PPI), and import price index. A use table (see Chapter 9) for a recent year would provide weights to derive industry-specific intermediate consumption deflators (or reflators). A more detailed level of reflation is preferable as it allows the effect of changes in the composition of output to be captured in the estimates.

Basic Prices and Producer Prices

3.43 The *2008 SNA* uses two kinds of prices to measure output. The preferred method is basic prices, but producer prices may be used if basic prices are not available. Both are actual transactions prices that can be directly observed and therefore recorded. Basic prices exclude taxes on products the producer receives from the purchaser and passes on to the government, but include subsidies received by the producer to lower prices. It measures the amount retained by the producer. Producer prices include taxes on products and are reduced on account of subsidies. It is therefore the price that the producer invoices the purchaser. Neither basic nor producer prices include amounts receivable in respect of VAT or similar deductible taxes invoiced on the output sold.

Market Output, Output for Own Use, and Nonmarket Output

3.44 The *2008 SNA* makes a fundamental distinction between market and nonmarket outputs. This distinction is important to determine how output is valued and therefore the data sources and techniques to be used in valuation. The classification of the activity of an enterprise as market or nonmarket output should not change from one quarter to the next. Therefore, the quarterly national accounts (QNA) compilation process should follow the classification of the annual national accounts in that regard.

Sources for Industries

3.45 Commonly used types of source data for the production approach on a quarterly basis include current price data from accounting records (through surveys) and administrative systems, quantity indicators, labor and other input measures, and price indices. Most commonly, deflation will be used to derive volume measures, and due to problems that are discussed below, deflation is preferable to direct measures of volumes. In other cases, there may be volume and price indicators only or current price value and volume indicators only. Annex 3.1 provides an overview of the value and volume indicators most commonly used for the production approach.

Current Price Data on Outputs and Inputs

3.46 To derive the value of output for goods-producing industries, the value of sales together with opening and closing values of inventories of finished goods and work-in-progress[5] are required. The simplest indicators cover only total sales of goods produced by the enterprise. Other revenue, such as sales of goods not produced by the factory, repairs, or rental services, might also be collected in total or separately. Data on inventories used in calculations should have the effects of holding gains/losses excluded.

3.47 Some countries may collect data on the value of construction through surveys of construction. If only the total value of a project is available, then the total value should be allocated over the expected life of the project. Compilers may allocate the value of the project equally in each period based on the assumption that the volume of work is distributed evenly over the life of the project. However, this also assumes that there is no inflation over the period. A preferred approach is to discount future income associated with the project. The *2008 SNA* paragraph 20.63 provides some details of how this approach may be applied.

[5] Output = sales + changes in inventories of finished goods and work-in-progress (excluding any revaluation effects).

3.48 An alternative approach is to collect data on the value of work done during the quarter. Collecting these kinds of data avoids the difficulties of making assumptions about the allocation of a total value for a whole project to particular quarters. However, the feasibility is limited by the availability of data, as construction enterprises are often small scale and work done may be hard to separate into quarters. Progress payments for work done may be an acceptable approximation if interviews suggest that they approximate the value of work put in place. (Construction indicators are discussed in paragraphs 3.111–133.)

3.49 Sales data are commonly used as quarterly indicators for the output of wholesale and retail trade. Sales data could be obtained from a survey of wholesalers and retailers or through tax records. Output at current prices is defined as the trader's margin: that is, sales less the cost of goods sold.

3.50 Government agencies and public corporations may be useful sources of information for the activities that they undertake, regulate, or tax. General government undertakes public administration, defense, and community services, and would be the primary source of information for these activities. In some countries, public corporations may be heavily engaged in or may have monopoly control over some activities, such as air transport, electricity, water, and so forth. Government agencies may be a useful source of information through their regulatory responsibilities of activities such as financial services, insurance, health, and gambling.

Quantities of Outputs and Inputs

3.51 The concepts of quantity measures and volume measures should be distinguished. Quantity data are expressed in terms of physical units and can only be expressed for a homogeneous product. Volume data are presented in terms of volume indices or values expressed at the prices of a common period; these data differ from the quantity data because quality changes are accounted for and because the measures can be meaningfully aggregated.

3.52 Quantities are easy to define for the goods-producing industries: for example, liters of petrol and kilos of flour. In some cases, businesses can supply quantity data more readily than they can supply financial information on a quarterly basis. The businesses may not compile quarterly accounts, or the data may take longer to compile than simply collecting numbers that do not require processing or valuation. Quantity indicators can be multiplied by price indices or average prices for the quarter to obtain current price indicators. Such estimates avoid the inventory valuation issues that arise for current price values that have been derived from data that include inventories measured at historic cost.

3.53 The limitations of quantity data are significant, and quantity data are not economically meaningful if products are heterogeneous or subject to quality change. The usefulness of quantity data is limited by the homogeneity of the products. For basic commodities, such as wheat and base metals, there is often relatively little variation in quality over time, particularly if data are broken down by grades of quality, so quantity indicators may be suitable. However, many products vary considerably in quality. For such goods, deflated current price data should be used. This situation applies to a large number of manufactured goods and to some agricultural and mining products. The more narrowly such products are defined, the more the estimates will be able to reflect the actual volume of output. For example, if cars are treated as a single product, changes in the mix of output toward larger cars or cars with more accessories (better quality) will not affect the number of cars, but should be treated as an increase in the volume of output. There are many products for which quantities are poor indicators or for which output is not readily quantifiable, such as clothing, medicines, and services. One way of dealing with the problems of heterogeneity of products is to collect extra detail, although it may not be practical owing to greater collection costs, respondent burden, and delay in tabulation.

3.54 Quantity indicators are usually developed on a case-by-case approach for each type of economic activity, rather than as a unified system. The following cases are considered:

- *Agriculture:* Government agencies (ministries of agriculture and government agricultural produce marketing agencies) may closely monitor the production of key agricultural commodities. Ideally, the data should be obtained at the farm, but quantity data may also be obtained at points of the distribution chain in cases where there are (i) a few producers, (ii) if the products/crops are produced primarily for export, or (iii) if the products are used as primary inputs for another industry. However, there will most likely be a difference in the quantity produced at the farm and quantity measured along the supply chain due to wastage/spoilage, timing differences, consumption, informal sales, and other factors. In measuring value added for agriculture, the compiler should recognize that there may be a timing difference between the period of harvest and allocation of output. Conceptual issues associated with work-in-progress and the timing of agricultural production are dealt with in Chapter 11.

- *Mining and quarrying:* In absence of quantity data, compilers in some countries may use the information on rent on the extraction of subsoil assets owned by governments (usually referred to as royalties) or severance taxes on the extraction of minerals from private lands. These payments are usually based on the quantity extracted and provide an estimate of the quantity of production. However, if the government accounts are compiled on a cash basis, it would not be possible to determine in which period the quantity was produced. In that case, additional information, such as the documents presented by the mining companies to support the payments, may provide some information as to when production took place.
- *Construction:* Floor area built distinguished by type of building. (Indicators for construction are discussed further under gross fixed capital formation on construction in the expenditure approach.)
- *Accommodation and food service activities:* Number of visitors may be an acceptable indicator in countries where foreign visitors constitute a significant proportion of the number of persons staying in paid accommodation. Some countries conduct regular (monthly or quarterly) surveys of visitor expenditure. Therefore, additional information from these surveys, such as average daily expenditure of visitors and average length of stay, may be used to fine-tune the estimates. In other cases, hotel tax revenue (hotel occupancy tax, hotel and restaurant service charge, and VAT on accommodation service) may provide some useful information.
- *Transportation and storage:* Number of passengers carried/embarked/disembarked, tons of freight or ton-kilometers, and numbers of licensed taxis or new vehicles registered. To the extent that prices, and therefore the volume of service, reflect distance, data with a kilometer dimension are better indicators. For example, metric ton-kilometers would be a better indicator of the volume of freight than a measure of metric tons that did not take into account differences in distances carried.
- *Information and communication:* Number of telephones in service or number of telephone calls (both landline and cellular). Indicators should be closely monitored over time because of the changing nature of this activity. The ratio of mobile phones to (fixed) landlines is continuing to grow in many countries; therefore, if landlines are used as an indicator, then the relative growth of this activity due to mobile phones will not be captured.
- *Real-estate activity (ownership of dwellings):* Numbers of dwellings, preferably broken down by location, size, and type of dwelling and with adjustments for new dwellings and alterations and quality change. (Sources and methods are covered later in more detail in the discussion of indicators for household consumption of rental services.)
- *Professional, scientific, and technical services:* Numbers of wills, court cases, and divorces for lawyers; numbers of registered land transfers for real-estate agents; and numbers of deaths for undertakers.
- *Public administration:* Licenses issued and court cases processed. Because these indicators are partial and do not reflect quality well, they are used to only a limited extent. Other services such as numbers of tickets sold by theaters and other forms of entertainment as well as numbers of vehicle repairs are indicators too. Government employment is also used for estimating the volume of public administration services.

3.55 The potential range of sources is very wide and these indicators are not usually part of a comprehensive system of indicators. As a result, there are typically many gaps and data often need to be obtained from different agencies. Some potential indicators may be unpublished, but could be obtained by making a request to the relevant agency.

Labor Input Measures

3.56 Measures of labor input are sometimes used as indicators of the volume of output of service industries. The assumption behind the use of this method is that employment is directly related to output and value added in volume terms. Labor is a major input to the service industries, and compensation of employees plus mixed income typically constitute very high proportions of value added. Labor and income per capita data are used to complete the coverage of economic activities by accounting for the non-observed economy. The number of hours worked is preferable to the number of employees as an indicator of labor input. For a given number of employees, total hours worked takes into account changes in standard weekly working hours, hours of overtime, and changes in the specific numbers of hours worked by individuals. Total output would be affected by these changes, whereas the total number of employees will not.

3.57 However, hours worked is still an imperfect measure of labor input. Ideally, labor input measures would take into account different types of labor (e.g., disaggregating by occupation or skill level) weighted by their different rates of remuneration. The total value of wages and salaries divided by a wage and salary index would give an indicator that also takes into account such compositional effects, but it would need to be supplemented by a measure for self-employed labor. It is preferable that actual hours worked be covered, rather than paid hours which include sick leave, vacations, and public holidays but exclude unpaid work. The labor input measure should include working proprietors and the self-employed as well as employees.

3.58 Comprehensive monthly or quarterly data on employment by industry may be available in many countries, from specific surveys or as a by-product of a payroll or social security tax system. However, the classification by economic activity used by the administrative source may not be consistent or sufficiently detailed for compiling QNA estimates.

3.59 Labor input is not an ideal volume measure because the relationship between labor and output is variable. The relationship between labor input and output also changes as a result of changes in capital intensity and total factor productivity.

3.60 In the case of the nonmarket activities of general government and nonprofit institutions serving households (NPISHs), current price output is measured on the basis of the cost of inputs. It is preferable that the output volume measure take into account the services provided by the government or nonprofit institution, if measurable. It is common, however, to use input indicators, such as labor and purchases of goods and services, if suitable volume measures are not available.

3.61 As with other sources, calculations at a greater level of detail will usually improve the estimates as the relationship between output and labor varies widely across industries and even within broad industry groups. For example, photographic activities and legal activities may both be in the same category, "*Professional, scientific, and technical services*," but the value of output per hour or employee of a photography business may be much less than that of a law firm. Accordingly, an indicator that separates the two activities will better reflect changes in output.

Indirect Indicators

3.62 Where direct measures are not available, a diverse range of indirect indicators may be considered. It is sometimes possible to identify a downstream or upstream activity that can be used as a basis to generate indicators. For example, the supply of building materials can be used as an indicator of construction activity. An indicator for wholesale and retail could be obtained from the supply of goods that are distributed by wholesalers and retailers. Although it would be conceptually preferable to obtain data on sales and purchases from the establishments and the margins received, data on the supply of goods may be more readily available and easier to estimate. This is because there are relatively fewer data sources on the supply of goods (imports and domestic producers) compared to the large number of mainly small-scale wholesalers and retailers. (Data on sales of goods to consumers are discussed later in this chapter in the context of GDP by expenditure category.) The distribution activity of specialist importers or expensive goods that can be identified should be measured separately. As the estimation procedures rely on an assumption of fixed markups (i.e., the margin as a percentage of the price), the method will give better results if calculated at a greater level of product detail to take into account the combined effect of changes in the product mix with varying markups of different products.

3.63 If data on road freight transport activities are inadequate, it may be possible to derive an indicator based on the supply of goods that are usually transported, or at least the major components. Indicators for other supporting industries may also be derived from the output of the industries served, such as services to agriculture, mining, and transport.

3.64 Population is sometimes used as an indicator in cases where a more specific indicator is not available, such as subsistence agriculture, owner-occupied dwellings, and some personal services. The indicators should be adjusted for long-term trends. For example, population could be used to represent dwelling services, but adjustments should be used to account for trends in the quality of dwellings and persons per household. Adjustments for divergence in long-term trends between the population indicator and the annual estimates can be incorporated through the benchmarking process.

3.65 All of the methods discussed in this section assume ratios based on the benchmark data. Such ratios are more likely to be stable in volume terms, so it is generally better to make the assumption in volume terms and then reflate to current prices. Also, in all of these cases, if the benchmark data are more detailed, the quarterly estimates will tend to be better if the calculations are done at a detailed level.

Price Indicators

3.66 If a current price value is available for an item, a volume measure can be obtained by deflating with a price index. Alternatively, if a volume measure is available, a current price measure can be obtained by reflating with a price index. Countries generally compile four major price indices: CPIs, PPIs, export price indices, and import price indices. Each index measures prices of transactions at different stages; therefore, these aspects need to be taken into account when deciding on which index should be used as a deflator. CPIs measure purchasers' prices, PPIs measures basic prices, export price indices measures export prices (usually free-on-board prices, or FOB), and import price indices measure import prices (usually cost-insurance-and-freight prices, or CIF). These indices may not always be appropriate deflators and sometimes suitable deflators will need to be derived. This may be done by either decomposing a major index (e.g., using components of the CPI) or obtaining supplementary price information.

3.67 In some cases, a specific index may need to be developed because the main indices are not compiled, not timely, or inadequate (outdated weights, poor coverage, or incorrect price basis). For example, compilers may develop a price index of agricultural products using information collected from ministries of agriculture and other government bodies that regulate or monitor agricultural production. The source data may have to be adjusted to derive basic prices because the prices may be purchasers' prices collected at the point of sale (produce market) and not from the producer. For some professional services, such as lawyers, architects, and engineers, the professional associations may have information on the fees, which could be used to construct an index.

3.68 Where no direct data are available, prices of one or more similar or closely related products or industries that have a tendency to move in the same way may be suitable. For example, if electricity is produced from imported fuel, then the price of electricity may be tracked by the price of fuel.[6]

3.69 It may be necessary to produce output deflators or reflators based on the costs of inputs, for example, weighting together wage indices or information on wage rates with the prices of major intermediate inputs. Because this technique does not account for operating surplus, it is unsatisfactory to the extent that profitability varies. However, to the extent that profitability and productivity are taken into account in annual data, the benchmarking process will incorporate the annual variations.

3.70 Wholesale and retail present special difficulties in identifying the price dimension. The difficulty arises because the output of this activity—a service—is the trade margin. The service component is combined with the prices of the good and the quality aspects are difficult to measure. Deflating the margin directly should be avoided. A volume indicator of the

[6] We must also be cognizant of the various factors that could affect the price of the product such as government action in the form of price controls, taxes, and subsidies.

margin service can be made from the volume of goods bought or sold using an assumption of a stable volume of the distribution service per unit of goods: that is, no quality change in the service. The suitability of the assumption is improved by compiling at a greater level of detail, as markups differ among products and between outlet types. The price indices of the goods should not be used as a proxy deflator or reflator of margins because margins have different cost structures and can vary differently than goods prices.

3.71 Financial intermediation services indirectly measured (FISIM) is a margin and so is not readily observable. One approach for quarterly GDP estimation is to use the deflated values of loans and deposits as a volume indicator of the service provided, in conjunction with the annual benchmarks. The value of loans and deposits should be deflated by a price index representing the general price level (e.g., the implicit GDP deflator excluding FISIM or the CPI). Ideally, this method should be applied at a disaggregated level, with a detailed breakdown of assets and liabilities by type, because the interest margins vary, reflecting the fact that the value of service provided varies for different categories. Interest margin changes are price effects and do not affect the volume of loans, so these changes will be shown as a price effect. The direct deflation of the value of FISIM by a general price index or by input prices for financial services is not a suitable alternative. These deflators do not measure the price of FISIM and ignore interest margin changes. Thus, changes in profitability of financial institutions would be incorrectly shown as a volume change. In cases where independent current price and volume measures for output are obtained, the corresponding implicit price deflator should be checked for plausibility.

3.72 Another more sophisticated approach is to deflate the monthly stocks of deposits and loans in its various components using the average of the stock at the end of the previous month (opening balance) and the stock of the following month (closing balance), the monthly weighted average reference rates (SNA rate: interbank interest rate, central bank interest rate, and average implicit effective interest rates of deposits and loans), and the interest rates for the base year (fixed-base year) or for the previous year (chain-linked series). The purchasing power of the monthly average stock of loans and deposits in national currency is estimated by deflating the overall stocks' last day of the previous month and the last day of the following month by the average CPI with the appropriate rebasing (base year or previous year).

3.73 The monthly average CPI of the two adjacent months is to be used in order to deflate the stock at last day of the month since the CPI reflects the average prices (midpoint of the month) of the month and the stocks should be valued at average prices of the previous year or of the base year. Loans and deposits in foreign currency is deflated monthly by a price index that integrates the changes in the exchange rate and inflation of the countries with which the country in question undertakes transactions of loans and deposits. Then, the deflated stocks are multiplied by the SNA interest rate and by the effective interest rates on loans and on deposits of the base or previous year, and FISIM results from the difference of both amounts (effective interest for loans at constant prices minus SNA interest for loans at constant prices, plus SNA interest for deposits minus effective interest on deposit at constant prices).

3.74 Intermediate consumption usually has no specific aggregate deflators, so it is necessary to build the deflators from components of other price indices for the relevant products. Note that even when a fixed coefficient method has been used to derive volume measures for a given type of economic activity, it is desirable to reflate intermediate consumption and output separately and is undesirable to use the fixed coefficient method at current prices.

3.75 Some countries compile indices for selected categories of services, although an overall index of services production may not be available. The coverage and definitions used in the index should be assessed to determine whether the index is consistent with the requirements of QNA compilation. The compiler must therefore weigh these factors against the cost and practicality of compiling separate indices to derive volume estimates of services.

Industrial Production Indices

3.76 Some countries may compile a monthly or quarterly industrial production index (IPI). The index is expected to cover the following ISIC Rev. 4 categories: Section B (mining and quarrying), Section C (manufacturing), Section D (electricity, gas, steam, and air conditioning supply), and Section E (water collection, treatment, and supply; sewerage; waste collection; and remediation activities). However, there may be gaps in coverage and not all activities will be covered in all cases. Countries use a range of methods to derive volume indicators of economic activity when compiling the IPI, such as deflated values, quantity measures, or selected inputs. In some cases, the IPI may use a mix of methods, such as quantities for homogeneous goods and deflation for others.

3.77 It is preferable to compile quarterly GDP estimates from the IPI source data or from IPI components at a disaggregated level, rather than from the total IPI. The more detailed compilation would facilitate the resolving of differences in coverage and concepts between the IPI and quarterly GDP. Benchmarking, structural assumptions, and reflation tend to be better when carried out at a greater level of detail. The national accounts measure of output requires weights to reflect output at basic prices or producers' prices, while in practice the IPI may use other weights or valuations. The IPI may have gaps in coverage that may need supplementary sources: for example, particular industries and goods that are not easily quantified. The base years may also differ. Published IPIs are sometimes adjusted for variations in the number of working days, rendering them unsuitable as quarterly indicators. For compilation of nonseasonally adjusted quarterly GDP, the data should reflect the actual activity in each quarter, before adjustments for working days or other calendar and seasonal effects.

3.78 If different methods are used in the IPI and quarterly GDP, then it would be useful if the quarterly GDP sources and methods documentation clearly states the differences. These differences should be explained (e.g., weights, coverage, and valuation) and quantified, if possible.

GDP by Category of Expenditure

General Issues

3.79 GDP by type of expenditure shows the final demand for goods and services. This approach does not rely as much on fixed ratios as the quarterly production estimates. Nevertheless, there are some issues relating to timing, valuation, and coverage of source data that are equally as important and should be considered. Some of these issues are as follows:

- *Time of recording*[7]*:* Timing differences are a much more important issue in quarterly data than in annual data because these differences are much more pronounced in higher frequency data. Government and international trade are typically well covered by quarterly data, but the time of recording of data is often inconsistent with the national accounts requirements.
    - Government data are often recorded on a cash basis, although accrual adjustments are sometimes made for particular, identifiable items. Accrual accounting is becoming more common in government accounts.
    - IMTS are recorded when the goods pass through the customs frontier of the reporting country and not when they are consumed as intermediate consumption or final consumption. The balance of payments compiler may make some adjustments to the IMTS data to account for change of ownership of the goods between residents and nonresidents; however, these adjustments are still not adequate for national accounts purposes. The balance of payments statistics are concerned with when the goods are acquired (when change of ownership occurs) and not when they are used in production. Thus, goods may be acquired and enter inventories and not used as intermediate inputs during the quarter under consideration.
- If the estimation process depends on data from surveys of enterprises, then the expenditure estimates may be more strongly influenced by coverage problems in the business register. This influence arises because of the high proportion of retailing and consumer services output that goes to household consumption and the high proportion of building output that goes to capital formation. These activities often have high proportions of smaller, shorter-lived, less formal businesses.

[7]The issue of time of recording for government finance statistics and merchandise trade statistics is also important for the GDP estimates by type of economic activity. This issue is addressed here because both represent significant components of GDP by expenditure category.

- Changes in inventories have serious valuation problems. These problems also occur in production and income approach estimates, although they may be partly avoided by use of quantities of output in the production estimates.

3.80 Although the expenditure data may have serious gaps, it may still be possible to derive a useful split of GDP by type of expenditure. Compilers in many countries face difficulty in developing reasonably reliable estimates of household consumption expenditure and changes in inventories. Therefore, in some cases, either or both of these components may be presented as a residual—the difference between the sum of the available estimated components and total GDP by type of economic activity. This is not an accurate approach to estimate household consumption expenditure and changes in inventories; nevertheless, the size and change in the residual from one period to the next could provide a useful check on the accuracy of the estimates. For example, a substantial decline in household final consumption expenditure (when measured as a residual) may suggest that one or more of the estimated components of expenditure on GDP may be overstated.

Data Sources

Household Final Consumption Expenditure

Value Indicators

3.81 Household final consumption expenditure is usually the largest category of GDP by expenditure. The main sources of data on household consumption expenditure are surveys of retailers and service providers, household expenditure surveys, imports of consumer goods, domestic production of consumer goods, and VAT systems. Compilers may use a single data source or a combination of the sources, but the compilation procedures would determine the data sources that are used.

3.82 Surveys of retailers and providers of other consumer services are common sources for data on household consumption at current prices. The retailers and service providers may be specialized (e.g. motor vehicle sales), but supermarkets and large stores sell a wide range of goods, so that collecting product breakdowns for these stores is desirable. As noted previously, a detailed breakdown by product improves the quality of the deflation. If product mixes are stable, satisfactory quarterly data by product can be estimated by using total sales of a retail industry as an indicator for the benchmark values of sales by product. Some countries conduct continuous household expenditure surveys. However, it is more common for countries to conduct these surveys at multiyear intervals. If the results are processed on a timely basis by quarter, they could be useful indicators for quarterly GDP. For surveys conducted at multiyear intervals, the data are usually combined with other data from business surveys—such as surveys of retail sales—to extrapolate the benchmark period. However, the increase in online retail—and the increasing sales to households by nonresident online retailers—poses a special challenge for data collection on household consumption based on the suppliers.

3.83 Household expenditure survey data may have some shortcomings. Reporting quality and omissions of small or sensitive items may be a problem in household surveys, depending on the behavior of respondents. For example, expenditure on alcohol and tobacco may be understated, requiring adjustments to be made on the basis of other information such as merchandise trade statistics, retail sales, and tax records. In cases where the smuggling of alcohol and tobacco may be a major issue, adjustments may be made based on information from law enforcement. The errors caused by the problem of recall of purchases, which is common in household income and expenditure surveys, could be magnified in the quarterly GDP. The purchases of consumer durables, which are usually large and infrequent, may be allocated to the incorrect quarter.

3.84 Household surveys provide good coverage of own-account production of goods, purchases from informal sector activity, and purchases of services, which are all difficult to cover or not covered by surveys of establishments. In this regard, they may be useful in developing countries in preference to business surveys. In developed economies with relatively smaller informal sectors, business surveys may be used because of issues such as collection cost, delay, and reporting quality of quarterly household expenditure data.

3.85 A VAT or sales tax system may provide data on sales by type of enterprise. Such a tax system may also divide sales into different product categories if different tax rates are applied. It is necessary to identify which sales are indicators of household consumption: for example, sales by retailers and consumer services. The systems used to collect other taxes, such as taxes on alcohol or tobacco, may also be a potential source of information.

3.86 In addition to broad sources such as retail sales, VAT systems, and household surveys, there are a range of specific indicators for components of household consumption. The sources of specific indicators include specialized statistical surveys, major supplying enterprises, and regulators. Where there are a small number of large suppliers of a particular item but no currently published data, the information can sometimes be collected specifically for quarterly GDP. Examples could include sales to residences of electricity and gas, as well as some components of transport, communication, and gambling.

3.87 Expenditure estimates may have to be adjusted to take account of expenditure by residents abroad and expenditure by nonresidents in the domestic economy. If the information is derived from a household income and expenditure survey, then expenditure by residents abroad may have been included in the estimates. However, if the information is derived from retail sales, then adjustments would be required. The balance of payments statistics record these expenditures in the travel account as travel credits (expenditures by nonresidents in the domestic economy) and travel debits (expenditures by residents abroad).

3.88 Commodity flow methods can be used in cases where there are good data on the supply of products. Total supply to the domestic market at purchasers' prices for a product can be derived as follows:

- domestic output at basic prices,
- *less* exports,
- *plus* imports,
- *less* changes in inventories,
- *plus* taxes on products,
- *less* subsidies on products, and
- *plus* trade and transport margins.

3.89 This method would provide the most reliable estimates if calculated at the most detailed product level, which would facilitate the exclusion of goods identified as intermediate goods (such as raw materials to be used in manufacturing) and capital goods. It is recognized that some of these products may have dual purposes as consumer goods and intermediate/capital goods. Thus, reasonable ratios should be applied to identify the consumer goods. Likewise, some products that may be identified as consumer goods may also have multiple purposes as intermediate goods or capital goods and reasonable adjustments should be made. For example, a motor vehicle purchased by a household for use as household transportation would be classified as a consumer product. The same make and model of vehicle, if purchased by an enterprise, would be classified as capital goods. In some countries, the merchandise trade statistics may classify the imports according to the importer and based on the importer, the compiler may be able to determine whether some products that have a dual purpose will be used in production or are available for household consumption.

3.90 The commodity flow method can be particularly useful for goods because goods are often supplied by a relatively small number of producers and importers, and data on the supply of the goods are easier to collect than data on sales at the retail level. Where a significant part of retailing is informal, surveys of retailers are likely to have incomplete coverage, so the commodity flow method could provide more suitable indicators than a survey of retailers.

Volume Indicators

3.91 Data on consumption of dwelling services can be estimated by extrapolation on the basis of the number of dwellings. If construction data do not allow estimates of the net increase in the number of dwellings, population could be used as a proxy (preferably adjusted for any trends in the average number of persons per dwelling). Because of differences in the average rental per dwelling, the quality of the estimation would be improved by doing separate calculations by location and for different dwelling types (e.g., house/apartment or number of bedrooms). It would also be desirable to put in an adjustment factor to account for any shortcomings in this method (e.g., for long-term changes in the size and quality of dwellings). These factors should be accounted for annually so that their effects can be incorporated in the quarterly GDP by the benchmarking process. Because the stock of dwellings is large and changes slowly, acceptable estimates can be derived for dwelling services, even in the absence of quarterly volume indicators. The methods used should be consistent with those used in the production estimates.

3.92 Indicators for some services, such as insurance, education, and health, may be obtained as a by-product of government regulation. In addition, motor vehicle regulation may provide indicators for the volume of vehicle purchases. The components to be included are household purchases of cars and other light vehicles, both new and secondhand, from businesses and governments.

3.93 Administrative data may help fill other gaps. For example, units engaged in providing financial services, medical health activities, and gaming activities (e.g., casinos, lotteries, and fantasy sports betting) are often highly regulated. As a result, indicators may be published or available from the regulatory authorities. Other administrative data can be used as indirect indicators. For example, numbers of court cases and wills in probate are potential indicators for legal services, numbers of deaths for funeral services, and total numbers of vehicles and numbers of road accidents for vehicle repairs. In each case, a direct survey would usually be better but may not be justifiable on a quarterly basis because of the data collection cost and the relatively small size of the activity.

3.94 Consumption from the own production of agriculture can be quite important in some countries. Depending on the method of estimation used, estimates of agricultural output may include own production, so there may be no need to identify the consumption separately. However, the methods used to derive household consumption may not distinguish between household consumption from own production and consumption of agricultural products acquired from other producers. The methods should be consistent with those used in the production estimates. The estimates may be based on household consumption of domestic production of agricultural output using information from household consumption surveys, food consumption (calorie intake) surveys, or poverty surveys. These methods do not provide adequate volume indicators; therefore, in the absence of quarterly surveys of subsistence production, population trends may be an acceptable indicator.

Price Indicators

3.95 The components of the CPI are appropriate deflators for household consumption. Deflation should be carried out at a detailed level to ensure that each component is deflated by the price index that most closely matches its actual composition. For example, it would be better to deflate each *Classification of Individual Consumption According to Purpose* (COICOP) class of food separately to account for different price movements. National accounts compilers should work closely with price statisticians to have consistent classifications and coverage of all required components. There may be gaps where a component of expenditure is not covered by a matching CPI item. An example is insurance services, which are measured as margins in the national accounts but which may be measured as total premiums in the CPI or, in some cases, may be excluded from the CPI altogether.

3.96 For expenditure by residents abroad, some compilers have used as deflators the CPIs of the main countries visited by residents, adjusted for exchange rate changes. However, the expenditure patterns of travelers (whether residents visiting abroad or visitors to the compiling economy) are different from that of residents. Therefore, the use of the overall CPI may provide biased estimates. For example, housing carries a significant weight in the CPI of many countries; however, this item is not expected to be a component of expenditure of visitors. If available, it would be preferable to obtain specific indices for the most relevant components of expenditure by visitors: for example, paid accommodation, transport, purchased meals, or any particularly important categories of goods. Likewise, expenditure of nonresidents could be deflated by the domestic CPI items that relate to the major components of tourist expenditures, such as paid accommodation, transport, meals, and so on.

Government Final Consumption Expenditure

Value Indicators

3.97 Government accounting data are often available on a monthly or quarterly basis. Even if not published, the data may be available on request. Data for the central government are generally readily available. In some cases, lack of data or delays may require estimation for state, provincial, or local government. In the absence of comprehensive data, consideration can be given to alternative indicators that relate to the actual level of activity in the quarter, such as the following:

- a sample collection for local governments,
- wages paid by the governments concerned (preferably excluding those involved in own-account capital formation such as road building),
- expenditure data classified or not by economic type,
- central government payments where these are the major source of funds, or
- budget estimates (before forecasts are used, the track record should be checked to see whether they are reliable).

3.98 As noted previously, for many countries, the government accounts are prepared on a cash basis, whereas economic statistics should be compiled on an accrual basis. Government cash payments can be large and lumpy, and the timing of these payments may be subject to political or administrative considerations. Differences between the cash basis used and the accrual basis required by the *2008 SNA* could cause errors and discrepancies in the estimates. These errors are the same for both quarterly and annual GDP, but the impact on quarterly GDP is likely to be larger. A particular instance of a distortion caused by cash recording is where government employees are paid every two weeks. While some quarters will have six paydays, others will have seven, causing fluctuations in the quarterly data that would not be a serious issue in annual data. Also, in many cases, government contractors are paid in full after the work is completed and there may be a considerable lag between the completion of the work and the finalization of payments. To the extent that such timing problems can be identified, adjustments that are supported by evidence can be used to get closer to an accrual basis.

3.99 The links to the production estimates for general government should be noted and monitored. If inconsistent methods or data are used, errors in the residual item or discrepancies will occur. The scope of government final consumption expenditure and government output differ, in that government final consumption expenditure is equal to the following:

- general government output,
- *less* own-account capital formation included in output,
- *less* any sales of goods and services at economically significant and economically insignificant prices,
- *plus* purchases from market producers for delivery to households free or at economically insignificant prices, and
- *less* changes in inventories of finished goods and work-in-progress.

Although the same indicators can often be used for both production and expenditure, the factors causing differences between them need to be taken into account, especially if they are changing proportions of the total.

Volume Indicators

3.100 In a few cases, it may be possible to obtain quantity measures for output of government services. For example, numbers of students at government schools, numbers of operations or bed nights for patients in public hospitals, and numbers of benefit recipients served by a government social assistance office may be available. However, these indicators fail to take into account important quality aspects. Further, there are many other activities of government where output is difficult to quantify, such as public safety and policymaking.

3.101 In the absence of suitable output volume indicators, an indicator based on labor inputs may be used, such as the number of employees or hours worked. Because government consumption is a labor-intensive service, this is a more acceptable assumption than it would be for other expenditure components. In addition to the limitations of labor input measures for measuring production, measuring consumption is more difficult because of work contracted out to the private sector, capital work on own account, and the offsetting effect of charges for some services. Structural changes in the proportions of staff engaged in capital work, the proportions of output recovered through charges, or the proportion of work outsourced could be significant on a quarterly basis.

Price Indicators

3.102 Although current price value-added measures for government are clearly defined as being based on costs, the price and volume dimensions are less clearly defined and have several alternatives. Prices are usually not directly observable. One option is to derive independent value and volume measures so that the price dimension is obtained indirectly. Alternatively, a deflator could be obtained as a weighted average of input costs. The usual input costs are wage indices or pay scales of civil servants and military staff, combined with relevant components of price indices reflecting typical input costs such as rents, electricity, stationery, and repairs.

3.103 Methods based on input costs have the shortcoming that they do not account for productivity changes. Of course, these measurement problems are the same for annual and quarterly estimates. For the QNA compiler, the simplest solution is usually to adopt the annual method and allow the benchmarking techniques to incorporate any adjustment factors.

Final Consumption Expenditure of Nonprofit Institutions Serving Households

Value Indicators

3.104 Much of the discussion on measurement of government consumption also applies to NPISHs. Like general government, their output and consumption of nonmarket services at current prices are measured at cost. However, quarterly accounting data are less available than for general government although data for some larger institutions may be published or available on request. Governments may be a good source of indicators if they monitor, regulate, or provide transfers to charities, private schools, and similar institutions. Otherwise, since NPISHs are mainly involved in services, wages and salaries paid may be an acceptable substitute. Balance of payments data on transfers to nongovernment institutions may be an important indicator in countries where foreign aid is a major source of funding for NPISHs.

Volume Indicators

3.105 Labor input measures may be suitable indicators. If data are unavailable and the NPISHs sector has been shown to be economically stable in annual data, past trends may be an acceptable volume indicator. The method for the expenditure estimates should be consistent with that for the equivalent production estimates.

Price Indicators

3.106 The methods are similar to those used for general government consumption, where output at current prices is also defined as the sum of costs. A weighted average of input costs may be used for consumption by NPISHs so that the deflator corresponds with the composition of the current price value measured from input costs. Items could include wages, rents, repairs, stationery, and electricity.

Gross Fixed Capital Formation

General Value Indicators

3.107 The *2008 SNA* classifies gross fixed capital formation by type of asset. For many countries, largest components are buildings (dwellings and other buildings and structures), and machinery and equipment. It also includes weapons systems, cultivated biological resources, and intellectual property products. Research and development, irrespective of whether or not it is successful, is considered gross fixed capital formation. Costs associated with the purchase of fixed and other assets are also included, such as transfer costs (including real-estate agents' commissions, legal fees, and taxes on real-estate purchases), architects' fees, and installation costs. In addition to purchases, own-account production of capital can be important in some cases, including construction, computer software, and legal work.

3.108 Annual and quarterly business surveys of capital expenditure are the conceptually preferred sources of data on capital formation, excluding dwellings. However, capital formation surveys are particularly expensive and difficult to conduct on a quarterly basis for the following reasons:

a. Such surveys are very sensitive to coverage problems in the business register because new enterprises, which may not yet even be in operation, are particularly likely to have higher rates of capital formation than established businesses.

b. The potential population is almost every enterprise in the economy, and there will be a large number of enterprises having little or no capital formation in any particular quarter. As a consequence, the sample frame needs frequent updating and the samples have to be relatively large.

c. Product splits are also more difficult to obtain than from the supply side.

d. Another issue that may be the source of some difficulty in estimation is that the *2008 SNA* includes work done on contract as capital formation of the final purchaser at the time it is done, while only progress payments will be known to the purchaser. If possible, it would be desirable to compare data from the alternative indicators for construction and equipment noted in this section.

3.109 VAT returns may not separate capital and intermediate purchases but where a VAT system requires capital and intermediate purchases to be split, a useful indicator of capital formation can be obtained. However, the VAT system lacks a product split and excludes work on own account. The lumpiness of capital formation may assist in identifying enterprises undertaking capital formation during the period and provide the basis for generating a split at the level of individual enterprise.

3.110 Commodity flow methods may provide an estimate of the gross acquisition of fixed assets; however, the compiler would have to obtain data on disposals from another source. For the total economy, the disposals would constitute assets acquired by nonresidents. The exports statistics would therefore constitute a useful source of information. Quarterly income tax records and quarterly financial statements of enterprises may also be useful sources.

Components of Gross Fixed Capital Formation

Buildings (Including Dwellings) and Other Structures

Value Indicators

3.111 Gross fixed capital formation on buildings and other structures includes the value of output of construction activity, including own-account construction as a secondary activity, and the cost of ownership transfer on the acquisition of the asset. It excludes the value of maintenance and repair.

3.112 Construction is often difficult to measure because of the large number of small-scale contractors, own-account work, and work done without permits. Further, many of the contractors remain in business for a relatively short period; therefore, it is difficult to get an accurate count of how many may be in operation during a given period. The supply of building materials, on the other hand, can often be obtained from imports statistics and a relatively small number of producers of construction materials and quarries (with adjustments for exports and imports, if applicable). To the extent that there is a stable relationship between building material inputs and output, this is a suitable indicator that can be obtained with relatively little cost or compilation time. The quality of the assumption deteriorates if there are changes in any of the mix of types of building, techniques of building, productivity, and inventories of building materials. If changes in these factors are known to be occurring, it may be desirable to explore more complex methods (e.g., a calculation that takes into account the different products used by different types of construction or collection of data on inventories).

3.113 The estimation of gross fixed capital formation on buildings and other structures raises a number of special measurement issues and problems, such as the following:

- *Large numbers of small enterprises:* Construction is typically carried out by numerous enterprises that are often small and informal. Therefore, data collection and obtaining sufficient coverage of these enterprises may be particularly difficult.
- *Projects with long gestation periods:* The length of construction projects gives rise to the issue of the allocation of output to the relevant quarters and hence the estimation of work-in-progress. This issue is addressed further in Chapter 11.
- *Subcontracting:* Work is often arranged by a prime contractor with a number of specialized subcontractors, which means that several enterprises may be involved in the same project, giving rise to the possibility of double counting or omissions.
- *Speculative construction:* Where the work is undertaken by a developer with no final buyer, the price is not known at the time that the work is done. In addition, land costs are included in the price, and holding gains and operating surplus are mixed together (*SNA 2008*, para. 6.140).
- *Construction exports and imports:* Construction undertaken by resident contractors/enterprises

(and not a branch office) in another economy (exports of construction) should be included in the estimates. Information on this activity may be available from the surveys of construction companies; however, these estimates will not be captured through commodity flow methods. Likewise construction imports may not be captured through the business survey and the compilers should be careful to exclude these estimates from the commodity flow estimates. Information on construction exports and imports may be obtained from the balance of payments compilers. However, some construction projects undertaken by a resident contractor overseas may give rise to a branch. This may be the case for major projects (such as bridges, dams, and power stations) that take a year or more to complete and that are managed through a local site office (branch) in that economy (*BPM6* para. 4.27 and para. 4.29). This output is considered part of the output of the economy where the branch is located. Activities undertaken by a branch of a resident enterprise is not considered part of the output of that enterprise.

3.114 These problems apply to the corresponding estimates for construction industry by the production approach as well. They also apply to annual data, but quarterly data are more sensitive to the slowness or high cost of data collection and more subject to difficulty allocating the value of long-term projects to quarters.

3.115 Gross fixed capital formation on buildings and other structures can be measured using various data sources or a combination of the following:

- supply of building materials,
- issue of government permits for particular projects,
- data reported by construction businesses,
- data reported by construction-purchasing businesses, and
- data reported by households engaged in own-account construction.

3.116 In many countries, construction requires permits from local or regional governments, and the permit system can be used as a source for estimates of construction in the national accounts. The permit system may cover only larger projects or urban areas, while in other cases it may cover all except minor construction work. Permits usually show the type of construction, value, size, proposed start and end dates, and the name and address of the owner or builder. If the data are in volume terms only (e.g., floor area—number of square feet or meters) or the value data are of poor quality, then an average price per unit is also necessary to derive current price values. Data in this form need to be allocated to the relevant period, usually with information from builders, regulatory authorities, or engineers in order to obtain average construction times for each building type.

3.117 It is also necessary to make adjustments, to the extent practical, to account for projects that do not go ahead (realization ratio), biases in builders' estimation of their costs, the effect of holding gains included in prices, and the proportion of projects that are carried out without a permit. Government decisions, other official channels, or newspapers may be used to identify large-scale projects that may not be captured through the permits process. These may include the construction of airport terminals, power plants, water treatment facilities, and so forth. These projects should be considered separately because the input–output structure is likely to be different. Information on the cost and inputs may be obtained from the relevant government department or the contractors.

3.118 One drawback of this approach is that the timing indicated in the permit may not match the timing of the project because there may be delays in project execution. In some countries, the unit undertaking the construction is expected to report on the expected date of construction if there is a change. However, this stipulation may not exist in all countries.

3.119 The approval process can also be used to identify construction projects that could then provide the frame for a sample survey. Direct information about the project, such as the value of work done each quarter and changes from the original proposal in the cost or size or starting/ending dates, can be collected in such a survey. Using survey information prevents the need for making the kind of assumptions that have to be made when permit data are used directly. The survey method is conceptually much closer to statistical requirements, but it is more expensive and time consuming to perform. The usefulness of the survey is also limited by the degree of sophistication of builders' accounting records about the value of work done in the period. In practice, the value of work done may have to be represented by progress payments.

3.120 The *2008 SNA* notes that when a contract of sale is agreed in advance for the construction of buildings and structures, spreading over several periods, the output produced each period is treated as being sold to the purchaser at the end of each period: that is, as a sale rather than work-in-progress. In effect, the output produced by the construction contractor is treated as being sold to the purchaser in stages as the latter takes legal possession of the output. It is therefore recorded as gross fixed capital formation by the purchaser and not as work-in-progress by the producer. However, in the absence of a sale contract, the incomplete output produced each period is recorded as work-in-progress of the producer. Construction undertaken without a contract of sale raises special issues regarding valuation and timing. For practical purposes, it may be recorded as gross fixed capital formation rather than work-in-progress. For example, if a commodity flow method is used to estimate construction, it would not be possible to identify how much is undertaken with a contract for sale and how much without.

3.121 Ultimately, the net effect on GDP of the different treatment of contract and speculative construction should be nil, since they cause offsetting differences in gross fixed capital formation and changes in inventories. However, if it is decided to include unsold construction work in gross fixed capital formation, there is a valuation issue in that the estimated price may differ from the realized price. If unsold construction work is shown as changes in inventories, there needs to be a valuation adjustment to make the withdrawal from inventories consistent with the gross fixed capital formation. When the contract calls for progress payments, the value of the output may often be approximated by the value of stage payments made each period.

3.122 Construction in rural areas in developing countries may sometimes be carried out by households on their own account and made with their own labor, outside the scope of official permits. A household survey may provide information on the numbers of households involved and the cost of materials. These results would need to be adjusted to an estimated market price by taking the equivalent market prices (if such a market exists) or a shadow price based on costs (including labor). Usually, these indicators would only be available for a benchmark period and not on a quarterly basis. The building material approach captures some of this activity to the extent that a significant proportion of materials is produced by factories, although some materials may be made by the household. In the absence of other data, the size of the rural population could be used as a quarterly indicator for this type of construction.

3.123 It is desirable to obtain data on gross fixed capital formation of construction by type of asset, both for economic analysis and for improving deflation. Data by the industry and institutional sector of the purchaser are also useful for analysts. The estimates based on building materials give little or no breakdown, while other estimation methods can give more. In some cases, the general government sector data could be obtained from the government finance statistics, allowing the nongovernment component to be derived as a residual. Because residuals magnify the effects of errors, implausible values of the residuals may point to data problems.

3.124 Both the estimates of gross fixed capital formation and output will often be derived from the same data sources. However, the estimates will differ because the following items are treated differently:

- repairs (part of output; however major repairs and renovation are treated as fixed capital formation);
- secondary activity (secondary construction by establishments outside the construction industry is part of capital formation, while establishments may have secondary activity in producing other goods and services);
- speculative construction (output and inventories of the industry when the work is put in place); and
- associated expenses, such as nonconstruction goods included in a structure and architectural, legal, and approval fees (which are not part of construction output, but are fixed capital formation), or the effect of any product taxes and subsidies.

Volume Indicators

3.125 Data on the supply of building materials may be the most readily available construction volume indicator. Whereas the number of builders may be large and their activities dispersed, building materials are often produced and supplied by a relatively small number of large factories, quarries, and sellers. Data on exports and imports of building materials are also generally available and may be important for some kinds of building materials in some countries. Therefore, measures of the total supply of building materials or selected major building materials to the domestic market can be obtained as output plus imports less exports. Preferably, trade, tax, and transport markups would be taken into account, to the extent that they have changed or that differential markups affected the weights of different components. A lag factor may be included to take into account the time it takes for materials to get from the factory (local production) and customs frontier (imports) until they are incorporated in construction work.

3.126 This method provides comprehensive coverage of construction as it also covers informal activity in construction. The limitation of this indicator is that it assumes a stable relationship between building materials and output. The assumptions may not be stable because different kinds of construction work use different materials and have different materials-to-output ratios. Thus, when the mix of construction projects changes, the materials-to-output ratio would also change. For example, the construction of a water dam or other major public sector project would alter this ratio and this effect could be quite pronounced in smaller economies. In that case, it may be useful to consider the large projects separately.

3.127 Building permit systems may provide volume indicators such as floor area. However, there is an interval between the permit's approval and the start of construction. This interval is not always known and if estimated for a given period, may fluctuate over time due to changes in demand for construction, supply of materials, and seasons.

Price Indicators

3.128 Because each construction project differs, compiling a price of construction presents special difficulties. Three alternative methods that are used to derive construction price indices are

- model specifications,
- hedonic techniques, and
- input costs.

3.129 One method of obtaining output prices is to collect or derive hypothetical prices for construction output. House builders may have standard models of houses that are offered. Although options and individual circumstances mean that the model is not implemented in every case, it can still form the basis of the builder's pricing, and it would be relatively easy to obtain quotations from the builder for the standard model on a consistent basis. However, standard models are usually only found for dwellings, where a mass market exists, but not for other types of construction. Another approach to model specification is to divide construction into a number of particular tasks: for example, painting a certain area of wall, laying a certain height and type of brick, and cost per hour of electrical work. A weighted total of each of these components could be used to represent overall prices for a particular type of construction. A possible shortcoming is that the most difficult jobs might be omitted, such as the prime contractor's organizational work and unique, large-scale engineering tasks. Construction is usually highly cyclical, with margins cut or increased in line with conditions. Because the prices are hypothetical, the statistician needs to be careful if list prices are being reduced by discounts or bargaining during a recession or if more is charged during a busy period to cover overtime costs.

3.130 Some countries have explored the use of hedonic techniques to measure prices of one-off goods. In addition to collecting the prices of a range of buildings, these countries also collect data on characteristics of the building that affect the price (such as floor area, height, fittings, materials, and location). A regression model is then developed to identify the effect of each characteristic on the price. This allows the prices of the different kinds of buildings to be converted to a standard basis and, hence, allows a price index to be derived. This method requires a great deal of work in data collection and analysis of data. A limitation is that characteristics may be too numerous or abstract to be quantified, so the model would only explain a limited part of the price variation. Also, the coefficients of the model may not be stable over time.

3.131 Input cost measures are based on the prices of construction materials and labor. These should include building materials (from a producer price index) and wages (preferably specifically for occupations employed in construction). An adjustment could also be made for changes in markups to account for builders' operating surplus and mixed income, if indicators were available, because these represent a major part of the price and could be quite variable. Data on intermediate consumption by product supplied to the construction industry would be required for a benchmark period. Use tables could present these data or they could be obtained directly from surveys of construction enterprises. Otherwise, it would be necessary to seek expert advice or a sample of bills of quantities for building projects. Data on employment in construction by type of employee (occupation groups) would also be useful for weighting the labor cost part of the index. Because of different input structures, it would be desirable to compile separate indices for different types of building and construction (i.e., houses, apartments, offices, shops, etc.).

3.132 Generally, it is desirable to avoid using input costs to represent output prices, because input costs ignore changes in productivity and profitability. However, the input cost method avoids the difficulties of obtaining an output price index for heterogeneous products. Many types of construction are one-off, and even where the same model is used in different places, differences in soil type, slope, or options mean that it is not possible to find exactly comparable observations. Finding actual buildings that are representative and consistently priced is close to impossible.

3.133 In practice, countries may often use a mix of different pricing measures for the different types of construction. In situations where independent volume and value indicators are available, it is beneficial to derive an implicit price per unit to check that the result is plausible. Erratic results may mean that one of the indicators is unsuitable (e.g., the implicit deflator may fluctuate because of quality changes that were not taken into account in floor area data used as a volume indicator).

Machinery and Equipment

Value Indicators

3.134 The five sources for measuring equipment, reflecting the stages along the distribution process, are the following:

a. survey data on supply of machinery and equipment,
b. survey data on purchases by enterprises,
c. VAT data on purchases,
d. registration and licensing of transport equipment, and
e. imports statistics.

3.135 The supply of machinery and equipment may be estimated using the commodity flow method. The supply of goods should exclude goods purchased by households and exports of domestic production. It may be difficult, but an adjustment should also be made for goods entering inventories and goods leaving inventories and acquired by enterprises. Relevant taxes, trade margins, transport margins, and installation costs should also be applied to the supply of domestic production and imports. In addition, adjustments should be made for disposals through sales to nonresidents (considered exports) and sales to households (considered fixed capital formation of household as producers or household final consumption expenditure).

3.136 Data from the supply side provide totals and splits by asset type, but not estimates by industry or institutional sector of use, which are of analytical interest. Like construction, government finance data could be used to obtain government capital formation of equipment, and then a private total could be calculated as a residual.

3.137 Transactions in secondhand goods present some additional issues. Some sources may only provide data on new products. Data on some secondhand components—such as government asset sales, goods sold or purchased internationally, or vehicles—may be available. Data in some cases may not need to be collected if the transactions are small, stable, or occur within a single component.

Price Indicators

3.138 Machinery and equipment is a heterogeneous group, so quantities are meaningless and indicators based on quantity should be avoided. Data derived from a survey of equipment purchases are at purchasers' prices. Components of the PPI and import price index could be weighted and used as a proxy. However, PPIs are derived at basic prices and exclude margins and some taxes. It would be desirable to make adjustments if trade, transport, and tax margins were known to be unstable. The most likely instance is taxes, where information on tax rates to adjust basic/producer prices for taxes on products including VAT would generally be available. Similarly, import price indices are typically measured at the point of arrival in the country rather than the point of final purchase, and thus exclude domestic trade, transport, and tax margins.

3.139 If the equipment data had been derived from the supply side, the current values for domestically produced goods would have been reported at basic or producers' prices. If so, the best method would be to develop volume indicators by deflating the supply values of domestically produced equipment by the relevant PPI component. As the value and price measures would be consistent, it would be expected to be a superior volume indicator to one derived from value and price measures that were based at inconsistent pricing points.

3.140 Imports are a major component of capital formation in many countries. Import unit values would be expected to be poor indicators of prices. If no import price index is available for some or all types of equipment, a solution may be to take advantage of the producer price or export price indices of the main equipment-supplying countries. These should be obtained at a detailed level so that the components can be weighted to reflect the composition of imported equipment in the importing country. The data should also be adjusted for exchange rate movements and lagged to account for shipping times, if the lag is substantial and if it is possible to identify the lag period. It is possible in practice that the effect of exchange rate changes is lagged or smoothed by forward exchange cover and by squeezing or expansion of margins. Further, because of changes in exchange rates and international specialization in types of equipment, prices of imported and domestically produced equipment may behave differently.

Intellectual Property Products

General Issues

3.141 The *2008 SNA* has introduced a new category of gross fixed capital formation that comprises many of the items under the previous category of intangible assets. The measurement of intellectual property products raises a range of conceptual issues such as the identification of originals, transactions in licenses versus transactions in copies, and licenses to use versus licenses to reproduce. In most cases, these conceptual issues determine whether the transaction is considered capital formation or (intermediate or household) consumption. The effect of incorrect inclusion or classification of these transactions would be magnified in the quarterly accounts.

Value Indicators

3.142 The estimates could be made on the supply side or the demand side, but the approach used would depend in part of the category of intellectual property products being considered.[8]

3.143 *Research and development and mineral exploration and evaluation:* In many cases, the enterprises engaged in these activities would be limited and known. If significant, a survey could be considered. For example, in countries where mineral exploration is important, a specific survey on the topic would be justified. The value data may be derived through quarterly or annual surveys that request information on the intentions of the enterprises during the upcoming quarters. Administrative data may also provide some useful information in terms of permits and licenses for research or mineral exploration.

3.144 *Computer software and databases:* Although all businesses may use software and databases, only a few may acquire these items as gross fixed capital formation. A demand side approach is further complicated by the fact that capital expenditure on this category may be lumpy and may not occur in every quarter. Quarterly surveys may therefore focus on the large enterprises. Supply data on domestic production may be easy to collect because of the

[8]The *Handbook on Deriving Capital Measures for Intellectual Property Products* (OECD 2010) provides detailed guidance on deriving value and volume estimates of intellectual property products.

relatively smaller number of businesses involved, but data on imports would be much more difficult and inaccurate. Software transferred on physical media constitutes only a proportion of total software and the value of the software may not be accurately recorded in the merchandise trade statistics. In addition, not all software acquired by businesses is to be considered gross fixed capital formation—some of it may be intermediate consumption. Likewise, a substantial proportion of computer software is for household consumption. Some computer software/applications and databases may be produced on own-account by enterprises for their own use. Quarterly income tax records and quarterly income and financial statements are useful sources of this kind of expenditure.

3.145 *Entertainment, literary, or artistic originals:* These activities may not be very important in some economies but where they are, the information could be collected through quarterly or annual surveys.

Price Indicators

3.146 The *2008 SNA* notes that intellectual property products are not well covered by available price indices partly because they may be produced for own use and may not have comparable observed market prices, and partly because they tend to be heterogeneous products. Originals and copies each present their own unique challenges and should be considered separately. The *Producer Price Index Manual: Theory and Practice* provides a summary of techniques that could be used to derive price indicators for unique products like intellectual property product originals. However, it should be noted that quarterly transactions in originals of intellectual property product may not be very common.

Cost of Ownership Transfer

3.147 The cost of the ownership transfer refers to all costs relating to the acquisition or disposal of an asset. For produced assets, the cost of ownership transfer is included in the value of the asset. For nonproduced assets, the cost of ownership transfer is shown separately in gross fixed capital formation. It includes all professional charges and commissions (lawyers, architects, surveyors, and engineers), trade and transport margins invoiced to the purchaser, taxes payable on the acquisition or disposal, delivery and installation charges, and terminal costs.[9]

3.148 Architectural and approval costs are related to construction activity, so construction indicators could be used as indirect indicators if more direct data are not available. However, as some of these expenses precede construction work, their timing is different. As a consequence, the timing pattern built into construction estimates may have to be adjusted.

3.149 Real-estate transfer costs consist of items such as lawyers' fees, real-estate agents' commissions, land title transfer taxes, loan application fees and other setup costs for finance, and inspection fees. These costs relate both to new construction and to purchases of land and existing buildings (including dwellings). If these land dealings are registered with a government agency, it may be possible to obtain a quarterly indicator from this source. Data on financing of land and building purchases is a poorer indicator; an even worse indicator is the value of new construction. For real-estate transfer expenses, numbers of transfers registered with the relevant government agency may be used as a volume indicator. To take into account compositional changes, it would be better to classify by type of property (e.g., houses, apartments, shops, and complexes) and other variables that may affect the cost (e.g., by state or province if charges are different). In some cases, it may be necessary to derive a current price measure from the volume measure, which would require information about transfer tax rates, real-estate commission rates, lawyers' fees, and so on.

Changes in Inventories

General Issues

3.150 Inventories are defined as goods and some services[10] that have been produced or imported but have not yet been used for consumption, fixed capital formation, or export. This delay between supply of the product and its use brings about valuation issues.

[9] Terminal costs are incurred at the end of the life of the asset to render the structure safe or to restore the environment. Terminal costs could be significant in the case of nuclear power plants and landfills.

[10] Inventories of services include work-in-progress on complex products such as films, computer programs, and architectural drawings that may take more than one period to complete.

Inventories appear explicitly only in the expenditure estimates. They must, however, be taken into account in both the production estimates (both output and intermediate consumption) and income estimates (operating surplus and mixed income). The valuation issues also arise in the other approaches, except where output or input measures are expressed in quantity terms for production estimates.

3.151 Inventories consist of materials and supplies, work-in-progress, finished goods, goods for resale, and military inventories. These components of inventories differ according to their stage and role in the production process. Materials and supplies are products that a unit holds with the intention of using it in production.

3.152 Work-in-progress is output that is not sufficiently processed to be in a state in which it is normally transferred to another institutional unit. It is especially important for activities where the time needed to complete a given unit of output spans more than one quarter and could exist for both goods and services. It must be recorded for any output that is not completed at the end of the period and although it is not complete, this output is transferrable to another institutional unit. It can span a wide range of products including crops, livestock for slaughter, ships, aircraft, computer software, and films.

3.153 Finished goods are part of output and are of the same form as their consumed equivalents. Work-in-progress is also part of output, but is harder to quantify than finished goods because the product is incomplete. Inventories of goods for resale—that is, goods held for the purpose of wholesaling and retailing—are neither part of output nor future intermediate consumption of the holder. Net increases in inventories of goods for resale need to be deducted from purchases of goods for resale to derive cost of goods sold and, hence, wholesale and retail margins, which are defined as the value of goods sold less the cost of goods sold. The separation of different components is important because they include different products and, therefore, the price indices to be used in deflation will also differ.

3.154 In practice, attention can be confined to those components of inventories that are of significant size. Inventories of work-in-progress may be very important for agriculture depending on the types of crops produced. However, the compiler may wish to focus on the crops produced on a commercial basis because of the practical issues associated with attempting to estimate work-in-progress for subsistence agriculture. Quarterly surveys may focus on large enterprises engaged in mining, manufacturing, and distribution.

3.155 Although changes in inventories may be a small component of GDP, they can swing substantially from strongly positive to strongly negative. Consequently, this small component can be a major factor in GDP movements. In the quarterly data, the average absolute quarterly contribution to growth can be large, often being one of the major quarterly growth factors. Over the long term, the contribution of changes in inventories to GDP growth tends to be small, because some of the quarterly volatility will cancel itself out over the year. The importance of inventories follows from its nature as a swing variable in the economy. It represents the difference between total demand (the sum of the other components of GDP by expenditure category) and total supply. An increase in inventories would represent supply that was not used during the period, while a reduction would show the amount of demand that was met from previous supply. Without these data, the expenditure estimates would show demand, not production. Data on changes in inventories are also important for analysis, because the gap between demand and supply can be an indication of future trends. For example, a decrease in inventories suggests that demand exceeds supply and output or imports will need to increase just to keep pace with the existing level of demand.

3.156 Changes in inventories present particular difficulties in terms of valuation. Businesses use several different varieties of historic cost, none of which match national accounting valuation concepts. Measurement practice also varies, from complete physical stocktakes to samples and estimates. The valuation problems are sometimes ignored but are significant, as can be illustrated with some simple but conservative assumptions: if inventories are stable, the total holdings of inventories of inputs and outputs are equivalent to three months of output, and if value added is half of output, then 1 percent of price change in inventories will amount to a valuation effect of 2 percent of quarterly value added. Thus, even quite low rates of inflation can cause a significant overstatement of the level of value added, and this effect will be concentrated in the major inventory-holding industries. Similarly, a small increase in the rate of inflation will overstate the growth of GDP.

3.157 It is not desirable to estimate changes in inventories as a fixed ratio of another component of expenditure on GDP because inventories do not have a fixed, stable relationship with any of the other components.

Value Indicators

3.158 A number of issues arise concerning data on inventories. Some businesses may have computerized inventory controls, others have full physical stocktaking at less frequent intervals with sampling or indicator methods for more frequent measures, and some small enterprises may not measure inventories on a quarterly basis at all. The values of inventories may also be a particularly sensitive commercial issue. Valuation effects can generally be better calculated with higher frequency data. This is because higher frequency data reduce the possibility of uneven price and volume movements within the period. As a consequence, the annual sum of the quarterly valuation adjustments may be superior to annually calculated ones, unless there is some other compelling difference, such as differences in coverage or detail. Similarly, if monthly data are available, the calculation should generally be done on a monthly basis for use in quarterly estimates. These factors all need to be assessed in light of each country's conditions.

3.159 Some countries derive changes in inventories in GDP by expenditure as a residual. The residual method could be used quarterly even if the annual measures were obtained directly. This method is only feasible if there is a complete measure of GDP from the production approach and estimates are available for all other expenditure categories. However, because inventories should also be included in estimates of output and intermediate consumption, the measurement problems still need to be dealt with, even though quantity data that sidestep these valuation issues can sometimes be used. Derived as a residual, changes in inventories would also include the net effect of errors and omissions. In that light, compilers should review it carefully for signs of any errors that could be dealt with directly. As well, users should be advised to use caution in interpreting the estimate of changes of inventories, which should be labeled as being "changes in inventories plus net errors and omissions" to emphasize the limitations. If direct data on changes in inventories are not available, a few questions could be added to the business/economic survey to determine the direction/sign of the changes in inventories: accumulation or decumulation of stocks of inputs, finished goods and goods for resale, as well as the intensity (strong, medium, or minor during the quarter). This qualitative information will be very useful to assess the residual estimates on changes on inventories.

3.160 One method that should not be used is to accept changes in inventories at book values as reported by enterprises without adjustment. Business accounting practices typically use historic costs, which result in the inclusion of holding gains in the value of changes in inventories. Quarterly income tax records and quarterly income and financial statements are useful sources of data on inventories.

3.161 *Valuation of work-in-progress:* For nonagricultural products with a production cycle of one year or less, the *2008 SNA* notes that the value of the additions to work-in-progress may be approximated by calculating the proportion of the total production costs incurred in that period and applying that ratio to the basic price realized by the finished product. This method assumes that prices and costs remain stable during the period of production. Thus, the value of the output of the finished product is distributed over the accounting periods in which it was produced in proportion to the costs incurred in each period. However, this method may not be satisfactory for agricultural products because a disproportionate share of the costs may be incurred during the sowing season with little, if any, costs being incurred until harvest.

3.162 Prorating the output to the physical growth of the crop may be considered a possibility, but in cases where there is serious risk of climatic damage just before the crop is harvested, this may give overoptimistic indications of probable output. Pragmatic distributions over quarters based on experience may have to be used, or where multi-cropping is the norm, to allow the whole output of each crop to be counted in the period when it is harvested.

Volume Indicators

3.163 Inventory data may be available in quantity terms for some products held by some enterprises. Because inventories include almost every type of goods (as well as a few kinds of services) and firms typically use a range of products (especially their inputs), this solution cannot be implemented comprehensively. However, it may be available for some of the major components of inventories, such as major agricultural commodities, oil, or some minerals (these goods have the most volatile prices and inventory holdings may be large). With quantity data, valuation problems can be sidestepped by directly revaluing the change in the quantity over the period by the base year average prices (volume measures) and average prices of the period (current price measures). The result will be an estimate of the value of the physical change in inventories. At current prices, this is only an approximation of the *2008 SNA* concept, which also includes adjustments for all valuation changes that occur between the time of production and the time of final expenditure. The two concepts will be the same if price changes and transactions are spread evenly over the quarter.

Price Indicators

3.164 Price indicators used may be based on the composition of the inventories, making use of CPIs, PPIs, trade prices, and average prices for specific commodities. The opening and closing levels of inventories (never the change in inventories) should always be deflated. If inventories are usually valued at historic cost, prices of several preceding periods may be relevant.

Valuables

3.165 Valuables cover a wide range of products that may be held for their intrinsic value, such as precious metals and stones, antiques, and other art objects among others. Surveys of enterprises are likely to provide most accurate data on the value of these transactions. Supply side methods are likely to understate the value of these items and this method of estimation should be avoided in this case. Merchandise trade statistics may record only the production value and not the market value of the items that are considered valuables. For example, for rare coins held for their intrinsic value, the merchandise trade statistics would only record the value of the stamped metal.

3.166 Many statistical agencies do not develop price indicators for valuables because of the inherent difficulty of deriving such indicators and the relative size of this component of GDP. Quarterly income tax records and quarterly income and financial statements are useful sources of inventories.

Exports and Imports of Goods and Services

Value Indicators

3.167 The concepts and definitions in the sixth edition of the *Balance of Payments and International Investment Position Manual* (*BPM6*) are consistent with that of the *2008 SNA*. Therefore, if the balance of payments statistics are compiled according to the *BPM6*, then no further adjustments to the value estimates may be required as the merchandise trade data should have been adjusted to *BPM6* basis. The main source of data on exports and imports of goods is the IMTS compiled through special report forms completed by importers and exporters. Some countries may also compile data on imports and exports through surveys of enterprises engaged in foreign trade or through international transactions reporting systems. Services data are typically derived from specific surveys, administrative systems, and international transactions reporting systems.

Price Indicators for Goods

3.168 Customs and other trade data systems usually collect quantity information (e.g., kilos and liters) and some countries compile unit volume and unit value indices directly from the information included on customs declarations. The unit values and volumes at the most detailed level of classification are combined to derive aggregate indices using weights from the value data.[11] These indices possess various weaknesses that make them unsuitable for use as price and volume indicators. Trade statistics—even at the most comprehensive level—are compiled by product group and not individual products. Thus, a given group will include products of varying specifications and quality. Unit

[11] The *Export and Import Price Index Manual: Theory and Practice* (ILO and others 2009) presents a more comprehensive assessment of the errors and bias in the use of unit value indices.

values are derived by dividing the value of imports or exports for a given product group by the quantity for that group. The result is that the index may be affected by changes in the mix of products comprising that specific product group, making it difficult to isolate the underlying price changes from changes in quality. For example, the specific trade classification, group of motor vehicles for the transport of persons would include motor vehicles with varying accessories that could result in substantial differences in the price. This anomaly will affect the reliability of the volume estimates of trade or intermediate inputs that may be derived using these statistics.

3.169 Unit value indices may be used for some homogenous products such as oil and gas or where quality variations may be minimal or no measurable for deriving price indices, such as some primary commodities.

3.170 Some countries compile import and export price indices using price quotes of exports and imports. These quotes are collected from businesses in the same way as the PPI. Import and export price indices do not possess the same weaknesses as unit value indices and provide more accurate measures of prices and volumes.

3.171 Components of these indices can also be used to deflate the current price value data at the most detailed level to derive volume measures. The price indicators should be consistent with any adjustments for transfer pricing in the value data.

3.172 A price index is a better way of dealing with heterogeneous products than is a unit value index. The price index approach of identifying products with fixed specifications and transaction conditions for each product allows price effects to be isolated. However, developing and maintaining a trade price index system could be costly and has the disadvantages of high respondent burden. Also, the actual transaction prices that make up trade may be affected by factors such as the mix of prices from contracts made at different times and the effects of foreign exchange hedging. These effects may not be easy to capture in a price index.

3.173 In some cases, neither unit value indices nor price indices may be available. In these cases, a solution may be to use price indices from other countries. In the case of imports, the export price indices of the main supplying countries can be used. If export prices are not available for some supplying countries, a producer price index may be an acceptable substitute, although factory gate prices are less relevant than export prices. Preferably, the indices would be obtained at a fairly detailed level so that different imported products could be deflated separately to reflect the actual composition of trade, rather than the fixed composition used in the indices of the supplying country or countries. It would also be desirable to obtain price index data from several of the main supplying countries, in order to take into account different composition and price pressures. The price indices should be adjusted for exchange rate movements between the currencies of the supplying countries and the importing country. If the source of the trade is remote, it may be desirable to allow a lag to account for shipping times (e.g., if shipping takes two months, the January export price represents the March import price).

3.174 For exports, the components of the PPI relevant for exports of goods may be used. For minerals and major agricultural commodities, world prices may be used to derive an index.

3.175 Imports are deducted from total expenditure to derive domestic output. In other words, the imported component of each type of final expenditure and intermediate consumption is excluded from total expenditure to derive the expenditure on domestic output. It is therefore highly desirable that the deflation of imports and the imported components in the corresponding other expenditure categories be as consistent as possible, so as not to create inconsistencies that lead to errors in total GDP. For example, different deflation methods for imported capital equipment in capital formation and imports could generate differences in data that would affect GDP.

Price Indicators for Services

3.176 Price or volume indicators may be available for various types of exports and imports of services, although overall indices for international trade in services may not be available. The indicators for exports of services may be similar to that used to estimate value added by type of activity; however, in some cases, such as travel, new indicators may be required.

3.177 In some cases, the balance of payments compilers may have derived the current price estimates of selected items of services by reflating the volume indicators of exports and imports. Therefore, it is important to determine what methods were used in estimating trade in services.

3.178 In other cases, other price indices may be relevant. Hotels and transport components of the consumer price index may be relevant to travel service exports, while prices of hotels and transport in the main destination countries may be relevant to travel service imports (adjusted for exchange rate movements). Price indices and implicit price deflators from particular industries in GDP by the production approach (exports) or from the supplying country (imports) may be useful. In the case of FISIM, the deflated value of loans and deposits may be used, as discussed under the production approach.

GDP by Income Category

General Issues

3.179 The income approach is not as widely used as the two other approaches for estimating quarterly GDP, partly because the required data, which may be derived on an enterprise level, may not be readily available on a quarterly basis as the relevant financial records may only be compiled annually. In addition, income components do not have price and volume dimensions and GDP by the income approach may only be estimated at current prices. GDP by income category represents the items of the generation of income accounts; therefore, it is possible to present the accounts by institutional sector. The estimates according to the income approach comprise the components of compensation of employees, operating surplus, mixed income, and taxes less subsidies on production and imports.

3.180 Income data provide a useful perspective on the distribution of income from GDP: for example, looking at compensation of employees and operating surplus as a proportion of value added for the nonfinancial corporations sector. The income approach requires that, at a minimum, businesses have quarterly data on, depreciation, and net interest payable, so that the availability of data on business incomes determines whether independent quarterly income estimates are developed. The data could be particularly important in analyzing issues such as rates of return and profitability. The income approach is potentially useful as an alternative measure of GDP if the other approaches have serious data problems: for example, if IO ratios in production data are known to be changing rapidly with the business cycle.

3.181 Benchmark data for the income approach can be compiled in two ways. The income estimates can be compiled in the same way as value added in the production approach—that is, from goods and services produced less goods and services used—with the additional step of using expense data to split value added among compensation of employees, net taxes on production, and the residual, namely, operating surplus/mixed income. As for the production approach, getting this information is not usually feasible in a quarterly context. Alternatively, income estimates can be built up from the primary income components. This method is viable in some countries on a quarterly basis using profits, interest, and depreciation as indicators.

3.182 In the absence of an independent estimate of GDP from the income side, an income split can usually be derived with one category as a residual. Such data are as analytically useful as the full approach. Operating surplus/mixed income is always the residual in countries that use this method, because it is the most difficult component to measure.

Value Indicators

Compensation of Employees

3.183 Compensation of employees has two main components: (a) wages and salaries in cash or in kind and (b) social contributions payable by employers. The major indicators may be derived from the following sources:

- administrative data from income tax, payroll tax, or social security;
- business surveys of employment; and
- household income and expenditure surveys.

Where government regulates employment, clear definitions of employment and data are usually readily available. The data may refer to total compensation of employees paid or received, but an industry or institutional sector split may also be available.

3.184 Pension fund contributions and other social contributions paid by employers are also included in the definition of compensation of employees. However, pension payments received by households are not compensation of employees, although these payments may be recorded as such in cases where government accounts are compiled on a cash basis. Data on social insurance programs administered by the government may be readily available, but data are less likely to be available for private programs, where they would need to be collected by surveys or derived indirectly based on the information on wages and salaries.

3.185 Wages and salaries in kind cover goods and services provided to the employees without charge or at reduced prices. It also includes the value of interest foregone when employers provide loans to employees at reduced or zero interest rates, as well as employee stock options. In terms of goods and services, it may not always be possible to distinguish between wages and salaries in kind and intermediate consumption. Ideally, quarterly source data should also cover these items. If some items are not available, and especially if these items are small and stable, use of the available items to indicate the unavailable ones will be quite acceptable (i.e., an implicit ratio adjustment through benchmarking the quarterly data to annual data that include these items). However, the larger or more volatile they are, the stronger the case for collecting additional data to record them separately.

Operating Surplus

3.186 An indicator that approximates gross operating surplus can be derived by adding operating profits, net interest payable, and depreciation. These kinds of business accounting data can potentially be collected directly from businesses by surveys.

3.187 Profits data should be collected with definitions as close as practical to national accounts concepts. Operating profit in the business accounts is closer to the national accounts concept than some bottom-line profit measures, to the extent that it excludes one-off items such as capital gains, foreign exchange gains and losses, and insurance claims. It should also exclude income from the operation of other enterprises: that is, profits received as dividends from subsidiaries and holdings of shares. The *2008 SNA* does not consider provisions for bad debts as being transactions, so these should be added back. In a quarterly context, some adjustments may need to be made implicitly through benchmarking an incomplete quarterly indicator to the more comprehensive annual data. Business accounting measures of profits include the effect of price changes from inventories, which should be excluded in national accounts measures. (The adjustment would be the same as the corresponding adjustments made to the production and expenditure estimates: i.e., the inventory valuation adjustment.)

3.188 Net interest accrued and depreciation should also be added back to profits to get closer to gross operating surplus. It would, therefore, be worth collecting data on these items at the same time as profits, because the relationship of operating surplus to profits is likely to be much less stable than the relationship of operating surplus to profits plus net interest and depreciation. Expense data from detailed annual or benchmark surveys would allow the identification of other expenses that are not intermediate consumption, compensation of employees, or taxes on production. Similarly, detailed income data would allow the exclusion of any items that were not from production. If these factors are small and stable, an implicit ratio adjustment through the benchmarking process may be suitable. Otherwise, consideration may need to be given to collecting the data quarterly.

3.189 Large enterprises often calculate their incomes on a quarterly or even monthly basis, and publicly listed companies are often required to release quarterly or half-yearly information. Similarly, data may be available for government enterprises and market producers within general government. Privately held corporations and unincorporated enterprises may be less inclined to produce detailed quarterly accounts.

3.190 Many small enterprises do not have quarterly accounts, particularly in developing countries. In these cases, their operating surplus cannot be collected, but it may be derived by estimating their output, intermediate consumption, and compensation of employees. The same indicators used for estimating value added under the production approach could be used and estimates of their wages and net taxes on production deducted.

Mixed Income

3.191 Mixed income covers compensation of employees, consumption of fixed capital, and the return on investment in cases where these cannot be identified separately. Thus, mixed income would be recorded for unincorporated enterprises in the household sector that do not compile separate financial statements. Estimates of mixed income may be derived from household income surveys or other information on the sales and revenue of these unincorporated enterprises.

3.192 In the case of ownership of dwellings, the sources for estimating output and value added can be used with the addition of data on property taxes paid and compensation of employees. To the extent that the same indicators are used in the income and production approaches, they become less independent and more integrated.

Taxes and Subsidies on Products, Production, and Imports

3.193 Data on total taxes on imports, VATs, other taxes and subsidies on products, and other taxes and subsidies on production are usually available from a government finance statistics system. Although government finance statistics systems are generally among the most accurate and timely data sources, the data can suffer from problems of time of recording, as noted in paragraph 3.23. The quarterly GDP compiler may be able to adjust some of the cash-based data to approximate the accrual basis. In some cases, state, provincial, or local government data may not be available for the most recent quarters. If this is the case, it would be necessary to make estimates. For large components, the estimate should be based on actual data on trends in the tax base and changes in tax rates, while simpler methods could be used on small items.

Volume and Price Indicators

3.194 The income approach is oriented to current price data only because prices of some income components are not observable. It is possible to measure labor inputs in volume terms and make estimates of net taxes on products at base year rates, but there is no meaningful price or volume dimension to operating surplus/mixed income and other taxes on production.

3.195 A few countries derive GDP by the income approach in volume terms by deflating by the implicit price deflator for GDP from the production or expenditure-based estimates. Only if the income-based GDP figure differs from the other approach will this give a different GDP, and it will differ from the other approach by the same percentage as at current prices. This treatment is valid only for total GDP and is not valid for splits by type of income. Deflating income components by a generalized price index, such as the CPI or the implicit GDP deflator by the production/expenditure approaches, is a measure of purchasing power (called "real" income in the *2008 SNA*) that should not be confused with volume measures of product.

Summary of Key Recommendations

General Data Sources

- *Use indicators that most closely match the definition, classification, and coverage of the target variable. Indicators that apply past trends or measure a variable that is connected to the target variable only by a behavioral relationship or statistical correlation should be avoided.*
- *Incorporate new businesses in the survey as soon as they start, either by drawing supplementary samples of new businesses or redrawing the sample for the whole population.*
- *Distinguish deceased business units from nonresponding units. The contribution of deceased businesses to their industry should be recorded as nil; for nonresponding businesses, values should be estimated.*
- *Consider the accuracy and reliability of secondary variables against the primary objectives of the survey when deciding on the suitability of data sources. Survey design and sample selection is usually determined by the primary variables being covered in the survey, sometimes to the detriment of the other variables.*
- *Undertake adjustments or grossing-up procedures at a detailed level with stratification by dimensions that explain variations in the ratio between target variables and grossing-up factors.*
- *Monitor indicators closely so that changes in the structure of the economic activity could be identified in a timely manner.*

Price and Volume Measures

- *Avoid using unit value indices of imports and exports in quarterly GDP compilation. The use of these indices may result in volatility in the estimates because they measure value changes for a group of products. Therefore, the indices may capture the effects of quality changes (e.g., caused by changes in the product mix) as well as price changes.*
- *Compile volume estimates at the most detailed level possible. For example, deflate household consumption expenditure using the components of the CPI, rather than the overall CPI.*

Labor Input Measures

- *Use hours worked instead of the number of employees as a measure of labor input. Include unpaid work in actual hours worked but exclude paid hours for sick leave, vacations, and public holidays. The labor input measure should also include working proprietors and the self-employed as well as employees.*

Data for Commodity Flow Methods

- *Classify imports and domestic production consistently to ensure that goods are allocated to the respective end use (consumption, intermediate inputs, and capital goods) and to avoid double counting and over/under estimation. Estimates of goods used for construction/gross fixed capital formation should exclude consumption goods and raw materials that will be used in manufacturing.*
- *Adjust the supply of goods for inventory changes, where possible. If no adjustments are made, then the estimation process will imply that the goods are used as inputs, fixed capital formation, or final consumption as soon as they are supplied.*

Annex 3.1 QNA—Overview of Data Sources for Output and Intermediate Consumption by Type of Activity

ISIC Rev. 4			Current Price Data[a]	Data on Quantity of Output	Labor Inputs[b]	Other Indicators/Data Sources
Sec.	Div.	Description				
A	01–02	Agriculture and forestry	X	X		Population and household consumption.
	03	Fishing	X	X		Fishing permits, household consumption, and exports.
B	05–09	Mining and quarrying	X	X		Industrial production index, exports, mineral exploration permits, rents, and severance taxes.
C	10–33	Manufacturing	X	X		Industrial production index and exports.
D	35	Electricity, gas, steam, and air-conditioning supply	X	X		Number of new electricity connections, and fuel consumption (intermediate inputs) assumes a stable relationship between fuel inputs and outputs.
E	36–39	Water supply	X	X		Number of new water connections.
F	41–43	Construction	X	X		Sales of new homes, supply of building materials, building permits issued, and square feet/ meters of construction.
G	45–47	Wholesale and retail	X			Supply of goods for resale and imports of goods (excluding direct imports).
H	49–53	Transportation and storage	X			Passenger movements, freight handled (cargo loaded/ unloaded), aircraft landings, and ship calls to port.
I	55	Accommodation	X			Number of visitors and number of bed nights.
	56	Food services	X			Beverage sales and index of accommodation.
J	58–63	Information and communication	X	X		Number of call and data units, number of telephone and cable connections, advertising rates/ number of advertising slots, and minutes of calls.
K	64, 66	Financial services and auxiliary services	X			Loans and deposits, interest rates, number of transactions, number of ATM withdrawals, number of checks, number of cashier checks, and number of loans.

ISIC Rev. 4			Current Price Data[a]	Data on Quantity of Output	Labor Inputs[b]	Other Indicators/Data Sources
Sec.	Div.	Description				
K	65	Insurance and pensions	X			Number of insurance policies in force, deflated average stocks of reserves, number of pensioners, and deflated average stocks of pension liabilities.
L	68	Real-estate activities	X		X	Total (new and existing) home sales, commercial real-estate rentals, rental rates, and number of titles.
M	69–75	Professional, scientific, and technical services	X		X	Professional fee rates and number of divorces, cases, and deaths.
N	77-82	Administrative and support services	X		X	
O	84	Public administration and defence; compulsory social security	X		X	No. of employees No. of social security beneficiaries
P	85	Education	X		X	No. of students
Q	86-88	Human health and social work	X		X	No of hospital patients No. of hospital beds No. of appointments No. of surgeries
R	90-93	Arts, entertainment and recreation	X		X	No. of tickets to performing arts, theatres, events, parks.

[a] Current price data may be derived from surveys of units or administrative data sources.
[b] Labor inputs should be measured as hours worked (paid hours adjusted by paid time off and unpaid work). If hours worked are not available, then number of employees may be considered.

Bibliography

Alexander, T., C. Dziobek, M. Marini, E. Metreau, and M. Stanger (2017), *Measure Up: A Better Way to Calculate GDP*, IMF Staff Discussion Note 17/02, Washington, DC: IMF.

International Labor Organization, International Monetary Fund, Organization for Economic Co-operation and Development, United Nations, Economic Commission for Europe, and World Bank (2004), *Producer Price Index Manual: Theory and Practice*, Washington, DC: IMF.

International Labor Organization, International Monetary Fund, Organization for Economic Co-operation and Development, United Nations, Economic Commission for Europe, and World Bank (2009), *Export and Import Price Index Manual: Theory and Practice*, Washington, DC: IMF.

International Monetary Fund (2009), *Balance of Payments and International Investment Position Manual* (*BPM6*), Washington, DC: IMF.

International Monetary Fund (2014), *Balance of Payments and International Investment Position Compilation Guide*, Washington, DC: IMF.

International Monetary Fund, Organization for Economic Co-operation and Development, Statistical Office of the European Union, United Nations, World Tourism Organization, and World Trade Organization (2012), *Manual on Statistics of International Trade in Services, 2010*, New York: United Nations.

Interstate Statistical Committee of the Commonwealth of Independent States, International Labor Organization, International Monetary Fund, and Organization for Economic Co-operation and Development (2002), *Measuring the Non-Observed Economy: A Handbook*, Paris: OECD.

Organization for Economic Cooperation and Development (2006), *Compilation Manual for an Index of Service Production*, Paris: OECD.

Organization for Economic Cooperation and Development (2009), *Measuring Capital: OECD Manual, 2009*, Paris: OECD.

Organization for Economic Cooperation and Development (2010), *Handbook on Deriving Capital Measures of Intellectual Property Products*, Paris: OECD.

Statistics Canada (2003), *Statistics Canada Quality* Guidelines, Ottawa: Statistics Canada.

United Nations (2008), *International Standard Industrial Classification of All Economic Activities (ISIC) Rev.4*, Statistical Papers, Series M, No.4/Rev.4.

United Nations, European Commission, International Monetary Fund, and Organization for Economic Cooperation and Development (2008), *The System of National Accounts, 2008*, New York: United Nations.

United Nations (2010), *International Merchandise Trade Statistics: Concepts and Definitions 2010*, New York: United Nations.

4 Sources for Other Components of the 2008 SNA

This chapter presents an overview of the sequence of accounts and balance sheets of the 2008 SNA. It is designed to give the compiler of the quarterly gross domestic product (GDP) estimates a broad understanding of the national accounting framework and an appreciation of how GDP estimates fit into the broad national accounting framework. The chapter also highlights the main data sources that may be used to compile these accounts at the quarterly frequency. However, it does not present a detailed analysis of data sources and the relative suitability of these sources for compiling the sequence of accounts beyond the production account. A comprehensive discussion of data sources and methods for the other accounts and balance sheets components is beyond the scope of this manual.

Introduction

4.1 The *2008 SNA* presents a comprehensive sequence of accounts and balance sheets that record all flows (transactions, price changes, and volume changes) and stocks (opening and closing). These accounts are of considerable analytical interest and can also help compilers identify inconsistencies and errors in the data. Thus, as with the annual accounts, a quarterly national accounts (QNA) system should seek to cover more than GDP and its components, which captured in the production account.

4.2 The previous chapter presented the data sources or estimating GDP based on the three approaches. The expenditure and income approaches also provide the basis for estimating components of some of the other accounts of the *2008 SNA*, such as the income accounts and the capital accounts. For example, some of the components of GDP by expenditure categories are also reflected in the income accounts (household final expenditure in use of income account) and the capital accounts (gross capital formation) and the income approach to GDP provides data used in the income accounts.

4.3 There is increasing interest in these data, as major economic developments often originate in parts of the economy other than goods and services. For example, some economies are driven to a large degree by remittances or aid, while other volume changes and revaluations can be major economic developments in some periods. Financial markets have been found to have major effects on the whole economy and have generated contagion that affects the whole economy. Thus, many countries now compile an increasing range of these types of data, and they have been incorporated in the IMF's Special Data Dissemination Standard Plus and the Inter-Agency Group's Data Gaps Initiative.

General Issues

4.4 The general issues associated with identifying and evaluating data sources discussed in Chapter 3 also apply to the other accounts in the sequence of accounts. As with data used in estimating GDP components, quarterly indicators for other national accounts variables often have shortcomings that need to be addressed.

4.5 QNA could be expanded to include the full sequence of accounts and balance sheets, not only for the total economy, but also on a sectoral basis and on a three-dimensional sector by sector basis (usually referred to as a from-whom-to-whom basis). However, ultimately, the choice and level of detail will depend on user priorities, the availability of indicators, and the stage of development of QNA in the country. The choice will also be influenced by the range of accounts published annually. Data for items beyond GDP and its components may not be included in the initial stage of QNA development and may have lower priority and accuracy than the quarterly GDP measures, but they should not be ignored, especially in the plans for future improvements.

4.6 The sequence of accounts can be presented in gross or net terms: that is, with or without deducting consumption of fixed capital. For simplicity, the following discussion refers to gross measures, but quarterly consumption fixed capital can be obtained. Annual estimates of capital consumption that follow *2008 SNA* concepts are usually derived by the perpetual inventory method (PIM); in the same way, quarterly estimates could be derived by enhancing the PIM calculations with a quarterly dimension.

4.7 Often, countries considering expanded quarterly accounts will already have done so on an annual basis, so have familiarity with the sources and methods. With the key role of balance of payments and financial statistics in this work, the annual techniques will be able to be applied quarterly.

Institutional Arrangements

4.8 One critical issue in compiling the sequence of accounts by institutional sector is the decision on which agency—between the national statistics agency and the central bank—should be responsible for the exercise. The national statistics agency is usually responsible for compiling estimates of GDP and related aggregates, whereas the central bank often compiles the financial statistics. Based on this traditional arrangement, the statistical agency may compile the current accounts (including the capital accounts and nonfinancial assets) and the central bank may compile the financial accounts and financial balance sheets. However, in deciding on the responsible agency, some basic factors should be considered. These include the following:

a. *The legal framework:* The compilers should determine which agency has the legal authority to compile the statistics or to collect source data from the relevant institutional units. The central bank may have authority to collect data from a limited number of financial units, but may not have the authority to collect data from nonfinancial units. On the other hand, the national statistics agency may be governed by a statistics law that allows it to collect data from all resident entities.

b. *Available resources:* Whereas the statistics agency may have the authority to collect the data, it may not have the resources to do so or to expand the compilation process beyond the estimates of GDP and related aggregates. Therefore, the central bank may assume the responsibility for compiling financial accounts and balance sheets, as a start.

c. *Needs and uses:* The central bank may already be compiling limited sectoral accounts for the financial sector for internal or external use. Therefore, expanding the exercise to cover the financial accounts may not require a significant increase in resources.

4.9 Many countries may therefore adopt a "special approach" to compiling the full sequence of sectoral accounts and balance sheets with the central bank focusing on the financial accounts and balance sheets and the statistics agency focusing on the current accounts. This arrangement requires regular coordination between the two units to ensure that the institutional units are classified consistently and that the same data sources are used, where feasible. Such coordination should serve to minimize the differences between net lending/net borrowing in the capital accounts and net lending/net borrowing in the financial accounts. In theory, these two aggregates should be the same but are never so in practice because of differences in data (e.g., timing, coverage, and definitions), missing data, and errors in compilation. When the agencies cooperate effectively, they can then investigate and explain—and eventually resolve—some of the causes of the discrepancies between the two aggregates. An effective tool to identify problems in the source data is by analyzing these discrepancies.

Identifying Data Sources

4.10 Compiling the sectoral sequence of accounts requires a vast amount of data. Therefore, in considering a compilation process, the compiler may first wish to determine what data are currently available and how these data could be used, before deciding on launching new data collection initiatives. Existing data sources may include financial/regulatory data (e.g., banking statistics and securities statistics), other administrative data, existing surveys, and statistics from macroeconomic frameworks (balance of payments and international investment position [IIP] statistics, government finance statistics, and monetary and financial statistics). The compiler should also establish a data availability matrix. For each transaction/instrument and sector, this matrix should show the available data sources, including the mirror data (or counterparty data) and data for cross-checks. If there are multiple sources, then these sources should be ranked in terms of their accuracy and reliability, against their timeliness. For example, the compiler may decide to use timely but less accurate data for the first set of estimates and use the more accurate but less timely data for the revisions. The next step is then to identify the data gaps and how they may be addressed. Factors such as the cost of data collection and the timeliness of the data should be considered carefully when attempting to fill data gaps. The compiler should also consider possible estimation techniques to address the data gaps, in the absence of suitable source data.

Accounts for the Total Economy

Main Aggregates for the Total Economy

4.11 The sequence of accounts for the total economy includes important balancing items such as gross national income (GNI), gross disposable income, saving, and net lending/net borrowing. The sequence of accounts for the total economy can be compiled at an early stage in the development of QNA if quarterly GDP by type of expenditure and quarterly balance of payments are available.

4.12 National accounting systems usually work "down" the sequence of accounts starting with the balance on the production accounts (i.e., value added on a sectoral basis and GDP for the total economy), and then deriving balancing items for the income and capital accounts. In some cases, financial accounts data may be available and it may be possible to compile the financial accounts and net lending/net borrowing. Because many of the data sources for transactions among residents have an institutional sector perspective, compilation of accounts for the total economy also contributes to some institutional sector data.

4.13 The production and income accounts constitute the current accounts of the system. The capital accounts, financial accounts, and other changes in assets accounts constitute the accumulation accounts.

Current Accounts

Production Account

4.14 The production account in gross terms shows output at basic prices as resources and intermediate consumption at purchasers' prices as uses. The balancing item for the institutional sector is value added, and when taxes less subsides on products are added, the balancing item for the total economy is GDP. In addition to the presentation of the production account and a fuller presentation of the production process, the explicit calculation of output and intermediate consumption is recommended as good compilation practice for reconciling data with other sources and revealing the implications of assumptions.

Income Accounts

4.15 The *2008 SNA* presents a sequence of income accounts that show the following:

a. how income is generated by institutional sectors,

b. how income is allocated among institutional sectors and the rest of the world,

c. how income is redistributed as current transfers among institutional sectors and the rest of the world, and

d. how disposable income is allocated by households, government units, and nonprofit institutions serving households (NPISHs) between final consumption and saving.

The accounts are discussed separately. In addition to the specific issues for each account, there are some general issues that are relevant to the QNA and apply to more than one of the income accounts.

4.16 Timing issues become particularly significant for some quarterly income account items. Incomes may be paid in lumps, rather than evenly through the year. Examples of payments that be made in lump sums include dividends, interest, taxes, and employee bonuses. The basic accounting principle of the *2008 SNA* is the use of accrual accounting. Thus, the transaction should be recorded when the claim arises rather than when the amount was paid. As noted in Chapter 3, time of recording also plays a role in the annual national accounts, but the effect is more pronounced in the QNA.

4.17 To address these timing issues, it is useful to identify two categories of payments based on their relationship to previous periods:

a. Payments that have a purely ad hoc character are recorded in the period in which they are made. Dividends, for example, are usually determined only after the books are closed on a fiscal year and may not even relate to the company's profits over that year.

b. Payments that have a fixed relation to a given period (e.g., accrued in a previous period or accrued over several accounting periods) should be allocated to the periods in which they accrued.

4.18 Examples are taxes on incomes and products that may be collected in a subsequent period and vacation bonuses that build up over the period of a year and on which employees have a claim if they leave the employment before payment is due. To obtain accrual-based data, the options may include surveys of enterprises—if businesses use accrual principles—allocating data on payments back to the relevant periods, or estimating the accrual of income from data on the underlying flow (e.g., income taxes from wages and profits, possibly subject to a lag). Once these issues are considered on a quarterly basis, the compiler may also realize that the annual data need to be adjusted to meet accrual principles.

4.19 Applying accrual principles to quarterly data in such cases may present such serious practical and conceptual problems that it becomes an obstacle to completing the estimates. In these cases, it may be better to publish data on a cash basis while clearly stating the problems than to publish nothing or publish estimates that have been subject to adjustments without a credible explanation or basis.

Generation of Income Account

4.20 The generation of income account shows the derivation of operating surplus/mixed income as GDP less the sum of compensation of employees and taxes less subsidies on production and on imports. This account shows the identity that underlies the calculation of GDP by the income approach. Accordingly, the required data would have already been compiled if the income approach is being used or an income split has been compiled with operating surplus/mixed income as a residual.

Allocation of Primary Income Account

4.21 The allocation of primary income account shows the derivation of national income. Primary incomes include compensation of employees property income (interest, dividends, etc.). The distributive income transactions paid between residents cancel out for the whole economy. Thus, GNI can be derived simply as GDP plus primary income receivable from the rest of the world less primary income payable to the rest of the world. The external primary income items can be obtained from the balance of payments and are usually derived from surveys of enterprises or banking records.

4.22 The allocation of primary income account requires estimates of property income paid by residents to other residents. Some of the components may be available as by-products of the system of financial regulation or financial sector surveys. Dividends could be estimated from a survey of businesses or from published statements of companies listed on the stock exchange. Alternatively, a model could be developed, such from (lagged) estimates of operating surplus. Dividend behavior depends on national circumstances such as company law, business practices, and tax law. The predictability of this behavior can be assessed from past annual patterns. Seasonal patterns within the year may be unknown without extra information but present fewer serious problems for analysis.

Secondary Distribution of Income Account

4.23 The secondary distribution of income account shows the derivation of disposable income from national income by considering redistribution of income through taxes, social security contributions and benefits, and other transfers. Statistics on transfers paid by governments are usually available from government finance statistics. Other items include nonlife insurance premiums and claims, which may be available from regulators or may be estimated based on distributed annual values if they are accrued evenly throughout the year. International aid, social contributions and benefits to governments of other countries, and other current transfers to and from the rest of the world can be obtained from the balance of payments.

Use of Disposable Income Account

4.24 The use of disposable income account shows disposable income as a resource. It shows the final consumption of household, NPISHs, and government as uses. Disposable income is obtained from the secondary distribution of income account, while consumption is derived as part of the expenditure approach to measuring GDP. The balancing item is saving, which has considerable analytical interest.

Accumulation Accounts

Capital Account

4.25 The capital account shows how the saving (derived as a balance from the use of disposable income accounts) plus capital transfers are available to finance capital formation and consumption of fixed capital with net lending/net borrowing as the balancing item. Saving is obtained from the use of disposable income account, while capital formation is obtained as was shown under the expenditure approach to GDP. Capital transfers payable or receivable by government can be obtained from the government finance statistics. Capital transfers between residents and nonresidents can be obtained from the balance of payments. The balance is net lending/net borrowing. The net lending/net borrowing for the total economy is equivalent to the balance of the current and capital accounts in the balance of payments.

Financial Account

4.26 The financial account shows changes due to transactions in financial assets and liabilities. These are classified by type of instrument. Data on stocks of financial assets or liabilities by counterpart sectors are often readily available from the financial corporations as a by-product of regulation or monitoring of the financial sector. Financial corporations tend to be relatively large and have sophisticated records, making collection of data financial stocks practical and feasible. In contrast, collecting data on the counterparts to these transactions (e.g. non-financial corporations, government, households) may not be feasible because they may be too numerous, small, and with less sophisticated record-keeping. In addition, a high proportion of financial transactions involve a financial intermediary as one of the parties.

4.27 Data on transactions may not always be available and the difference between opening and closing balance sheet positions is sometimes used as proxy. However, this estimation process is not appropriate. In addition to changes due to transactions, the difference between opening and closing values also includes revaluation and other changes in volumes of assets. Therefore, estimates for transactions as the difference between opening and closing balance sheet positions is misleading and not reconcilable with the information from the current accounts. Further, data on revaluations and other volume changes are analytically useful and should be presented separately in the relevant accounts (see sections on *Other Changes in Assets Accounts* and *Revaluation Account*).

4.28 Other sources may be available to check or complement data from the financial corporations. Data on government financial transactions can often be obtained directly. The financial account of the balance of payments records transactions with nonresidents. It is important that consistent classifications and valuations be used in all these sources. If all are consistently defined, the government and external transactions with the financial sector can be reconciled. Also, the transactions not involving the financial sector can be obtained to complete the totals. The data will also support the simultaneous development of the accounts by institutional sector.

4.29 Information on financing through equity and investment fund shares can be more difficult to obtain. This financing may originate from non-financial entities, and thus data may be less accessible. For listed companies, data may be available from stock-exchange registers. In other cases, company registration requirements include issue of equity. In still other cases, surveys would be necessary. The securities by securities databases in some countries may have data on issuance of debt and equity securities, and may have information on holders.

4.30 The balancing item on the financial account is net lending/net borrowing. The net lending/net borrowing in the financial account is conceptually the same as in the capital account. In practice, if the measure is derived independently, it could differ significantly because of compilation errors and missing data.

Other Changes in Assets Account

4.31 These accounts record changes in the value of assets and liabilities between the opening and closing balance sheets that result from flows other than transactions (other flows). They record two broad types of changes as follows:

a. changes relating to holding gains or losses are recorded in the revaluation account and

b. all other changes are considered changes in volume and are recorded in the "other changes in the volume of assets accounts."

Other Changes in the Volume Assets Account

4.32 This account in turn has three functions as follows:

a. It records the economic appearances and disappearances of assets.

b. It records exceptional, unanticipated events that affect the economic benefits that could be derived from the assets.

c. It records changes in classifications of institutional units and the structure of the assets held by institutional units.

The Revaluation Account

4.33 This account records nominal holding gains, which can then be decomposed into neutral holding gains and real holding gains. A nominal holding gain that is negative is a holding loss. The calculation of holding gains and losses requires records of the assets acquired and disposed of during the period, and the prices at which they were acquired and disposed. The prices of the assets at the beginning of the period are also required. This implies that suitable price indices would need to be developed for the various groups of assets. This type of information may be available for some financial assets, such as listed shares; however, it is more limited for nonfinancial assets, although price indexes for residential and commercial property are available in some countries and have been given priority in the Inter-agency Group's Data Gaps Initiative and the IMF's Financial Soundness Indicators. For other nonfinancial assets, the same deflators used for the relevant part of capital formation can be used for the stock.

Balance Sheets

4.34 The balance sheets show the opening and closing values of assets and liabilities. The difference between the opening and closing values in the balance sheets is explained by transactions, revaluations, and other changes. The transactions are shown in the capital accounts for nonfinancial assets and financial accounts for financial assets. The revaluations could be obtained separately or residually. The financial assets and liabilities part of the balance sheets use similar sources as, and should be compatible with, the transactions data shown in the financial accounts. The IIP is the balance of payments equivalent of the national accounts balance sheets for the financial assets and liabilities.

4.35 Estimates for nonfinancial assets are derived by methods similar to those used annually. For inventories, the same source as for changes in inventories can provide either inventory or an estimate of the change in the levels since the previous estimate of the level. For land, the basic volume is fixed or changes only slowly. For fixed capital, these estimates tend to be based on calculations with the PIM. The same issues arise for estimates of consumption of fixed capital. The calculations could be made quarterly, or, alternatively, they could be made as interpolations from the annual values. The stability of capital is typically strongest in volume terms, while asset prices can be volatile. Thus, current price measures should preferably be derived from the volume measures for each component if there are price indices available for each of the major asset types (e.g., land, buildings, and various categories of equipment).

4.36 The collection of balance sheet data is more subject to problems in valuation than transaction data. Because some stock data in business accounts are valued at historic costs rather than current values, adjustments may be needed (though they will require assumptions about the composition). It is a good practice to obtain information on valuation methods at the same time the value data are collected.

4.37 Balance sheet data are useful in measuring productivity (using capital input) and analyzing spending and saving decisions (through wealth effects). Thus, policy analysts and researchers have shown increasing interest in these data.

Accounts by Institutional Sector

Overview

4.38 The institutional sector accounts could be introduced simultaneously or, more commonly, be gradually developed in several stages. Accounts for the general government and the financial corporations sectors may be introduced first because of the availability of source data, the analytical usefulness of the statistics, and the desirability to have the data in a national accounting framework that would allow these sectors to be linked to the rest of the economy. On the other end of the spectrum, the households and NPISHs sectors are usually more difficult to obtain. Therefore, these sectors could initially be combined and calculated as a residual. The *2008 SNA* framework is a powerful tool for gap filling because of the comprehensive view of relationships and consistent counterparty recording.

4.39 Financial accounts may be easier to implement than the current and capital accounts, because data on transactions and stocks of financial assets or liabilities by counterpart sectors are often available readily from the financial corporations as a by-product of regulation or monitoring of the financial sector. Data compilers often find the usefulness of institutional sector accounts is not appreciated until after the data become available, so statistical compilers should anticipate future uses. For some institutional sectors, income accounts may be developed before capital accounts because of lack of data on transactions in secondhand assets.

4.40 Box 4.1 presents the sequence in matrix form, similar to Tables 2.13 and 2.14 in the *2008 SNA*. The tabulation emphasizes the interrelationships between sectors. It is intended for presentational purposes and should not be taken as a recommended main presentation of the data for a QNA publication for two reasons: (i) because it would be expected in practice that some accounts and sectors would initially be missing and (ii) because the QNA usually emphasize time series, the main presentation should be time-series oriented.

4.41 A basic principle of compiling institutional sector accounts is making use of counterparty information: that is, in any transaction involving two parties, information can be collected from the party from which it can be most efficiently collected. For instance, data on interest payable by government to households can be obtained from one or a relatively small number of government agencies, rather than a large number of households. Counterparty information is the equivalent of using commodity balances in the goods and services and production accounts to fill gaps. Counterparty information becomes particularly important in a quarterly context when there are more likely to be gaps. One issue to be considered is that data providers may not always be able to provide data on the institutional classification of the counterparts if they do not have sufficient information or motivation to do so.

4.42 The use of counterparty information also provides the foundation for from-whom-to-whom presentation. This presentation is very suitable for showing linkages between different parts of the economy, as well as the potential for contagion.[1]

4.43 If the production accounts are based on surveys of businesses and other units, the derivation of production by institutional sector is practical. All that is required is that the institutional sector of the unit be identified in the relevant survey. Some of the less direct methods, however, may not provide any institutional sector splits.

4.44 The income approach to GDP is a foundation for the income accounts by institutional sector. The availability of data on GDP by income component and institutional sector provides the primary income accounts to be completed by institutional sector. Thus, countries that compile quarterly estimates of GDP using the income approach typically have better-developed quarterly accounts by institutional sector.

4.45 Estimates of capital formation by institutional sector are practical if the data are collected from the purchaser rather than the supplier of the capital. These estimates are an important component of the capital accounts. For institutional sector data, it is necessary to cover the secondhand assets; while for the total economy, transactions in existing assets largely cancel out (except for transactions with nonresidents, which can be obtained from trade and balance of payments

[1] An example of a from-whom-to-whom matrix is shown in Tables 8.11-8.15 of the handbook on "*Financial Production, Flows and Stocks in the System of National Accounts*" (United Nations and European Central Bank, 2014).

Box 4.1 Sequence of Accounts and Balance Sheets in the *2008 SNA*

Uses				Transactions and balancing items	Resources			
Total economy	Rest of the world	Goods and services	Total		Total economy	Rest of the world	Goods and services	Total
		499	499	Imports of goods and services		499		499
	540		540	Exports of goods and services			540	540
				Production account				
		3604	3604	Output	3604			3604
1883			1883	Intermediate consumption			1883	1883
		141	141	Taxes on products	141			141
		–8	–8	Subsidies on products (-)	–8			–8
1854			1854	Value added, gross / Gross domestic product				
222			222	Consumption of fixed capital				
				Generation of income account				
				Value added, gross / Gross domestic product	1854			1854
1150			1150	Compensation of employees				
235			235	Taxes on production and imports				
–44			–44	Subsidies				
452			452	Operating surplus, gross				
61			61	Mixed income, gross				
				Allocation of primary income account				
				Operating surplus, gross	452			452
				Mixed income, gross	61			61
	6		6	Compensation of employees	1154	2		1156
			0	Taxes on production and imports	235			235
			0	Subsidies	–44			–44
391	44		435	Property income	397	38		435
1864			1864	Balance of primary incomes, gross / National income, gross				
				Secondary distribution of income account				
				Balance of primary incomes, gross / National income, gross	1864			1864
1212	17		1229	Current transfers	1174	55		1229
212	1		213	Current taxes on income, wealth, etc.	213	0		213
333	0		333	Net social contributions	333	0		333
384	0		384	Social benefits other than social transfers in kind	384	0		384
283	16		299	Other current transfers	244	55		299
1826			1826	Disposable income, gross				
				Use of disposable income account				
				Disposable income, gross	1826			1826
1399			1399	Final consumption expenditure			1399	1399
11	0		11	Adjustment for the change in pension entitlements	11	0		11
427			427	Saving, gross				
				Capital account				
414			414	Gross capital formation			414	414
376			376	Gross fixed capital formation			376	376
–222			–222	Consumption of fixed capital			–222	–222
				Gross fixed capital formation by type of asset				
28			28	Changes in inventories			28	28
10			10	Acquisitions less disposals of valuables			10	10

Box 4.1 Sequence of Accounts and Balance Sheets in the *2008 SNA* (continued)

Uses				Transactions and balancing items	Resources			
Total economy	Rest of the world	Goods and services	Total		Total economy	Rest of the world	Goods and services	Total
0			0	Acquisitions less disposals of non-produced assets			0	0
				Capital transfers, receivable	62	4		66
				Capital transfers, payable	–65	–1		–66
10	–10		0	*Net lending (+) / net borrowing (–)*				
				Financial account				
				Net lending (+) / net borrowing (–)	10	–10		0
436	47		483	Net acquisition of liabilities	426	57		483
				Other changes in the volume of assets account				
13			13	Total other changes in volume	3			3
–7			–7	Produced non–financial assets				
17			17	Non–produced non–financial assets				
3			3	Financial assets	3			3
				Revaluation account (holding gains/losses)				
280			280	Non–financial assets				
84	7		91	Financial assets/liabilities	76	15		91
				Opening balance sheet				
4621			4621	Non–financial assets				
8231	805		9036	Financial assets/liabilities	7762	1274		9036
				Net worth	5090	–469		4621
				Total changes in assets and liabilities				
482			482	Non–financial assets				
523	54		577	Financial assets/liabilities				
				Changes in net worth, total	500	–18		482
				Saving and capital transfers	202	–10		192
				Other changes in volume of assets	10			10
				Holding gains/losses	288	–8		280
				Closing balance sheet				
5103			5103	Non–financial assets				
8754	859		9613	Financial assets/liabilities	8267	1346		9613
				Net worth	5590	–487		5103

statistics, and sales of used vehicles from businesses and governments to households). The same considerations apply to the stocks of nonfinancial assets for balance sheets. Similar to the stocks for the whole economy, they are likely to be stable in aggregate, although transactions in secondhand assets may be a more significant issue.

4.46 The financial accounts and the financial components of the balance sheets are usually among the more complete institutional sector data. Balance sheet data are often already collected from financial corporations. If the counterparts in each transaction, asset, or liability are classified by institutional sectors, there is a strong basis for compiling the data for all the sectors, not only the financial corporations themselves. In addition, balance of payments and IIP data would show transactions, assets, and liabilities between nonresidents and residents that are not financial corporations. One should also pay attention to financial transactions and stocks of assets and liabilities not included in financial sector and balance of payments data, such as household equity in corporations and direct financial relationships between nonfinancial corporations.

4.47 If the accounts are derived independently, net lending/net borrowing for both the capital and financial accounts will act as checks on each other. Alternatively, if only one account is available, the balancing item can be used as a starting point for compiling the other. Of course, although the relationship between the balancing items on the two accounts is a conceptual identity, the balancing item is a small residual of several large items and could turn out to be of poor quality if there are problems in any of the component series.

Nonfinancial Corporations

4.48 A direct survey of corporations would provide the necessary data, but such surveys may not be available on a quarterly basis. Data may be available for nonfinancial corporations because of the lodgment of information under company legislation. Alternatively, companies listed on the stock exchange or corporations may be required to disseminate quarterly or half-yearly data, and these companies may constitute a significant or representative proportion of the nonfinancial corporations sector. It would be necessary to investigate from annual data whether the other nonfinancial corporations behaved in the same way as the unobserved ones.

4.49 If such direct sources are unavailable, data for nonfinancial corporations may be obtained from counterpart transactions with the other sectors or as a residual. Dividends play a large part in the income accounts for nonfinancial corporations. Taxes and dividends are often not determined on a quarterly basis: for example, dividends may be payable twice a year and profits tax four times a year based on the previous year's earnings.

Financial Corporations

4.50 There is often a wide range of data obtained as a by-product of regulation of the financial corporations sector. As mentioned in the context of financial assets and liabilities, this sector is usually relatively good in terms of the availability of administrative by-product data and ability to provide survey data.

4.51 The monetary and financial statistics are a key source of information for the accounts of financial corporations. The data used to complete the "standardized report forms" used in reporting to the IMF are an important input into the financial accounts. They include extensive detail by financial instrument and by counterparty institutional sector. Some countries may also compile securities databases and this information could be used across various sectors to measure transactions and levels in debt securities.

General Government

4.52 Quarterly data may be readily available for the central government. However, in some cases, complete accounts for the general government may be available with some delay because of difficulties in compiling data for the various levels of state and local government. Government accounting data may be limited to the transactions accounts as the availability of data on government balance sheets may not be as widely available. In addition, issues of timing may be a problem in countries where the government accounts are on a cash basis, because timing issues are more significant in quarterly data (as indicated in Chapter 3). If the IMF's *Government Finance Statistics Manual 2014* (GFSM 2014) is followed to compile and present the government finance statistics, then the data could be used to compile the accounts for the general government. Like the standardized report forms for the financial sector, government finance statistics also provide standard tabulations with detail by instrument and counterparty sector.

4.53 Quarterly government accounting data that do not follow national accounts principles may already be available in some countries. Analysts may already use these data to meet many needs. It is worthwhile, however, to also produce the national accounts presentation of government, as it adds value by facilitating analysis of links between government and other parts of the economy and requires relatively little extra compilation cost.

Households

4.54 Households are key drivers of economic activity and there is likely to be keen interest in the household saving ratio. Some countries may conduct continuous household surveys that could provide some statistics for the accounts of the household sector. As mentioned in Chapter 3 in the discussion of sources for household consumption, household surveys may suffer from level biases; but for QNA purposes, the data are suitable indicators of movement if the bias is consistent.

4.55 Alternatively, many of the items for the household accounts can be derived from counterpart data: for example, compensation of employees from employers and other income and financial instruments from financial corporations and government. Resident households receive almost all the compensation of employees, mixed income, and social benefits payable by resident sectors. Pensions and annuities are also specific to households, and data are often available from pension providers or are likely to be relatively stable from one quarter to the next. Interest receivable and payable by households could be available separately from financial corporations, or it could be estimated from data on household deposits and loans if those assets and liabilities are identified separately by the financial corporations. The remaining major income component is dividends. The timing and data issues for dividends were discussed in the context of accounts for the total economy. It may be possible to estimate dividends receivable by households based on lagged estimates of operating surplus of corporations and (in some cases) property income receivable from the balance of payments, if they show a stable relationship with the corresponding household income items in annual data.

4.56 For the uses of income, a range of indicators is usually already available. Household final consumption is derived as part of the expenditure approach to GDP and relates entirely to the household sector. Social contributions are obtainable from government accounts and are also specialized to households. Taxes have varying degrees of specificity to households. Interest and insurance premiums payable by households can be obtained or estimated in similar ways to the corresponding income items discussed in the previous paragraph.

4.57 A capital formation survey covering businesses may be designed to produce gross capital formation by institutional sector by identifying the institutional sector of each business in the survey. If all the above items were obtained, it would be possible to derive income and capital accounts for households, and, hence, the analytically important household saving and net lending balancing items.

4.58 Financial corporations may also provide information on household borrowing and household assets in the form of deposits. In some countries, financial corporations may be required to provide separate information on mortgage loans to households and other consumer credit. This counterparty information could be used to compile data for the household sector.

Nonprofit Institutions Serving Households

4.59 The NPISHs sector often receives little attention in the annual accounts and is not always economically volatile enough to justify high priority in quarterly data, although the activities of NPISHs may be quite important in some countries. The *2008 SNA* defines the NPISHs sector more narrowly than the normal use of the term nonprofit may suggest. This sector covers nonprofit institutions that meet two key additional criteria:

a. They provide goods and services to households free or at prices that are not economically significant.

b. They are not controlled by government.

4.60 Government transfers from the rest of the world may be major contributions to the disposable income of NPISHs. When that is the case, such indicators would be available from counterparts through government accounts or the balance of payments, respectively. A household expenditure survey could provide data on transfer from households, such as donations in cash and in kind. In some countries, regulation of charities, trade unions, or political parties may provide data. If the NPISHs sector is economically significant, as it is in some countries, surveys of the institutions themselves would be necessary. Although undesirable for analytical purposes, the NPISHs sector is sometimes combined with the household sector in quarterly data.

Rest of the World

4.61 Balance of payments and IIP statistics provide the data required for the rest of the world accounts. The rest of the world accounts are from the perspective of the nonresidents, whereas the balance of payments and IIP statistics are from the perspective of the reporting country. Therefore, they are mirror images of each other and the signs are reversed. If the reporting country compiles balance of payments and IIP statistics on a quarterly basis, then there is no need to compile separate quarterly accounts for the rest of the world. Like the standardized report forms for the financial sector, the standard components of the sixth edition of the IMF's *Balance of Payments and International Investment Position Manual* (BPM6) also provide tabulations with detail by instrument and counterparty sector. However, these data use a functional classification (separately identifying direct investment portfolio investment, other investment, financial derivatives, and reserve assets) as the highest in the classification hierarchy, while instrument and counterparty sector detail are the next level down in the classification system, so some rearrangement is needed.

Bibliography

United Nations and European Central Bank (2014), *Financial Production, Flows and Stocks in the System of National Accounts*, New York: United Nations.

United Nations, European Commission, International Monetary Fund, and Organization for Economic Cooperation and Development (2008), *The System of National Accounts, 2008*, New York: United Nations.

5 Specific QNA Compilation Issues

The compilation of quarterly accounts generates specific compilation issues due to the quarterly frequency of the source data. This chapter provides guidance on how they should be addressed to provide accurate measurement of short-term macroeconomic developments.

Introduction

5.1 The compilation of quarterly accounts requires specific techniques and estimation methods to process, transform, and integrate quarterly source data within the System of National Accounts (SNA) framework. Typically, sub-annual data are derived from a small sample of the population they are influenced by seasonal effects, and they are subject to short-term volatility or atypical events. Quarterly data may require specific treatment to be usable for national accounts purposes. Specific compilation issues may arise at all compilation levels of the quarterly national accounts (QNA) and should be resolved by the compiling agency. Users should receive QNA data that are as ready for economic analysis as possible. Compilers should not expect users to make their own adjustments, because this would generate confusion between alternative estimates and reduce the serviceability of the official QNA data. Compilers usually have considerable information to perform adjustment to quarterly data. However, some treatment may require skills and competence beyond the pure knowledge of national accounts methodology.

5.2 In the next chapters, the manual covers three specific methods of the QNA: benchmarking, seasonal adjustment, and chain-linking techniques for quarterly series. Benchmarking is needed to incorporate the comprehensive annual information into the quarterly estimates, ensuring that quarterly and annual data are temporally consistent. The aim of seasonal adjustment in the QNA is to allow for a short-term analysis of trends and turning points in the economy. Finally, specific quarterly techniques should be used to chain-link quarterly series with a shifting base year.

5.3 This chapter provides guidance on other specific issues that typically arise when compiling the quarterly accounts. First, a few considerations are provided on when to implement, or possibly deviate from, a full-accrual principle in the QNA. Next, good-quality estimates of seasonal effects in the QNA are required to provide an accurate measurement of seasonal fluctuations in the economy. Finally, the chapter gives advice on how to perform backcasting exercises to produce long and continuous QNA series when major revisions in the national accounts are conducted.

Time of Recording Issues

5.4 The general time of recording principle in the SNA is the accrual basis. This principle applies to both annual and quarterly accounts. Under the accrual principle, flows are recorded at the time economic value is created, transformed, exchanged, transferred, or extinguished. Accrual accounting is in full agreement with the way economic activities and other flows are defined in the SNA. For example, the accrual principle implies that intermediate consumption of a good or service is recorded at the time when the good or service is used in the production process, and not at the time it is acquired by the producer. It also implies that output is recorded at the time the production process takes place, and not at the time the final product is sold or withdrawn from inventories.

5.5 The application of accrual principles may present specific practical and conceptual problems for quarterly flows. These situations typically arise when monthly or quarterly statistics record flows referring to economic events that accrue to periods longer (or shorter) than a calendar month or quarter. For example, wage arrears may be recorded in a particular month although they accrue to a number of past payroll periods. The accrual recording is more complicated when there is a significant delay between the reporting period and the full-accrual event, which may give rise to long and hard-to-justify revision processes of quarterly estimates.

5.6 In order to deal with timing issues, it is useful to identify two categories of transactions based on their relationship to previous periods:

- Transactions that have a purely ad hoc character should be recorded in the period in which they are actually declared payable. Dividends, for example, are usually determined only after the books are closed on a fiscal year and may not even relate to the company's profits over that year. Another case is a discretionary bonus payment that cannot be linked to a particular period.
- Transactions that have a fixed relation to a particular period (e.g., accrued in a previous period or accrued over a number of accounting periods) should be allocated to the periods in which they accrued. Examples are taxes on incomes and products that may be collected in a subsequent period and vacation bonuses that build up over the period of a year and on which employees have a claim if they leave the employment before payment is due. To obtain accrual-based data, the options may include surveys of enterprises—if businesses use accrual principles—allocating data on payments back to the relevant periods or estimating the accrual of income from data on the underlying flow (e.g., income taxes from wages and profits, possibly subject to a lag). Another option is to use indicators of seasonal activity or other appropriate indicators to allocate annual totals. Once these issues are considered on a quarterly basis, the compiler may also realize that the annual data need to be adjusted to meet accrual principles.

5.7 Compilers should be aware that a pure accrual recording in the QNA can generate inconsistencies between transactions of the accounts that are linked by economic relationships. A typical example is the payment of an extra salary at the end of the year (usually called the 13th salary). Employees who worked all the 12 months are entitled to receive the full payment. The accrued part of the 13th salary should be recorded as compensation of employees throughout the year (in equal parts or in proportion of the monthly paychecks received), whereas the accrual adjustment should be recorded in the other accounts receivable or payable. However, this recording may create a timing difference between income and consumption patterns, and consequently, a measurement error in the saving rate. A peak in household consumption generally occurs in the month when the 13th salary is disbursed (e.g., for purchases of gifts during a holiday period). This consumption should be accrued to the month when it occurs, and not allocated to previous periods—in contrast with the extra salary that paid for it. Inconsistencies may also appear when the accrual principle is not applied symmetrically to both parties of a transaction or when it is not applied uniformly in the quarterly and annual accounts.

5.8 Uncertainty in the amount to be allocated is another element that may complicate the compilation of quarterly data on an accrual basis. For example, the amount of a tax that is paid at the end of the year may not be known at the beginning of the year. If the government introduces a tax reform during the year, there could be a significant difference between the estimated amount and the true amount. This problem does not arise usually in the annual accounts, where the true amount of tax is recorded once annually. An exception is when the tax is paid in the subsequent year (e.g., income tax), which requires an accrual distribution to the previous year in the annual accounts. Similar uncertainty exists in the allocation of expected crops output based on the work-in-progress principle (see Chapter 11 for details).

5.9 The lack of accrual data should never be an obstacle for the compilation of QNA. Some flexibility in the application of accrual principles is permitted, especially in the initial steps of a new QNA system. Its implementation in the QNA is likely to be more complex than in the annual national accounts (ANA) and may require additional estimates. Compilers may decide to use the recording basis of the data sources received, without making complex and dubious transformations to satisfy the accrual principle. Alternative recording principles identified in the *2008 SNA* are the following: (i) cash basis, with flows recorded when cash is received or disbursed; (ii) commitment basis, with flows recorded when an institutional unit commits itself to a transaction; and (iii) due-for-payment basis, with flows recorded at the time cash payments can be paid without incurring additional charges or penalties. If QNA compilers choose to deviate from the accrual principle, they should clearly state the reasons of this deviation and how the adopted principle influences the evolution of QNA estimates. This information should be given in the national accounts metadata.

5.10 Another issue related to time of recording arises when reported data do not coincide with calendar periods. For example, enterprise data may be reported for four- or five-week intervals or government data may be available for the fiscal year. In these cases, the QNA can play an important role in moving estimates in a fiscal year to their calendar year of reference (and vice versa).

Seasonal Effects

5.11 QNA series should display seasonal variations when they measure economic flows that are influenced by weather conditions, administrative reasons, or other recurrent within-a-year patterns. Annual accounts variables, in contrast, do not contain seasonal patterns because the seasonal movements disappear when the quarterly data are aggregated into annual data. The presence of seasonal effects brings additional conceptual and compilation issues that are specific to the QNA. Some of these issues are briefly discussed in this section.

5.12 As noted in the introduction to this manual, seasonal effects in the QNA disturb the identification of turning points in the business cycle. For this reason, it is common practice for QNA compilers to produce seasonally adjusted data based on well-established seasonal adjustment procedures (which are discussed in Chapter 7). Seasonally adjusted data combine the long-term trend, the business-cycle movements, and the irregular effects in the series, excluding seasonal and calendar effects.

5.13 However, there is also an interest from users in analyzing seasonal effects of the QNA variables. Seasonality of macroeconomic variables can offer an illustrative view on how economic activity is distributed across the quarters. Unadjusted data can also be useful in econometric models to exploit the information contained in the seasonal component of the series in modeling the dynamic relationship among the variables. In the context of QNA compilation, unadjusted series may be better suited for balancing purposes when the seasonal component is significant. Clearly, to be relevant for users the unadjusted QNA data should reflect true underlying seasonal patterns in the economy. Sometimes compilers tend to care less about the quality of seasonal effects, as their main focus in the dissemination of QNA is on year-on-year rates or quarter-to-quarter rates from seasonally adjusted data.

5.14 Seasonal effects in the QNA are important for two reasons. First, unadjusted data observe the true behavior of macroeconomic variables. Indicators of economic activity are normally received in unadjusted form, as a measurement of what is happening in the economy. It would be a waste of information if the seasonal effects from these indicators were removed in the seasonal adjustment process, and not used to produce unadjusted QNA. Many users prefer to work with unadjusted data and possibly apply seasonal adjustment procedures by themselves. Second, seasonal adjustment procedures require that seasonal effects are stable and consistent for the entire length of the unadjusted series. Seasonal adjustment procedures do not produce accurate results when the seasonal component has an unstable and fast-evolving pattern or when it shows breaks in the seasonal pattern. Clearly, the unadjusted data should contain such effects if they reflect the reality. Structural changes in the seasonal patterns can be handled by seasonal adjustment procedures. However, compilers should avoid that implausible or artificial seasonal effects are treated as true signal and passed on as such to the seasonal adjustment phase.

5.15 The seasonal pattern of QNA series should be checked and validated. Before applying seasonal adjustment; one quick way to validate the seasonal effects is to look at the quarter-to-quarter rates of change of unadjusted QNA series (or their corresponding indicators). These changes can be tabulated or plotted in a chart to appreciate the regularity and magnitude of the seasonal component. Another convenient way to look at the stability of seasonal effects is to plot the level (or the rate of change) of each quarter over time in four separate graphs (see Figure 7.3 for an example). The four lines, which should not present seasonal movements, should highlight how stable each quarter is throughout the years. It may also be useful to compare the seasonal effects of indicators with the seasonal effects of QNA series, so that compilers can verify that the observed seasonal pattern is fully transmitted to the QNA variables. After seasonal adjustment, a common method to validate the seasonal component is to calculate and plot the ratio between the unadjusted series and the seasonally adjusted series (the so-called seasonal factors).

5.16 In the assessment of seasonality, compilers should pay particular attention to possible breaks in the seasonal pattern. Sudden breaks in the seasonal pattern can arise due to administrative and economic reasons. Possible examples are when the government introduces changes in the national calendar of public holidays or when corporations decide to change their production plans in response to booms and recessions phases. When these breaks are noted, it is necessary to investigate the causes behind these breaks and understand whether these events are temporary or permanent (which may influence their treatment in the seasonal adjustment procedure). The news in the media may offer an explanation for important events, otherwise it may be necessary to request clarifications from data providers. When breaks in the data are visible in the main QNA aggregates such as the gross domestic product (GDP), an explanation of the break should be given in the press release notes and included in the QNA metadata.

5.17 A further element to consider in the compilation of unadjusted QNA data is to verify that the seasonality in the indicator is representative of the seasonality in the QNA series. Quarterly indicators may fail to reproduce the true seasonal effects of QNA series (which are unknown), even when they are good at reproducing their short- and long-term changes. Typically, this happens when the indicator covers just a subset of a much broader concept measured in the national accounts, which may be influenced by different seasonal effects. An example of this type is when an indicator of tourist arrivals in hotels, which usually presents strong seasonal variation, is used to estimate the output of accommodation services as a whole, whose fluctuations are more evenly spread out across the year. When the seasonal pattern in the indicator is not considered adequate, compilers should make adjustments to the seasonal pattern of the QNA variable. Seasonal effects from other related indicators or ad hoc assumptions on the quarterly pattern of the QNA underlying concept should be used to make these adjustments.

5.18 Seasonal movements of related variables of the accounts should be coherent. It is expected that seasonal peaks and troughs are consistent in the supply and use components of the same product. These checks are promptly available when supply and use tables (SUT) are available on a quarterly basis: discrepancies between supply components (output and imports) and use components (consumption, capital formation, and exports) can be calculated for each quarter in an automated manner (see the supply and use model presented in Chapter 9). A seasonal pattern in this discrepancy may signal the need for a better integration of QNA indicators. When quarterly SUT are not available, a validation should be performed by cross-checking the seasonal effects of related QNA variables (e.g., by using a simple commodity flow model). In some situations, deviations between seasonal effects of related variables may be caused by different patterns in the decisions of economic agents. For example, production and consumption of motor vehicles may peak at different quarters. In such case, a deviation between production and consumption seasonal patterns may be justified by a concurrent change in the seasonal pattern of inventories.

5.19 Finally, consistency in seasonality should also be preserved between price, volume, and value components of the same QNA variable. Price changes are often nonseasonal, but they can show seasonal movements for products with specific price changes that occur repeatedly at the same time of the year (e.g., tuition fees, rents, harvests, and tourism activities). Normally, seasonal changes in the QNA are observed in value and volume indicators. When the price index is implicit, the value and volume indicators should show a consistent seasonal pattern. At a minimum, they should show peaks and troughs in the same quarters of the year. However, there are cases when the value component is strongly seasonal, while the volume component is not (or vice versa). For example, the output at current prices of nonmarket services (e.g., health or education) may show a pronounced seasonality, while the output in volume shows a fairly flat level during the year.[1] This situation may occur if the output at current prices is estimated using an indicator of wages and other current expenses (which

[1] However, the volume estimate of nonmarket output may show strong seasonal effects when the volume measure is done using hours worked.

contain seasonal effects), while the output at constant prices is based on employment indicators or measures of outcome (which are generally less influenced by seasonal fluctuations).

Backcasting

5.20 A major strength of the national accounts is to offer long and consistent time series, which are a necessary ingredient for short-term economic modeling and forecasting. QNA data should be comparable over time to provide accurate measurements of short- and long-term economic changes. In theory, new concepts and methodologies of national accounts should be carried as far backward as possible to avoid breaks in the QNA series. In practice, this task is complex because the data to compile backward periods under new principles may not be available or new classifications may simply not be applicable to previous periods. Consequently, it may not be possible to recalculate back series following the same methodology used for current periods.

5.21 The term "backcasting" (or "back-calculation") indicates all the steps undertaken to reconstruct backward data using current measurement standards. The objective is to provide the user with long and consistent time series. In the national accounts, a backcasting exercise is typically required at the time of a major revision for introducing methodological changes, new accounting standards, new classifications, new benchmark years or base years, or new data sources. These revisions may lead to breaks in the time series when they cannot be applied for the entire length of the national accounts. These breaks can hamper the comparability between observations in the pre- and post-revision periods. Backcasting can also refer to specific items of the accounts, when there is a need to revise the specific methodology for those components.

5.22 A backcasting exercise should be conducted in a coordinated manner for both annual and quarterly accounts. The same principles of backcasting should apply for both annual and quarterly accounts. However, in some situations, it may not be possible to use the same approach for the quarterly data. For example, data sources for back periods may only be available at the annual level. In addition, the QNA are often compiled using a different, simplified framework than the one used for the ANA. Whatever approach is used, QNA and ANA should be consistent in any backward period. The benchmarking methods presented in Chapter 6 can be used to realign quarterly data to annual benchmarks that are back-calculated independently.

5.23 There are two backcasting approaches in QNA compilation: (i) the micro approach and (ii) the macro approach. The micro approach aims at recompiling the QNA variables starting from the source data at the elementary level of detail. The micro approach guarantees the most accurate results as the micro data are processed and aggregated using the new concepts, principles, and definitions. However, it may not be feasible to rerun the entire compilation process with available resources and time constraints. The micro approach is the best approach in the annual accounts, as these usually determine the levels of national accounts variables. In the QNA, instead, an exact reconstruction of the levels may not be essential when the same calculations are done in the ANA. The main purpose of the QNA is to provide a measurement of short-term changes in the economy, which may be reconstructed without recurring to complex and tedious calculations at the micro-level.

5.24 Opposite to the micro approach, the macro approach aims at backcasting at more aggregate levels. The macro approach comprises statistical techniques and estimation methods that make a greater use of assumptions about how new concepts and principles apply to the past. These methods can make use of previously published QNA series, indicator series, or intermediate series calculated in the various steps of the QNA compilation process. Results may differ according to the aggregation level of the data; compilers should choose the preferred detail level taking into account the complexity of the backcasting exercise and the quality of the recalculations. Ideally, backcasting methods should be applied at the most detailed level of the GDP compilation. It is also preferable to start from the original quarterly indicator series instead of previously published QNA data. In practice, countries should adopt a mix of methods that best suit the specific circumstances and needs of their particular backcasting exercise.

5.25 Splicing (or linking) is the simplest and most common backcasting method. Splicing can be used to link the new series with the old published national accounts series. The only requirement is to have an overlap between the old and new series for at least a period. The old and new series should measure as much as possible the same concept. Backward data are obtained by multiplying the values of the old series by the ratio between new and old levels in the overlap period. In the case of quarterly series, the overlap period can be either the first quarter or the first year in the new series. In the former case, the new series will show the same quarter-to-quarter rates of change of the old series in the backward period. The underlying assumption is that the impact of the changes in the overlap period remains the same in the backcasting period. With an annual splicing, the adjustment ratio is taken from the whole year; in this case, the spliced series will preserve the old annual rate for the overlap year. The two splicing techniques are shown in Example 5.1.

5.26 Quarterly splicing is the preferred approach as it provides the smoothest transition between the old and new series. However, compilers should be aware that quarterly splicing may introduce a break in the seasonal pattern if the new series presents seasonal effects that are different from those in the old series. Annual splicing could be preferable when there is a need to preserve the annual movements in the overlap period.

5.27 Another splicing possibility is to link gradually the old series to the new series. This approach aims at interpolating the new level of the series with a particular point in time of the backcasting period (one year or one quarter). The rates of change in the in-between periods will change accordingly. This method can be appropriate when a particular level in the old series should be preserved. This situation could arise when it is required to maintain levels of national accounts variables that had been estimated from previous benchmark revisions. A possible method to obtain a graduated splicing is explained in Example 5.2.

5.28 More sophisticated estimation methods may be required when the assumptions underlying basic splicing techniques do not hold. For example, a more elaborated backcasting solution should be devised when there is an update of classifications. In such cases, assuming that the new series present the same movements of the old series may lead to incorrect results. New classifications bring items that did not exist before, or may change the way previous items were aggregated in top-level groups. Furthermore, an additional constraint for pure classification changes is that the total should not change. Bridge tables between old and new classifications should be created to help reconstruct old indicators according to a new classification. One way to reconstruct short-term dynamics of new items in past periods is to estimate regression models between QNA series and proxy indicators

Example 5.1 Basic Splicing Techniques

	QNA Series		Spliced QNA Series	
	New	Old	Quarterly Splicing	Annual Splicing
Quarter	(1)	(2)	(3)	(4)
q1 2010		885.7	1,080.9	1,129.7
q2 2010		862.7	1,052.8	1,100.4
q3 2010		696.6	850.1	888.5
q4 2010		845.3	1,031.6	1,078.2
q1 2011		907.0	1,106.9	1,156.9
q2 2011		963.6	1,176.0	1,229.1
q3 2011		798.8	974.9	1,018.9
q4 2011		900.8	1,099.3	1,149.0
q1 2012	1,189.4	974.6	1,189.4	1,189.4
q2 2012	1,242.5	1,037.3	1,242.5	1,242.5
q3 2012	1,178.3	876.1	1,178.3	1,178.3
q4 2012	1,318.4	976.0	1,318.4	1,318.4
q1 2013	1,370.1	1,155.4	1,370.1	1,370.1
q2 2013	1,388.9	1,171.7	1,388.9	1,388.9
q3 2013	1,279.5	989.0	1,279.5	1,279.5
q4 2013	1,402.9	1,090.5	1,402.9	1,402.9

Basic Splicing Techniques

Example 5.1 presents two alternative splicing techniques for quarterly series. The quarterly splicing is the preferred method in most cases. The annual splicing can be used when there is a need to preserve the annual movements in the old series.

- **Quarterly Splicing** (column 3). The splice point is the first overlapping quarter for the two series, which is the first quarter of 2012 in this example. The splice factor is the ratio between the new value and the old value for q1 2012 $\Rightarrow$ 1,189.4/974.6 = 1.2204.
  The backward series is obtained by multiplying the values of the old indicators and the splice factor: q4 2011 $\Rightarrow$ 900.8 $\cdot$ 1.2204 = 1,099.3 and so forth.
- **Annual Splicing** (column 4). The splice point is the first overlapping year. The splice factor is calculated for 2012 as the ratio between the new annual value and the old annual value for 2012: 2012 $\Rightarrow$ (1,189.4 + 1,242.5 + 1,178.3 + 1,318.4) / (974.6 + 1,037.3 + 876.1 + 976) = 1.2755
  The backward series is obtained by multiplying the values of the old indicators and the annual splice factor: q4 2011 $\Rightarrow$ 900.8 $\cdot$ 1.2755 = 1,149.0 and so forth.

Example 5.2 Graduated Splicing

	QNA Series		Graduated Spliced QNA Series	
	New	Old	Step 1	Step 2
	(1)	(2)	(3)	(4)
2010		3,290.3	3,290.3	
2011		3,570.2	3,891.0	
2012		3,864.0	4,601.3	
2013	5,441.3	4,406.6	5,441.3	
2014	5,753.3	4,668.5	5,753.3	
q1 2010		885.7		867.8
q2 2010		862.7		852.6
q3 2010		696.6		700.2
q4 2010		845.3		869.7
q1 2011		907.0		962.0
q2 2011		963.6		1,045.8
q3 2011		798.8		880.5
q4 2011		900.8		1,002.7
q1 2012		974.6		1,088.4
q2 2012		1,037.3		1,147.3
q3 2012		876.1		1,104.5
q4 2012		976.0		1,261.1
q1 2013	1,370.1	1,155.4		1,345.0
q2 2013	1,388.9	1,171.7		1,387.7
q3 2013	1,279.5	989.0		1,290.5
q4 2013	1,402.9	1,090.5		1,418.1
q1 2014	1,409.2	1,242.3		1,416.4
q2 2014	1,447.8	1,236.8		1,448.9
q3 2014	1,383.8	1,046.9		1,380.8
q4 2014	1,512.6	1,142.5		1,507.1

Graduated Splicing Technique

The graduated splicing technique can offer a convenient approach for linking a new benchmark level to an old one.

Example 5.2 shows a possible way to recalculate a QNA series for the period 2010–2012 maintaining the level of the 2010 benchmark year. In the first step (column 3), the annual data for 2011 and 2012 are reconstructed using the following equations:

$$2011 \Rightarrow \left(\frac{5{,}441.3}{3{,}290.3}\right)^{1/3} \cdot 3{,}290 = 3{,}8919.0$$

$$2012 \Rightarrow \left(\frac{5{,}441.3}{3{,}290.3}\right)^{2/3} \cdot 3{,}290 = 4{,}601.3$$

The 2011 and 2012 data are reconstructed by extrapolating the 2010 benchmark level using a variable adjustment factor: the ratio between the 2013 benchmark level (5,441.3) and the 2010 benchmark level (3,290.3) raised to the power of $\frac{t}{3}$, where t is the number of years from 2010.

It should be noted that this interpolation method reconstructs the annual levels between two benchmark years assuming a constant annual rate of change in the backcast period. In fact, the rate of change for 2011–2013 remains constant in this example:

$$2011/2010 \Rightarrow \left(\frac{3{,}891.0}{3{,}290.3} - 1\right) = 18.3\%$$

$$2012/2011 \Rightarrow \left(\frac{4{,}601.3}{3{,}891.0} - 1\right) = 18.3\%$$

$$2013/2012 \Rightarrow \left(\frac{5{,}441.3}{4{,}601.3} - 1\right) = 18.3\%$$

In the second step, the quarterly spliced series obtained in Example 5.1 is benchmarked to the annual series (3) using the Denton proportional benchmarking method illustrated in Chapter 6. The new QNA series in (4) maintains the two benchmark levels of 2010 and 2013, and preserves at the best the quarterly movements of the original quarterly spliced series.

This approach produces a much faster growth in the period 2010–2012 than the old series. When this method is used, compilers should verify that revisions in the trend between benchmark periods accurately describe the true developments in the economy and are not generated by a pure statistical construct.

for those items. For example, the output of a newly classified economic activity can be related to employment or wage data from affine activities. The regression model can include lags of the variables and other auxiliary information. This approach should be used with caution as these methods rely on behavioral relationships between national accounts variables and related information that may not hold for the entire time period.

5.29 In the backcasting exercise, compilers of QNA should be mindful of preserving consistency with the annual accounts and within the quarterly accounts. Benchmarking methods should be used to realign backcast QNA series with the counterpart series of the annual accounts. To maintain consistency across the accounts, it may be chosen to derive one item of the accounts as a residual component. Alternatively, back-calculated QNA series can be made consistent across time and space using reconciliation methods that align the series with both temporal and cross-sectional constraints. Benchmarking and reconciliation methods are presented in Chapter 6.

5.30 One problem of consistency that may arise from the application of backcasting techniques at all levels of compilation is the lack of additivity between components and aggregates. Backcasting at detailed level has the advantage of preserving the original information for each series. However, it will show discrepancies between components and aggregates. This problem can be solved if these techniques are applied at the component level only, while the aggregate is derived as the sum of the reconstructed components. A disadvantage of this approach is that the aggregate rates of change will differ from the original ones, which may lead to confusion and criticisms from the user. The choice will also depend on the types of revision introduced. If there is a change in classifications, components that are not affected by the classification change should be preserved. When new methods are introduced, the aggregate changes should not be preserved. Generally speaking, compilers should implement a backcasting solution that preserves as much as possible the consistency property of national accounts and, at the same time, minimizes the changes in the economic history of a country.

5.31 QNA series should always be recalculated as far back as the annual accounts. However, it may not be possible to reconstruct the entire QNA series at the time of a major revision of national accounts when all the resources are focused on developing the new benchmark estimates. In such cases, the reconstruction of QNA series should take place as soon as possible after the completion of the revision. Short QNA series can be accepted by users for a limited time if there is a clear plan on when the backward series will be communicated. Users may question the capability of a compiling agency if it takes a long time to release long QNA series. In case of delays, other institutions or individuals may decide to compile their own "unofficial" recalculations of QNA series. This would add confusion in the user and pressure on the compiling agency. The best approach is that sufficiently long QNA series are reconstructed and published by the compiling agency when a benchmark revision on national accounts is released.

5.32 Backcasting exercises have resource implications that need to be considered at a very preliminary stage. A great deal of work is required to recalculate the QNA series and to validate the consistency and coherence of the results. When national accounts managers consider pros and cons of alternative backcasting techniques, they should have in mind how much time will be required to achieve the expected results. Simplified approaches should be preferred over more sophisticated methods when the gain in quality is relatively small. When the cost is too high, it may be decided that old QNA series are not reconstructed or are reconstructed starting from a later period. When the old QNA database is left in the public domain, the metadata should clearly describe the differences with the new database and warn users of potential breaks in comparing the two sets of series.

5.33 Backcasting of the QNA should be planned as an integral part of major revisions of national accounts. All the steps of a backcasting exercise should be decided well in advance, and not left for future implementation after the release of a revision. Decisions should be taken on the coverage of backcasting: namely, how far back the series should be recalculated and at what level of detail. Furthermore, the different kinds of revisions should be identified and properly accounted for in the backcasting methods used. Sufficient time should be allocated to analyze and validate the results of backcasting before the new series are released to the public. Compilers should detect all the changes in the pattern of main QNA aggregates and connect them to one or more specific sources of revisions due to changes in data sources, statistical methods, or compilation practices. Compilers should also ensure that all these changes are economically plausible. Finally, the publication date of back-calculated QNA series should be scheduled in the advance release calendar. Users should be informed in advance if the length of QNA series will be shorter than in the previous estimates.

5.34 The results of a backcasting exercise should be validated and carefully assessed before publication. A comparison between old and new QNA series is essential for assessing the impact of the revision on historical data (see Chapter 12 for details on revisions analysis). Large deviations from previous quarterly movements should be explained and accounted for, especially for the GDP and other macroeconomic aggregates. In particular, compilers should check that the timing of turning points in the quarterly GDP is broadly maintained. In general, the QNA team should be able to address any possible queries from users about the revised short-term developments of the main QNA aggregates.

5.35 Consultations with stakeholders and other major users of the QNA should be held during the various steps of the backcasting exercise. At an early stage, it is advisable to reach out to key users such as the central bank and the ministry of finance when the most important decisions of backcasting are taken. These preliminary meetings can be useful to get informal views from users on how to conduct the backcasting exercise and how to communicate the results. Before the official release, the compiling agency can organize internal seminars for broad groups of users to present the backcasting methodology and show some key results. Finally, the publication of revised QNA series should be accompanied with detailed metadata describing the different approaches used in the recalculation. Revisions studies should also be published at the time of release (using the methodology presented in Chapter 12). Particular attention should be given to the changes in the quarterly and annual movements of the GDP and the main production and expenditure components.

Summary of Key Recommendations

- *Although the general time of recording principle in the SNA is the accrual basis, the application of accrual principles may present specific practical and conceptual problems for quarterly flows. Some flexibility in the application of accrual principles in the QNA may be necessary when this may generate incoherent patterns in related QNA variables and increase uncertainty in the preliminary estimates.*
- *Seasonal effects in the QNA should be estimated accurately. Seasonality of macroeconomic variables can offer an illustrative view on how economic activity is distributed across the quarters. Stability in the seasonal pattern is also a requirement for seasonal adjustment procedures.*
- *Backcasting techniques should be used to produce long and consistent QNA series when a benchmark revision on national accounts is conducted. QNA should preferably be recalculated as far back as the annual accounts. All the steps of a backcasting exercise should be decided well in advance as an integral part of major revisions of national accounts.*

6 Benchmarking and Reconciliation

Benchmarking methods in the national accounts are used to derive quarterly series that are consistent with their corresponding annual benchmarks and, at the same time, preserve the short-term movements of quarterly economic indicators. Similarly, reconciliation methods may be necessary to adjust quarterly series that are subject to both annual and quarterly aggregation constraints. This chapter presents benchmarking and reconciliation methods that are considered suitable for quarterly national accounts (QNA) compilation. Practical guidance is also provided to address and resolve specific issues arising from the application of these methods in the national accounts.

Introduction

6.1 Benchmarking deals with the problem of combining a series of high-frequency data (e.g., quarterly data) with a series of low-frequency data (e.g., annual data) for the same variable into a consistent time series. The two series may show different levels and movements, and need to be made temporally consistent. Because low-frequency data are usually more comprehensive and accurate than high-frequency ones, the high-frequency series is benchmarked to the low-frequency data.

6.2 This chapter discusses the use of benchmarking to derive QNA estimates that are consistent with annual national accounts (ANA) estimates. Annual estimates derived from the ANA system provide benchmark values for the QNA estimates. Usually, quarterly data sources rely on a more limited set of information than annual data. For this reason, quarterly data may present nonnegligible differences in levels and movements with respect to annual data. Consequently, the annual data provide the most reliable information on the overall level and long-term movements for the national accounts variable, while the quarterly source data provide the only available explicit information about the short-term movements in the series. Benchmarking is a necessary step to combine the quarterly pattern in the indicator with the annual benchmarks of the ANA variable.

6.3 Benchmarking techniques help improve the quality of QNA series by making them consistent with ANA benchmarks and coherent with the short-term evolution of quarterly economic indicators. However, the accuracy of QNA data ultimately depends on the accuracy of the annual benchmarks and quarterly indicators. A prerequisite of quality for the QNA data is to rely on information that measures precisely what is happening in the economy, both in normal times and during periods of sudden and unexpected changes. The role of benchmarking is to combine in the best possible way the annual and quarterly information at disposal.

6.4 While quarterly-to-annual benchmarking is the most relevant case in QNA compilation, benchmarking can also be conducted to adjust national accounts data available at other frequencies. For example, a monthly activity indicator can be benchmarked to a quarterly gross domestic product (GDP) series (monthly-to-quarterly benchmarking). Benchmarking can also be useful for ANA data, when preliminary annual accounts need to be adjusted to meet comprehensive benchmark revisions of national accounts available every five or ten years. Even though this chapter is focused on the quarterly-to-annual benchmarking, principles and methods outlined here apply to benchmarking of any other high-frequency to low-frequency data.

6.5 For some variables, quarterly data sources are used directly to derive the annual data of the ANA system. In this situation, annual totals automatically meet their quarterly counterparts and the benchmarking step is unnecessary. This happens, for instance, when annual data are derived from the aggregation of monthly or quarterly information that is not subject to future revisions. In a few cases, quarterly data may be superior and so may be used to replace the annual data. One instance is annual deflators that are best built up from quarterly data as the ratio between the annual sums of the quarterly current and constant price data (as explained in Chapter 8). Another example is when annual data are derived using nonstandard accounting practices. More generally, annual data should be quality assured prior to any benchmarking. Compilers should not adjust good-quality quarterly data to lower-quality annual data. However, such cases are infrequent and the standard practice in the QNA is to use quarterly data as indicators to break down more comprehensive and accurate annual figures.

Objectives of Benchmarking

6.6 In the QNA, benchmarking serves two purposes:

- quarterly distribution (or interpolation)[1] of annual data to construct time series of benchmarked QNA estimates ("back series") and
- quarterly extrapolation to derive the QNA estimates for quarters for which ANA benchmarks are not yet available ("forward series").

6.7 Ideally, both distribution and extrapolation of QNA series must be based on quarterly indicators that are statistically and economically correlated to the annual variables considered.[2] The term "indicator" is adopted in a broad sense in this context. It indicates either a sub-annual measurement of the same target variable or a proxy variable that closely approximates the (unknown) quarterly behavior of the target variable. An example in the first group is the quarterly value of merchandise imports (or exports) from foreign trade statistics as a short-term approximation of imports (exports) of goods at current prices in the ANA; in the second group, the quarterly industrial production index could be used as a proxy of the volume measure of the annual gross value added of manufacturing. When such indicators are absent, it is advisable to look at other indicators that are closely related to the concept measured by the variable to be estimated or consider the movements of related QNA aggregates. Application of mathematical procedures to distribute annual totals into quarters without the use of related quarterly indicators should be minimized (see paragraphs 6.75–77 for further details on when this approach can be considered feasible). To be relevant for the user, short-term movements of the QNA should closely reflect what is happening in the economy.

6.8 The format and level of the indicators should not influence the benchmarking results of the QNA.[3] In the benchmarking framework, the objective is to combine the quarterly movements of the indicator with the annual levels of the ANA variables. The quarterly indicator may be in the form of index numbers (value, volume, or price) with a reference period that may differ from the base period in the QNA, may be expressed in physical units, may be expressed in monetary terms, or may be derived in nominal terms as the product of a price index and a volume index. The indicator serves only to determine the quarterly movements in the estimates (or quarter-to-quarter change), while the annual data determine the overall level and long-term trend. However, the annual movements of the indicator are used to assess whether the indicator is a good approximation of the annual movements of the ANA target variable. Therefore, the annual relationship between the ANA variable and the quarterly indicator directly affects the preservation of movements and the accuracy of extrapolation.

6.9 In this chapter, quarterly distribution and extrapolation are unified into one common benchmark-to-indicator (BI) ratio framework for converting quarterly indicator series into QNA variables. The relationship between the annual data and the quarterly indicator can be assessed by looking at the movements of the annual BI ratio: namely, the ratio of the annual benchmark to the sum of the four quarters of the indicator. In mathematical terms, the annual BI ratio can be expressed as follows:

$$\frac{A_n}{\bar{I}_n} \quad \text{for } n = 1, \ldots, y \tag{1}$$

[1] Distribution is associated with flow series, when the annual series is calculated as the sum (or the average) of the quarterly data. Interpolation usually applies to stock series, when quarterly series needs to match the annual value in a specified time of the year (e.g., January 1st). As this manual focuses on quarterly GDP, which is a flow series, the term "quarterly distribution" will be used in the chapter to indicate quarterly-to-annual benchmarking.

[2] More details on the selection process of indicators are given in Chapter 5.

[3] For this reason, benchmarking methods should produce results that are invariant to level difference in the same indicator. The proportional benchmarking methods discussed in this chapter satisfy this requirement.

where

A_n is the ANA target variable for a generic year n;

$\bar{I}_n$ is the annual sum of the quarterly observations of the indicator for the same year n, that is, $\bar{I}_n = \sum_{t=4n-3}^{4n} I_t$; and

y is the time index of the last available year.[4]

When the BI ratio changes over time, it signals different patterns between the indicator and the annual data; instead, a constant annual BI ratio means that the two variables present the same rates of change.[5] As a result, movements in the annual BI ratio (equation (1)) can help identify the quality of the indicator series in tracking the movements of the ANA variable over the years. The benchmarking methods considered in this chapter distribute and extrapolate the annual BI ratio on a quarterly basis.

6.10 In the QNA, the main objectives of benchmarking are the following:

- to estimate quarterly data that are temporally consistent with the ANA data: that is, to ensure that the sum (or the average) of the quarterly data is equal to the annual benchmark;
- to preserve as much as possible the quarterly movements in the indicator under the restrictions provided by the ANA data; and
- to ensure, for forward series, that the sum of the four quarters of the current year is as close as possible to the unknown future ANA data.

6.11 The ideal benchmarking method for QNA should be able to meet all three objectives. Quarterly movements in the indicator need to be preserved because they provide the only available explicit information on a quarterly basis that are deemed to approximate the unknown quarterly pattern of QNA series. This strict association with the indicator series applies to both the back series and the forward series. In addition, the forward series should be as close as possible to the annual benchmark when it becomes available. These two requirements, however, might be at odds: in some cases, quarterly extrapolation should deviate from the quarterly movements in the original indicator in order to obtain better estimate of the ANA variable for the next year.

6.12 Benchmarking can also be useful to identify and correct distortions in the national accounts compilation, and reduce revisions in the preliminary estimates of QNA. Bad-quality results of benchmarking can highlight inconsistencies between quarterly and annual sources as soon as they happen. The use of benchmarking methods could help identify areas of research to improve the consistency between annual and quarterly accounts data. In seasonal adjustment, benchmarking can detect when seasonally adjusted results drift away from unadjusted data (see Chapter 8).

Overview of Benchmarking Methods

6.13 The pro rata method, which is a simple method of benchmarking, should be avoided. The pro rata method distributes the temporal discrepancies—the differences between the annual sums of the quarterly estimates and the annual data—in proportion to the value of the indicator in the four quarters of each year. The next section shows that the pro rata approach produces unacceptable discontinuities from one year to the next (the so-called step problem) and therefore does not preserve the movements in the indicator from the fourth quarter of one year to the first quarter of the next. Techniques that introduce breaks in the time series seriously hamper the usefulness of QNA by distorting economic developments and possible turning points. They also thwart forecasting and constitute a serious impediment for seasonal adjustment and trend analysis.

6.14 To avoid the step problem, proportional benchmarking methods with movement preservation of indicators should be used to derive QNA series. The preferred solution is the proportional Denton method. The proportional Denton method keeps the quarterly BI ratio as stable as possible subject to the restrictions provided by the annual data. Paragraph 6.31 shows that minimizing the movements of the quarterly BI ratio correspond to preserving very closely the quarterly growth rates of the indicator.

6.15 In extrapolation, the proportional Denton method may yield inaccurate results when the most

[4] In this chapter, index n denotes the years and index t denotes the quarters. The quarterly index of the four quarters of a generic year n are identified by $4n - 3$ (first quarter), $4n - 2$ (second quarter), $4n - 1$ (third quarter), and $4n$ (fourth quarter). As an example, $t = 1, 2, 3, 4$ for the first year ($n = 1$).

[5] When the BI ratio is constant, any level difference between the annual sum of the indicator and the annual data can be removed by simply multiplying the indicator series by the constant BI ratio.

recent annual BI ratios deviate from the historical BI average. This happens when the annual movement in the indicator diverges from the annual movement in the ANA variable for the most recent years. This problem can be circumvented using an enhancement for extrapolation to the proportional Denton technique. The enhanced version provides a convenient way of adjusting for a temporary bias[6] and still maximally preserving the short-term movements in the source data. However, the enhanced solution requires an explicit forecast of the next annual BI ratio to be provided by the user.

6.16 As an alternative to the Denton method, the proportional Cholette–Dagum method with first-order autoregressive (AR) error can be used to obtain extrapolations adjusted for the historical bias.[7] This method is derived as a particular case of the more general Cholette–Dagum regression-based benchmarking model (illustrated in Annex 6.1). As shown in paragraph 6.56, under specific conditions for the value of the AR coefficient, the proportional Cholette–Dagum method with AR error provides movements in the back series that are sufficiently close to the indicator (and similar results to the Denton method). More importantly, it returns extrapolations for the forward series that takes into account the historical bias with the indicator.

6.17 The chapter tackles more specific issues arising from the application of benchmarking in the compilation of QNA. The Boot–Feibes–Lisman smoothing method—a method equivalent to the proportional Denton method with a constant indicator—provides an appropriate solution for benchmarking ANA variables without the use of a related indicator. Practical solutions are given to solve difficult benchmarking cases, such as short series, series with breaks, series requiring specific seasonal effects, or series presenting negative or zero values. The chapter also discusses the impact on benchmarking when either (preliminary) annual benchmarks or (preliminary) quarterly values of the indicator are revised.

6.18 Finally, the chapter extends the benchmarking methodology to solve reconciliation problems in the QNA. Reconciliation is required to restore consistency in quarterly series that are subject to both annual and quarterly aggregation constraints. The main difference with benchmarking is that the reconciled estimates have to satisfy both annual benchmarks and quarterly constraints. As an example, quarterly value added by institutional sector may be required to be in line with ANA estimates by institutional sector and independently derived quarterly value added for the total economy.

6.19 The multivariate proportional Denton method is recommended for reconciling QNA series subject to both ANA benchmarks and quarterly aggregates. However, when the number of variables is large, the multivariate solution could be computationally challenging. To avoid this complication, the following two-step procedure is suggested as a close approximation of the multivariate Denton approach:

- use the proportional Denton method to benchmark each quarterly indicator to the corresponding ANA variable and
- use a least-squares balancing procedure to reconcile *one year at a time* the benchmarked series obtained at the first step with the given annual and quarterly constraints of that year.

6.20 Benchmarking and reconciliation techniques should be an integral part of the compilation process. These techniques are helpful to convert short-term indicators into estimates of QNA variables that are consistent with the ANA system. While benchmarking and reconciliation techniques presented in this chapter are technically complicated, it is important to emphasize that shortcuts generally will not be satisfactory unless the indicator shows almost the same trend as the benchmark. The weaker the indicator is, the more important it is to use proper benchmarking and reconciliation techniques. While there are some difficult conceptual issues that need to be understood before setting up a new system, the practical operation of benchmarking and reconciliation are typically automated and are not problematic or time consuming using computers nowadays available. In the initial establishment phase, the issues need to be understood and the processes automated as an integral part of the QNA production system. Thereafter, the techniques will improve the data and reduce future revisions without demanding time and attention of the QNA compilers.

[6] Instead, when the bias in the movements is permanent, the basic proportional Denton method may still provide accurate extrapolations.

[7] In a first-order autoregressive model, the current value of the error is linearly dependent to the value of the previous period.

Box 6.1 Software for Benchmarking

The benchmarking methods presented in this chapter are available in some commercial and open-source software. Compiling agencies using a specific package for QNA compilation should consult the technical guide to see if built-in benchmarking functions are available. If not, an Internet search can reveal if a plug-in or toolbox containing benchmarking routines is available for the specific package.

At the time of writing, compiling agencies may also consider two off-the-shelf solutions that have been specifically designed for the production of QNA and other official statistics:

- **XLPBM** (IMF). XLPBM is an add-in function to Microsoft Excel for benchmarking quarterly series to annual series using the proportional Denton method and the proportional Cholette–Dagum method with first-order autoregressive error. It also implements the enhanced solution of the Denton method. It has been developed by the IMF Statistics Department to assist member countries within its technical assistance and training program. It is particularly suited for QNA compilation systems based on spreadsheets.
- **JDemetra+** (National Bank of Belgium, Eurostat). JDemetra+ contains a plug-in offering several options for temporal disaggregation and benchmarking. The Denton and Cholette–Dagum methods are provided, as well as a generalization of the Denton multivariate case. It also implements regression-based methods such as Chow–Lin, Fernandez, and Litterman. It can deal with any valid combination of frequencies. For more information on JDemetra+ for seasonal adjustment, see Box 7.1.

Compiling agencies may also choose to implement benchmarking techniques in their preferred computing environment. Annex 6.1 offers a matrix formulation of the Denton and Cholette–Dagum benchmarking solutions. Both methods can easily be coded in any programming language that offers matrix algebra operations.

6.21 Box 6.1 presents a brief overview of the benchmarking software available at the time of preparing this manual. Countries introducing QNA or improving their benchmarking techniques may find it worthwhile to obtain existing software for direct use or adaptation to their own processing systems. Alternatively, Annex 6.1 provides the algebraic solution (in matrix notation) of the proportional Denton method and the proportional Cholette–Dagum method. This formal presentation can facilitate the implementation of the two benchmarking solutions in any computing software.

The Pro Rata Distribution and the Step Problem

6.22 The aim of this section is to illustrate the step problem created by pro rata distribution and extend the pro rata approach to cover extrapolation from the last available benchmark. The ratio of the QNA benchmarked estimates to the indicator (the quarterly BI ratio) implied by the pro rata distribution method shows that this method introduces unacceptable discontinuities into the time series. Also, viewing the quarterly BI ratios implied by the pro rata distribution method together with the quarterly BI ratios implied by the basic extrapolation with an indicator technique shows how distribution and extrapolation with indicators can be put into the same BI framework. Because of the step problem, the pro rata distribution technique is not acceptable.

6.23 In the context of this chapter, distribution refers to the allocation of an annual total of a flow series to its four quarters. A pro rata distribution splits the annual total according to the proportions indicated by the four quarterly observations. A numerical example is shown in Example 6.1 and Figure 6.1.

6.24 In mathematical terms, pro rata distribution can be formalized[8] as follows:

$$X_t = I_t \cdot \left(\frac{A_n}{\bar{I}_n}\right) \quad \text{for } n = 1,\dots,y \text{ and } t = 4n-3,\dots,4n \qquad (2)$$

where

X_t is the level of the QNA estimate for quarter t,

I_t is the level of the quarterly indicator for quarter t

A_n is the level of the ANA estimate for year n,

$\bar{I}_n$ is the annual aggregation (sum) of the quarterly values of the indicator for year n,

[8] Unless otherwise specified, in this chapter, the annual benchmarks are denoted with A_n, the quarterly indicator series with I_t, and the quarterly benchmarked series with X_t.

Example 6.1 Pro Rata Method and the Step Problem

	Indicator					Pro Rata Method						
	Indicator	Quarter-to-Quarter Rate of Change (%)	Year-on-Year Rate of Change (%)	Annual Data	Annual BI Ratio	Benchmarked Data					Quarter-to-Quarter Rate of Change (%)	Year-on-Year Rate of Change (%)
	(1)			(2)	(3)=(2)/(1)	(1)	×	(3)	=	(4)		
q1 2010	99.4					99.4	×	2.5000	=	248.5		
q2 2010	99.6	0.2				99.6	×	2.5000	=	249.0	0.2	
q3 2010	100.1	0.5				100.1	×	2.5000	=	250.3	0.5	
q4 2010	100.9	0.8				100.9	×	2.5000	=	252.3	0.8	
2010	**400.0**			**1,000.0**	**2.5000**					**1,000.0**		
q1 2011	101.7	0.8	2.3			101.7	×	2.5329	=	257.6	2.1	3.7
q2 2011	102.2	0.5	2.6			102.2	×	2.5329	=	258.9	0.5	4.0
q3 2011	102.9	0.7	2.8			102.9	×	2.5329	=	260.6	0.7	4.1
q4 2011	103.8	0.9	2.9			103.8	×	2.5329	=	262.9	0.9	4.2
2011	**410.6**		**2.7**	**1,040.0**	**2.5329**					**1,040.0**		**4.0**
q1 2012	104.9	1.1	3.1			104.9	×	2.4884	=	261.0	–0.7	1.3
q2 2012	106.3	1.3	4.0			106.3	×	2.4884	=	264.5	1.3	2.2
q3 2012	107.3	0.9	4.3			107.3	×	2.4884	=	267.0	0.9	2.4
q4 2012	107.8	0.5	3.9			107.8	×	2.4884	=	268.2	0.5	2.0
2012	**426.3**		**3.8**	**1,060.8**	**2.4884**					**1,060.8**		**2.0**
q1 2013	107.9	0.1	2.9			107.9	×	2.4884	=	268.5	0.1	2.9
q2 2013	107.5	–0.4	1.1			107.5	×	2.4884	=	267.5	–0.4	1.1
q3 2013	107.2	–0.3	–0.1			107.2	×	2.4884	=	266.8	–0.3	–0.1
q4 2013	107.5	0.3	–0.3			107.5	×	2.4884	=	267.5	0.3	–0.3
2013	**430.1**		**0.9**	—	—					**1,070.3**		**0.9**

The Annual Data and the Quarterly Indicator
In this example, we assume that the annual data are expressed in monetary terms and the quarterly indicator is an index with 2010 = 400. The annual data and the quarterly indicator show different movements in 2011 and 2012. The quarterly indicator shows a stable, smooth upward trend since 2010, with annual growth rates of 2.7 and 3.8 percent in 2011 and 2012, respectively. The annual data are characterized by a much stronger growth in 2011 than in 2012 (4.0% compared with 2.0%).

Pro Rata Distribution
The annual BI ratio for 2010 (2.5) is calculated by dividing the annual value (1,000) by the annual sum of the index (400.0). This ratio is then used to derive the benchmarked estimates for the individual quarters of 2010. For example, the benchmarked estimate for q1 2010 is 248.5: that is, 99.4 times 2.5.

The Step Problem
Observe that quarter-to-quarter rates are different only in the first quarters: +2.1% in the benchmarked data versus +0.8% in the indicator in q1 2011 and –0.7% versus +1.1% in q1 2012. These discontinuities (or steps) are caused by the different pace of growth of the two series, which causes sudden changes of the annual BI ratios in the years 2011 and 2012.

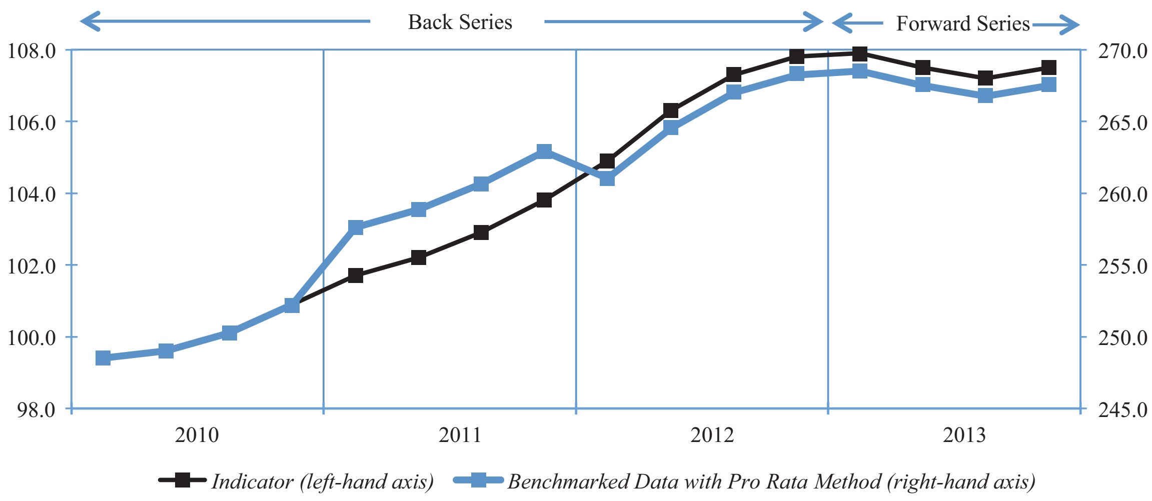
Extrapolation
The 2013 indicator data are linked to the benchmarked data for 2012 by carrying forward the BI ratio for the year 2012 (2.4884). For instance, the extrapolation for q3 2013 (266.8) is derived as 107.2 times 2.4884. Note that all extrapolated quarters present the same quarter-to-quarter rates and year-on-year rates of the indicator. In addition, the annual rate of change is the same (0.9%).

(These results are illustrated in Figure 6.1. Rounding errors in the table may occur.)

Figure 6.1 Pro Rata Method and the Step Problem

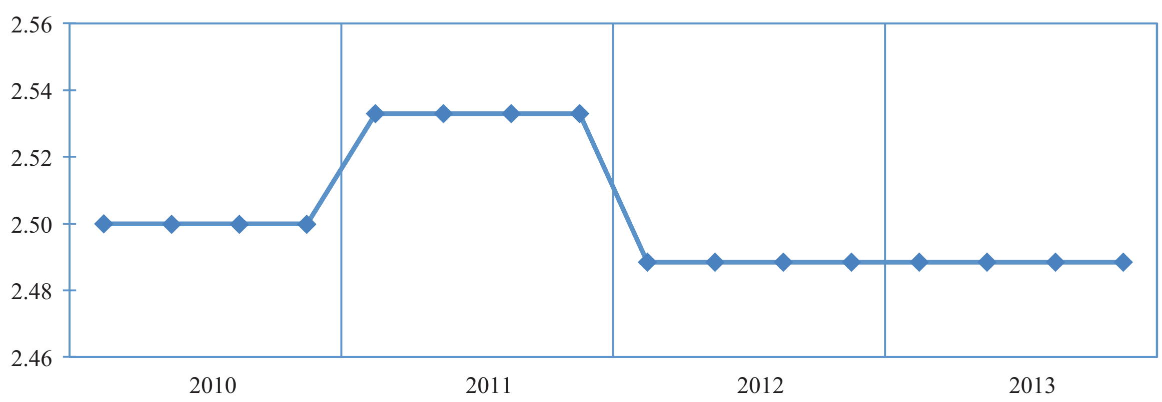
The Indicator and the Derived Benchmarked Series

(The corresponding data are given in Example 6.1)



In this example, the step problem shows up as an increase in the benchmarked series from q4 2010 to q1 2011 and as a subsequent drop from q4 2011 to q1 2012. Both movements are not matched by similar movements in the indicator.

Benchmark-to-Indicator Ratio



It is easier to recognize the step problem from charts of the BI ratio. It shows up as abrupt upward or downward steps in the BI ratios between q4 of one year and q1 of the next year. In this example, the step problem shows up as a large upward jump in the BI ratio between q4 2010 and q1 2011 and a subsequent drop between q4 2011 and q1 2012.

n is the temporal index for the years,

y is the last available year, and

t is the temporal index for the quarters.

Equation (2) derives the QNA estimate by raising each quarterly value of the indicator I_t by the corresponding annual BI ratio $\left(A_n/\bar{I}_n\right)$.

6.25 The step problem arises because of discontinuities in the annual BI ratio between years. If an indicator shows different annual growth rates than the annual benchmark, as in Example 6.1, then the BI ratio will move from one year to the next. When the annual BI ratio is used to elevate the indicator's value for all the quarters, the entire difference in the quarterly growth rates is put into the first quarter, while other quarterly growth rates are left unchanged.[9] The significance of the step problem depends on the size of variations in the annual BI ratio.

6.26 Extrapolation with an indicator refers to using the movements in the indicator to update the QNA time series with estimates for quarters for which no annual data are yet available (the forward series). A numerical example is shown in Example 6.1 and Figure 6.1.

6.27 In mathematical terms, extrapolation with an indicator can be formalized using the same BI ratio presentation used for the distribution case:

$$X_t = I_t \cdot \left(\frac{A_y}{\bar{I}_y}\right) \text{ for } t = 4y+1,\ 4y+2,\ 4y+3,\ 4(y+1) \quad (3)$$

where y indicates the year with the last available annual benchmark and extrapolations are needed for the quarterly values of the year $y+1$. It is assumed that the indicator is available for all the quarters of year $y+1$.

6.28 When equation (3) is applied, quarterly growth rates in the forward series reproduce exactly the quarterly growth rates in the indicator in year $y+1$. This can be shown by dividing equation (3) for two adjacent quarters: the common BI ratio for year y in the right-hand side of equation (3) cancels out and the remaining ratios

$$\left(\frac{X_{4y+k}}{X_{4y+k-1}}\right) = \left(\frac{I_{4y+k}}{I_{4y+k-1}}\right) \qquad \text{for } k = 1,2,3,4$$

show that the QNA series (equation (3)) present the same quarter-to-quarter rates of the indicator. Similarly, it can be shown that the QNA series has the same year-on-year growth rates of the indicator in the extrapolated quarters. Although in general these features may look like desirable properties, the extrapolated series might need to deviate from the movements of the indicator to match different annual movements in the ANA series for the next year.

6.29 In summary, pro rata distribution calculates the back series by using the corresponding BI ratios for each year where ANA benchmark is available as adjustment factors to scale up or down the indicator. The forward series is calculated by carrying forward the last annual BI ratio. This method is unacceptable for QNA benchmarking because it could introduce a step in the first quarter of the year, thus violating the stated objective of preserving the original movements in the indicator. The next section illustrates proportional benchmarking methods that are designed to preserve the movements in the indicator in all quarters.

Proportional Benchmarking Methods with Movement Preservation

6.30 From a quarterly perspective, the main objective of benchmarking is to preserve the quarterly movements in the indicator. The most common measurement of movement in quarterly (seasonally adjusted) series is the quarter-to-quarter (or quarterly) growth rate, which is measured by the ratio of the level of one quarter (I_t) to the level of the previous quarter $\left(I_{t-1}\right)$.[10] Another common way of measuring movements on quarterly (unadjusted) series is with year-on-year growth rates: the ratio of the level of one quarter (I_t) to the level of the same quarter in the previous year $\left(I_{t-4}\right)$. Year-on-year quarterly growth rates are useful in benchmarking, because they can be directly related to the annual growth[11] computed from the ANA series.

6.31 Ideally, the benchmarked series should maximally preserve the quarterly growth rates in the

[9] In addition, the distributed series with the pro rata method presents year-on-year growth rates (i.e., one quarter compared with the corresponding quarter of the previous year) that differ from those of the indicator in all the quarters.

[10] For example, if the ratio I_t/I_{t-1} is 1.021, the indicator has increased by 2.1 percent in quarter t compared with the previous quarter $t-1$.

[11] Approximately, the annual average of year-on-year rates from a quarterly series returns the annual growth computed from the annually aggregated quarterly variable.

indicator subject to the constraints given by the annual benchmarks. In mathematical terms, this statement can be formulated as the minimization of the objective (penalty) function:[12]

$$\min_{X_t} \sum_{t=2}^{q} \left[\frac{X_t}{X_{t-1}} - \frac{I_t}{I_{t-1}} \right]^2 \tag{4}$$

subject to the annual constraints

$$\sum_{t=4n-3}^{4n} X_t = A_n \qquad \text{for } n = 1, \ldots, y, \tag{5}$$

where

q is the last quarter for which quarterly source data are available, denoting either the fourth quarter of the last available year ($q = 4y$) in case of a distribution problem or any subsequent quarter ($q > 4y$) for a problem with extrapolation.

Solving problem (4) subject to (5) corresponds to finding the quarterly (unknown) values X_t (i.e., the QNA series) that match the required annual benchmarks and present growth rates that are as close as possible to the growth rates of the indicator. Problem (4) is also known as growth rate preservation (GRP) function.

6.32 Despite being an ideal criterion for benchmarking from a theoretical viewpoint, the GRP problem (4) is a rational function of the target values and as such can only be minimized using nonlinear optimization algorithms.[13] The implementation of these algorithms requires advanced knowledge of optimization theory and use of commercial software (see Annex 6.1 for reference). Furthermore, these algorithms may be characterized by slow convergence and possible troubles in finding actual minima of the objective function. For this reason, GRP-based benchmarking procedures are considered impractical for QNA purposes.

6.33 The next section introduces the proportional Denton method, which is a close linear approximation of the GRP function and obtains the benchmarked series using simple matrix algebra operations.

[12] The quadratic expression in equation treats positive and negative differences symmetrically and assigns proportionally higher weights to large differences than small ones.

[13] Formula presents the benchmarked values at the denominator and therefore is a nonlinear function of the benchmarked series.

The Proportional Denton Method

6.34 The proportional Denton benchmarking technique keeps the ratio of the benchmarked series to the indicator (i.e., the quarterly BI ratio) as constant as possible subject to the constraints provided by the annual benchmarks. A numerical illustration of its operation is shown in Example 6.2 and Figure 6.2.

6.35 Using the same notation of equations (4) and (5), the proportional Denton technique can be expressed as the constrained minimization problem:[14]

$$\min_{X_t} \sum_{t=2}^{q} \left[\frac{X_t}{I_t} - \frac{X_{t-1}}{I_{t-1}} \right]^2 \tag{6}$$

subject to

$$\sum_{t=4n-3}^{4n} X_t = A_n \qquad \text{for } n = 1, \ldots, y \tag{7}$$

6.36 The individual term of the penalty function (6) minimized by the proportional Denton method (also known as proportional first difference variant of the Denton method) —is the first difference of the quarterly BI ratio. With the Denton method, movement preservation is achieved by distributing the quarterly BI ratios smoothly from one quarter to the next under the annual restrictions (equation (7)). Implicitly, the quarterly benchmarked series will present growth rates similar to those of the indicator. It can be shown that function (6) approximates very closely the ideal GRP function (4). More importantly, the constrained minimization problem is a linear function of the objective values (X_t only appears in the numerator). The first-order conditions for a minimum permits to derive a closed-form solution of the problem, and the benchmarked series can be calculated using standard matrix algebra operations (see Annex 6.1).

6.37 Under the BI framework, the proportional Denton technique implicitly constructs from the annual observed BI ratios a time series of quarterly BI ratios

[14] This presentation deviates from Denton's original proposal by omitting the requirement that the value for the first period be predetermined. As pointed out by Cholette (1984), requiring that the values for the first period be predetermined implies minimizing the first correction and can in some circumstances cause distortions to the benchmarked series. Also, Denton's (1971) original proposal dealt only with estimating the back series.

Example 6.2 The Proportional Denton Method

	Indicator					Denton Proportional Method			
	Indicator	Quarter-to-Quarter Rate of Change (%)	Year-on-Year Rate of Change (%)	Annual Data	Annual BI Ratio	Benchmarked Data	Quarter-to-Quarter Rate of Change (%)	Year-on-Year Rate of Change (%)	Estimated Quarterly BI Ratios
	(1)			(2)	(3)=(2)/(1)	(4)			(5)=(4)/(1)
q1 2010	99.4					247.5			2.4897
q2 2010	99.6	0.2				248.4	0.4		2.4938
q3 2010	100.1	0.5				250.4	0.8		2.5020
q4 2010	100.9	0.8				253.7	1.3		2.5143
2010	**400.0**			**1,000.0**	**2.5000**	**1,000.0**			
q1 2011	101.7	0.8	2.3			257.4	1.5	4.0	2.5308
q2 2011	102.2	0.5	2.6			259.4	0.8	4.4	2.5382
q3 2011	102.9	0.7	2.8			261.0	0.6	4.2	2.5366
q4 2011	103.8	0.9	2.9			262.2	0.4	3.4	2.5259
2011	**410.6**		**2.7**	**1,040.0**	**2.5329**	**1,040.0**		**4.0**	
q1 2012	104.9	1.1	3.1			262.9	0.3	2.1	2.5060
q2 2012	106.3	1.3	4.0			264.8	0.7	2.1	2.4910
q3 2012	107.3	0.9	4.3			266.2	0.5	2.0	2.4810
q4 2012	107.8	0.5	3.9			266.9	0.3	1.8	2.4760
2012	**426.3**		**3.8**	**1,060.8**	**2.4884**	**1,060.8**		**2.0**	
q1 2013	107.9	0.1	2.9			267.2	0.1	1.6	2.4760
q2 2013	107.5	–0.4	1.1			266.2	–0.4	0.5	2.4760
q3 2013	107.2	–0.3	–0.1			265.4	–0.3	–0.3	2.4760
q4 2013	107.5	0.3	–0.3			266.2	0.3	–0.3	2.4760
2013	**430.1**		**0.9**	**—**	**—**	**1,064.9**		**0.4**	

BI Ratios

- For the back series (2010–2012)
  - The quarterly estimates of 2010 sum to 1,000: that is, the weighted average BI ratio for 2010 is 2.5.
  - The quarterly estimates of 2011 sum to 1,040: that is, the weighted average BI ratio for 2011 is 2.5329.
  - The quarterly estimates of 2012 sum to 1,060.8: that is, the weighted average BI ratio for 2012 is 2.4884.
  - The estimated quarterly BI ratio (column 5) increases through q2 2011 to match the increase in the observed annual BI ratio in 2011, and then it goes down to match the drop in the BI ratio in 2012.
- For the forward series (2013), the quarterly estimates are obtained by carrying forward the quarterly BI ratio (2.4760) for the last quarter of 2012 (the last benchmark year).

Rates of Change for the Back Series and the Forward Series

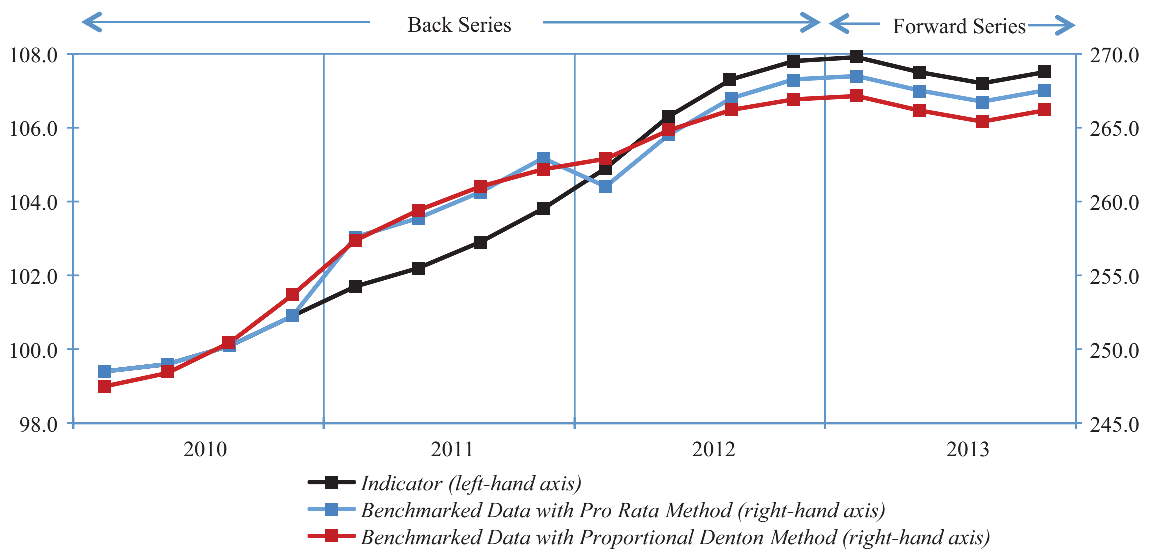
- For the back series, the quarterly percentage changes in 2011 and 2012 are adjusted upwards from q1 2010 to q2 2011 and then downwards from q3 2011 to q4 2012. These adjustments to the quarterly indicator series are needed to match the different annual rates of change of the target annual variable.
- For the forward series, the quarterly percentage changes in 2013 are identical to those of the indicator. However, the annual (extrapolated) growth for 2013 in the benchmarked series (+0.4%) is lower that the annual rate of the indicator (+0.9%). The mechanical extrapolation of the Denton method takes into account the slower growth of the ANA variable for 2012 (+2.0%) compared with that of the indicator (+3.8%).

(These results are illustrated in Figure 6.2. Rounding errors in the table may occur.)

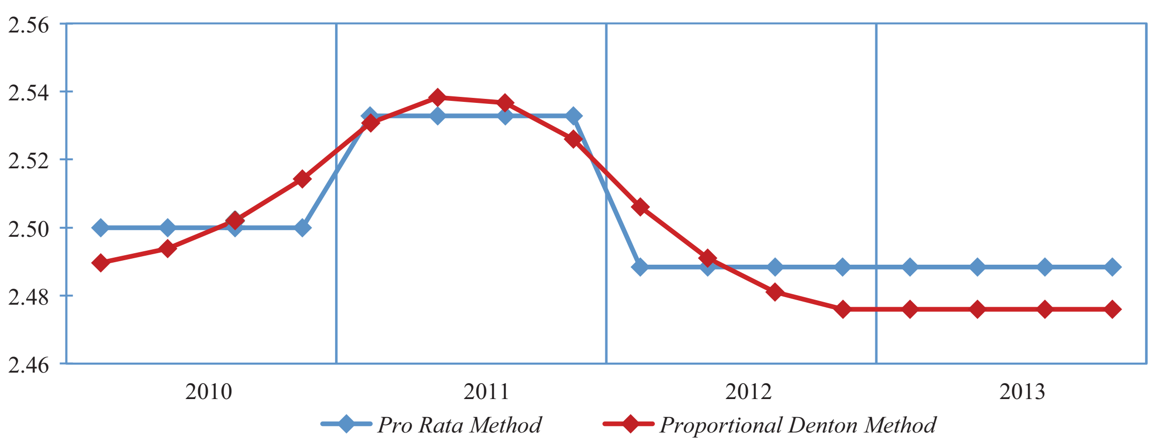
Figure 6.2 Solution to the Step Problem: The Proportional Denton Method

The Indicator and the Derived Benchmarked Series

(The corresponding data are given in Example 6.2)



Benchmark-to-Indicator Ratio



that is as smooth as possible and such that, in the case of flow series,

- the quarterly BI ratios are in line with weighted averages of the annual BI ratios for each year for the back series ($t = 1,...,4y$), with weights given by the indicator's quarterly share in each year and
- the quarterly BI ratios are kept constant and equal to the ratio for the fourth quarter of the last benchmark year ($t = 4y$) for the forward series ($t > 4y$).

Because the forward series has no constraints, the minimum impact on equation (6) is attained when $\left(\frac{X_{4y+k}}{I_{4y+k}} - \frac{X_{4y}}{I_{4y}}\right) = 0$ for any $k > 0$: that is, when $\frac{X_{4y+k}}{I_{4y+k}} = \frac{X_{4y}}{I_{4y}}$.

6.38 For the back series, the Denton method returns a QNA series that optimally inherits the growth rates from the indicator—under the close approximation of the ideal GRP function—and fully incorporates the information contained in the annual data. The quarter-to-quarter growth rates of the QNA variable generally differ from those in the indicator (e.g., see Example 6.2). The size of the difference between the quarterly movements depends on the size of the difference between the annual movements shown by the ANA series and the indicator; in other words, the movements in the annual BI ratio.

6.39 For the forward series, the proportional Denton method results in quarter-to-quarter growth rates that are identical to those in the indicator but also in an annual growth rate for the first year of the forward series that differs from the corresponding growth rate of the annually aggregated indicator (see Example 6.2). This difference in the annual growth rate is caused by the way the indicator is linked in. By carrying forward the quarterly BI ratio for the fourth quarter of the last benchmark year, the proportional Denton method implicitly "forecasts" the next annual BI ratio as different from the last observed annual BI ratio and equal to the quarterly BI ratio for the fourth quarter of the last benchmark year: that is,

$$\frac{A_{y+1}}{\bar{I}_{y+1}} = \frac{X_{4y}}{I_{4y}}.$$

6.40 Carrying forward the quarterly BI ratio for the fourth quarter of the last benchmark year is equivalent to extrapolating in the next year the diverging pattern between the ANA variable and the indicator arising from the last available year. Technically, with the Denton method in extrapolation, the value of the last quarterly BI ratio depends to a large extent on the last two annual BI ratios. When the annual BI ratio of the last available year is larger than the annual BI ratio of the previous year,

$$\frac{A_y}{\bar{I}_y} > \frac{A_{y-1}}{\bar{I}_{y-1}},$$

the quarterly BI ratio for the fourth quarter of year y is likely to be larger than the annual BI ratio of the whole year (A_y): that is,

$$\frac{X_{4y}}{I_{4y}} > \frac{A_y}{\bar{I}_y}.$$

Consequently, the annual BI ratio for the next year A_{y+1} will be higher than the last observed one A_y. Put differently, if the ANA variable grows faster than the indicator in year y, this (local) diverging pattern is mechanically extrapolated into year y+1 by assuming that the QNA variable grows faster than the indicator (even though the extrapolated quarterly growth rates are identical to those in the indicator). The opposite happens when the annual BI ratio of the last available year is smaller than the annual BI ratio of the previous year (i.e., when the ANA variable grows at a slower rate than the indicator in year y),[15]

$$\frac{A_y}{\bar{I}_y} < \frac{A_{y-1}}{\bar{I}_{y-1}},$$

which is likely to generate a quarterly BI ratio for the fourth quarter of year y that is lower than the annual BI ratio[16] (i.e., the QNA variable will be extrapolated at a lower annual rate than the indicator)

$$\frac{X_{4y}}{I_{4y}} < \frac{A_y}{\bar{I}_y}.$$

6.41 The proportional Denton method mechanically extrapolates the quarterly values of the current year

[15] The inequalities shown may not apply to cases when the last two annual BI ratios are very close to each other (i.e., similar annual growth rates between the ANA variable and indicator for the last available year) and the previous values of the BI series follows a systematic trend.

[16] This is the case shown in Example 6.2, where the extrapolated QNA variables show an annual rate of 0.4 percent compared with the original 0.9 percent annual growth of the indicator.

from the last quarterly BI ratio. To overcome the drawbacks of this solution, two alternative approaches can be followed. First, the proportional Denton method can be enhanced in extrapolation when external information is available on the development of the annual BI ratio for the year with no annual benchmark. Second, this section illustrates the Cholette–Dagum method—an alternative benchmarking method to the Denton approach that can be used to calculate automatically bias-adjusted extrapolation based on the historical relationship between the annual variable and the quarterly indicator.

Enhancement for Extrapolation of the Proportional Denton Method

6.42 The forward series is the most relevant information for many QNA users. The main purpose of the QNA is to provide timely information on the current economic developments before the ANA data become available. When the benchmarking framework is used to extrapolate QNA series, the method used should make efficient use of the complete time-series information available to generate reliable estimates for the current quarters.

6.43 The proportional Denton method mechanically extrapolates the quarterly BI ratio from the fourth quarter of the last available year in all the subsequent quarters. Consequently, the last quarterly BI ratio provides an implicit forecast for the next annual BI ratio. As mentioned before, the value of the last quarterly BI ratio is largely dominated by the values of the last two annual BI ratios only. When the annual BI ratio presents systematic or identifiable patterns historically, it could be possible to incorporate this information for improving the estimates for the most recent quarters (the forward series) and reducing the size of later revisions.

6.44 To understand whether it is possible to improve the Denton extrapolations, it is convenient to look at the historical series of annual BI ratio in the observed sample:

$$\frac{A_n}{\bar{I}_n} \qquad \text{for } n = 1, \ldots, y.$$

A simple plot of the annual BI series would suffice to identify instability and breakdowns in the historical relationship between the ANA variable and the indicator. For this purpose, it may be useful to tabulate the growth rates of the BI ratio (i.e., the ratio of one BI ratio to the previous one), which has a useful interpretation in terms of annual growth rates of the variables involved. The growth rate of the BI ratio in a generic year n is equivalent to the ratio between the growth rate of the ANA variable to the growth rate of the (annualized) indicator in that year, as shown below by simply rearranging the terms involved:

$$\frac{A_n / \bar{I}_n}{A_{n-1} / \bar{I}_{n-1}} \Leftrightarrow \frac{A_n / A_{n-1}}{\bar{I}_n / \bar{I}_{n-1}}.$$

When the growth rate of the BI ratio is larger than one, the ANA variable grows faster than the indicator. Conversely, when the growth rate of the BI ratio is smaller than one, the ANA variable's growth is smaller than the indicator's growth. When the BI ratio is constant, the ANA variable and the indicator move at the same rate.

6.45 The enhanced proportional Denton method for extrapolation requires an explicit forecast for the annual BI ratio of the year $y+1$. Possible ways to forecast the next annual BI ratio are indicated as follows:

- If the annual BI ratio fluctuates symmetrically around its mean, on average, the best forecast of the next year's BI ratio is the long-term average BI value. This approach is very close to the solution offered by the proportional Cholette–Dagum method with AR error.
- If the annual BI ratio shows a systematic upward or downward tendency (i.e., growth rates in the indicator are biased compared to the annual data), then, on average, the best forecast of the next year's BI ratio is a trend extrapolation in the next year. A deterministic trend could be used to generate the extrapolation. If the trend is stochastic (i.e., random walk process), the best forecast is the annual BI ratio of the last year. However, the basic Denton method may also provide satisfactory extrapolations for this case.
- If a historically stable annual BI ratio presents a structural break in the last year, which is expected to continue in the future, then the best forecast of the next year's BI ratio is the previous annual value. For example, the BI ratio may show a structural break in the last year because of changes introduced in the calculation of the ANA variable. Assuming the same annual BI ratio for

the next year implies that the structural break is carried forward in the QNA extrapolations.

- If the movements in the annual BI ratio follow a stable, predictable time-series model, then, on average, the best forecast of the next year's BI ratio may be obtained from that model. However, a sufficient number of observations (minimum 10 years) is required to fit time-series models and calculate forecasts with an acceptable level of confidence.
- If the fluctuations in the annual BI ratio are correlated with the business cycle (e.g., as manifested in the indicator), then, on average, the best forecast of the next year's BI ratio may be obtained by modeling that correlation.

6.46 One convenient way to derive a forecast of the next annual BI ratio is by applying a rate of change from the last available annual BI ratio:

$$\frac{\hat{A}_{y+1}}{\bar{I}_{y+1}} = \frac{A_y}{\bar{I}_y} \cdot \hat{\delta}_{y+1}. \tag{8}$$

The rate $\hat{\delta}_{y+1}$ can be interpreted as the expected (approximate) difference between the ANA growth rate and the indicator growth rate in the year $y+1$. For example, if $\hat{\delta}_{y+1} = 1.02$, the growth rate of A_{y+1} compared to A_y is expected to be approximately 2 percent higher than the growth rate of $\bar{I}_{y+1}$ compared to $\bar{I}_y$. This kind of information may be available to national accountants through internal discussion with subject-matter and survey experts.

6.47 The same principles used by Denton to formulate the constrained minimization problems (6) and (7) can be used to incorporate the annual forecast (equation (8)). An additional constraint is included to impose that the estimated quarterly BI ratios for the extrapolated quarters are consistent with the forecast. More specifically, the additional constraint is that a weighted average of the estimated quarterly BI ratios for the year $n+1$ be equal to the forecast annual BI ratio. Formula (6) is extended to minimize the impact on period-to-period change in the extrapolated quarterly BI ratios (see Annex 6.1 for reference to the mathematical solution of the enhanced problem). A consequence of the enhanced extrapolation is that the quarter-to-quarter rates of the QNA variable diverge from the quarter-to-quarter rates of the indicator (provided the annual forecast is different from the last quarterly BI ratio).

6.48 The enhanced Denton method requires that only the annual BI ratio, and not the annual benchmark value, has to be forecast. The rationale behind this choice is that the BI ratio could be easier to forecast than the annual benchmark value itself. When the ANA variable displays a predictable pattern over the years, the basic Denton method can also be used in conjunction with a direct forecast of the ANA variable for the next year. National accountants are usually reluctant to make forecasts, because they increase the estimation uncertainty of the variables and are subject to criticisms from users. However, all possible extrapolation methods are based on either explicit or implicit forecasts, and implicit forecasts are more likely to be wrong because they are not scrutinized.[17]

6.49 It should be common practice to check the effects of new and revised benchmarks on the BI ratios. A table of observed annual BI ratios over the past several years should be regularly updated. While it is common that the BI ratio forecasts have errors of different degrees from the actual ones, the important question is whether the error reveals a pattern that would allow better forecasts to be made in the future. In addition, changes in the annual BI ratio reveal issues related to the indicator.

6.50 The annual series of the BI ratio should be regularly assessed as a way to determine whether the proportional Denton method requires an enhancement for extrapolation. Whenever a predictable behavior is noted in the annual BI series—especially in the last two years—compilers should try to incorporate such information in extrapolation by calculating an annual forecast of the next BI ratio and including it as an additional constraint for the benchmarked series.

The Proportional Cholette–Dagum Method with Autoregressive Error

6.51 Cholette and Dagum (1994) proposed a benchmarking method based on the generalized least squares regression model. The Cholette–Dagum method provides a very flexible framework for benchmarking. It is grounded on a statistical model that allows for (a) the presence of bias and autocorrelated errors in the indicator and (b) the presence of nonbinding benchmarks. The benchmarked series

[17] For additional reference on forecasting time series in the QNA, see Chapter 10.

is calculated as the generalized least squares solution of a regression model with deterministic effects and autocorrelated and heteroscedastic disturbance (for details see Annex 6.1). The Denton method can be regarded as a particular (approximate) case of the Cholette–Dagum regression-based model.

6.52 The proportional Cholette–Dagum benchmarking method with first-order AR error is a convenient way to calculate extrapolations of QNA series when the indicator is an unbiased measurement of the ANA variable. The proportional Cholette–Dagum method with AR error is obtained as a particular case of the Cholette–Dagum regression-based model. The (first-order) AR model for the error—under specific values for the AR coefficient—guarantees that (i) movements in the indicator are sufficiently preserved in the back series and (ii) extrapolations of the forward series are adjusted for a local level bias in the indicator. The implicit forecast of the next annual BI ratio converges to the historical BI ratio, which takes into account the full relationship between the ANA series and the indicator in the period. A numerical illustration of the Cholette–Dagum method is shown in Example 6.3 and Figure 6.3.

6.53 The proportional Cholette–Dagum benchmarking method with AR error consists of the following two equations:

$$I_t^a = X_t + e_t \qquad \text{for } t = 1,\ldots,q \tag{9}$$

$$A_n = \sum_{t=4n-3}^{4n} X_t \qquad \text{for } n = 1,\ldots,y \tag{10}$$

where

I_t^a is the quarterly indicator I_t adjusted for the historical level bias,

X_t is the QNA target series,

e_t is a quarterly autocorrelated and heteroscedastic error,

A_n is the ANA benchmark series, and

q is the number of quarters available, possibly with extrapolation ($q \geq 4y$).

Equation (9) defines the quarterly bias-adjusted indicator I_t^a as a measurement of the unknown quarterly series X_t plus the error e_t. Equation (10) establishes the identity at the annual level between each benchmark A_n and the corresponding sum of quarterly values X_t.[18]

6.54 The bias-adjusted indicator I_t^a is calculated by rescaling the original indicator I_t as follows:

$$I_t^a = d \cdot I_t \tag{11}$$

where d is the historical BI ratio

$$d = \frac{\sum_{n=1}^{y} A_n}{\sum_{t=1}^{4y} I_t},$$

that is, the ratio between the sum of the annual benchmarks over the available years and the sum of the quarterly values of the indicator over the same period. The factor d can be interpreted as an estimate of the level bias in the indicator I_t in measuring the benchmark A_n. The rescaling factor d shrinks or amplifies the original values of the indicator, but never generates negative values unless the original values are negative. It also exactly preserves the growth rates of the original series, because $I_t / I_{t-1} = I_t^a / I_{t-1}^a$. Rescaling the indicator series is a convenient way to cancel a level bias and avoid the estimation of a constant term in the regression model.

6.55 The quarterly error e_t is assumed to be both autocorrelated and heteroscedastic. The heteroscedasticity assumption is required to make the error adjustment proportional to the value of the indicator. It is possible to calculate a standardized quarterly error by dividing e_t by I_t^a,[19] that is,

$$e'_t = \frac{e_t}{I_t^a} \qquad \text{for } t = 1,\ldots,q. \tag{12}$$

It is assumed that the standardized error e'_t follows a first-order stationary AR model:

$$e'_t = \phi e'_{t-1} + v_t, \tag{13}$$

where $|\phi| < 1$ is a necessary condition for stationarity of the AR model and the v_t's are independent and identically distributed innovations.

[18] As shown in Annex 6.1, the Cholette–Dagum regression-based model allows for nonbinding benchmarks by assuming an error term in the annual equation.

[19] This corresponds to assuming that the error is heteroscedastic with standard deviation equal to the value of the indicator in period t. The Cholette–Dagum method offers alternative options for standardization; for more details, see Dagum and Cholette (2006).

Example 6.3 The Proportional Cholette–Dagum Method with Autoregressive Error

	Indicator						Proportional Cholette–Dagum Method			Estimated Quarterly BI Ratios
	Indicator	Bias-adjusted Indicator	Quarter-to-Quarter Rate of Change (%)	Year-on-Year Rate of Change (%)	Annual Data	Annual BI Ratio	Benchmarked Data (ϕ = 0.84)	Quarter-to-Quarter Rate of Change (%)	Year-on-Year Rate of Change (%)	
	(1)	(2)			(3)	(4)=(3)/(1)	(5)			(6)
q1 2010	99.4	249.2					247.7			2.4917
q2 2010	99.6	249.7	0.2				248.4	0.3		2.4940
q3 2010	100.1	250.9	0.5				250.4	0.8		2.5010
q4 2010	100.9	252.9	0.8				253.6	1.3		2.5131
2010	**400.0**				**1,000.0**	**2.5000**	**1,000.0**			
q1 2011	101.7	255.0	0.8	2.3			257.4	1.5	3.9	2.5307
q2 2011	102.2	256.2	0.5	2.6			259.4	0.8	4.4	2.5386
q3 2011	102.9	258.0	0.7	2.8			261.0	0.6	4.3	2.5368
q4 2011	103.8	260.2	0.9	2.9			262.1	0.4	3.4	2.5255
2011	**410.6**			**2.7**	**1,040.0**	**2.5329**	**1,040.0**		**4.0**	
q1 2012	104.9	263.0	1.1	3.1			262.7	0.2	2.1	2.5040
q2 2012	106.3	266.5	1.3	4.0			264.6	0.7	2.0	2.4894
q3 2012	107.3	269.0	0.9	4.3			266.2	0.6	2.0	2.4812
q4 2012	107.8	270.2	0.5	3.9			267.3	0.4	2.0	2.4794
2012	**426.3**			**3.8**	**1,060.8**	**2.4884**	**1,060.8**		**2.0**	
q1 2013	107.9	270.5	0.1	2.9			268.0	0.3	2.0	2.4838
q2 2013	107.5	269.5	–0.4	1.1			267.4	–0.2	1.1	2.4875
q3 2013	107.2	268.7	–0.3	–0.1			267.0	–0.2	0.3	2.4906
q4 2013	107.5	269.5	0.3	–0.3			268.0	0.4	0.3	2.4932
2013	**430.1**			**0.9**	—	—	**1,070.4**		**0.9**	

Historical BI Ratio and Bias-Adjusted Indicator

The historical BI ratio (2.5069) is calculated as the ratio of the sum of the annual data from 2010 to 2012 (3,100.8) to the sum of the quarterly values of the indicator from q1 2010 to q4 2012 (1,236.9). The historical BI ratio is shown as a dashed horizontal line in the bottom panel of Figure 6.3. It represents the long-term average of the annual BI ratio. The bias-adjusted indicator in column 2 is obtained by multiplying the indicator series by the historical BI ratio (2.5069).

Extrapolation with AR Error

In this example, we use the value 0.84 for the AR parameter. The error for q4 2012 is equal to 2.9709 (i.e., 270.2452 – 267.2743). Using formulas (9) and (15), quarterly extrapolations for 2013 are derived as the sum of the bias-adjusted indicator in the four quarters of 2013 and AR extrapolation of the last quarterly error in q4 2012:

q1 2013	270.5 – [(0.84) × 2.9709] =	270.5 – 2.4956 =	268.0
q2 2013	269.5 – [(0.84^2) × 2.9709] =	269.5 – 2.0963 =	267.4
q3 2013	268.7 – [(0.84^3) × 2.9709] =	268.7 – 1.7609 =	267.0
q4 2013	269.5 – [(0.84^4) × 2.9709] =	269.5 – 1.4791 =	268.0

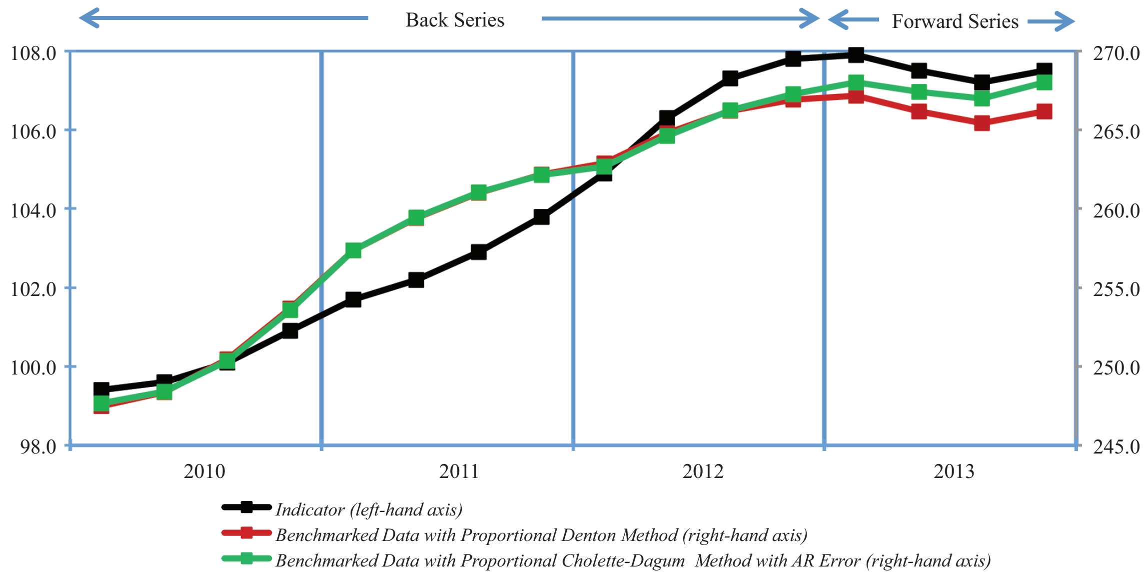
The extrapolated quarterly BI ratio for q4 2013 (2.4932) is the midpoint between the quarterly BI ratio for q4 2012 (2.4794) and the historical BI ratio (2.5069). In fact, as explained in the text, a value of 0.84 for ϕ eliminates 50 percent of the bias after one year from the last available quarter. It is worth noting that for 2013 (i) the annual growth rate of the QNA extrapolated series is 0.9 percent (the Denton method extrapolates a 0.4% increase in 2013) and (ii) the quarterly extrapolated growth rates of the QNA series are different from the quarterly growth rates shown by the indicator.

(These results are illustrated in Figure 6.3. Rounding errors in the table may occur.)

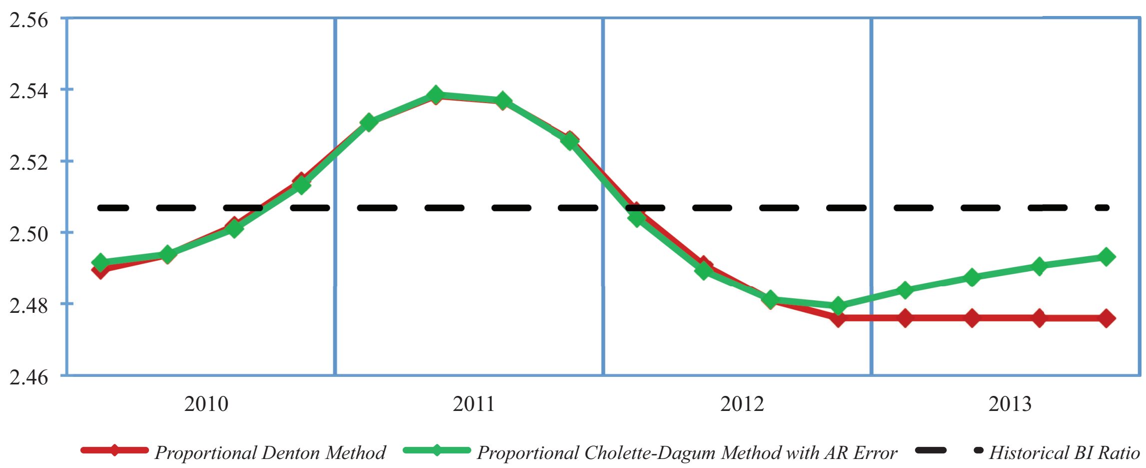
Figure 6.3 Solution to the Extrapolation Problem: The Proportional Cholette–Dagum Method with Autoregressive Error

The Indicator and the Derived Benchmarked Series

(The corresponding data are given in Example 6.3)



Benchmark-to-indicator Ratio



6.56 The AR model assumption for the standardized error e'_t implies that the quarterly BI ratio is also distributed according to a first-order AR model. In fact, the standardized error e'_t is proportional to the quarterly BI ratio. This is easily shown by rearranging the elements of equations (9) and (12)

$$\begin{aligned} X_t &= I_t^a - e_t \\ X_t &= I_t^a - e'_t I_t^a \\ e'_t &= \frac{I_t^a - X_t}{I_t^a} \end{aligned} \tag{14}$$

which corresponds to the term (with opposite sign) that defines the proportional criterion minimized by the Denton method. It can be shown that as the value of ϕ in model (13) approaches 1, the benchmarked series obtained with the proportional Cholette–Dagum method converges to the solution given by the proportional Denton method.

6.57 In extrapolation, the quarterly (standardized) error is calculated by multiplying the AR parameter recursively by the last quarterly error observed:

$$\hat{e}'_{4y+k} = \phi^k e'_{4y} \qquad \text{for any } k > 0. \tag{15}$$

When ϕ lies between 0 and 1, the extrapolated error $\hat{e}'_{4y+k}$ tends to zero as k increases (at different rates depending on the value of ϕ). As $e'_{4y+k} \to 0$ (and so does e_{4y+k}), the extrapolated QNA variable converges to the bias-adjusted indicator:

$$\hat{X}_{4y+k} \to I^a_{4y+k} = d \cdot I_{4y+k}.$$

The previous expression is equivalent to say that the extrapolated BI ratio converges to the historical BI ratio:

$$\frac{X_{4y+k}}{I_{4y+k}} \to d = \frac{\sum_{n=1}^{y} A_n}{\sum_{t=1}^{4y} I_t}.$$

6.58 The value of the AR parameter ϕ determines how fast the QNA extrapolated series converges to the bias-adjusted indicator. Values of ϕ closer to zero tend to eliminate quickly the bias and provide fast convergence rates to I^a_{4y+k}; on the contrary, values closer to one would maintain the bias in extrapolated quarters. However, a value of ϕ too far from 1 would generate a QNA series with growth rates distant from those of the indicator (both in the back series and in the forward series). An optimal value of ϕ should balance the trade-off between adjusting extrapolations for the current bias and maintaining close adherence to the growth rates of the indicator.[20]

6.59 A convenient value for the AR parameter ϕ in model (13) is 0.84. This particular value ensures that (about) 50 percent of the bias observed in the last quarterly error is eliminated after one year. In fact, using formula (15) with $\phi = 0.84$ and $k = 4$ returns

$$\hat{e}'_{4y+4} = (0.84)^4 e'_{4y} \approx 0.5 e'_{4y}.$$

A 50 percent reduction in the bias implies that the quarterly BI ratio in the fourth quarter of the next year is the midpoint between the last observed quarterly BI ratio and the historical BI ratio d. Although not grounded on strong theoretical arguments, this solution appears pragmatic and suitable to many practical benchmarking problems. However, different values may be chosen according to the development of the annual BI ratio in the most recent years:

- When the annual BI ratio is erratic, it is best to eliminate rapidly the bias. In such situations, the value of ϕ should be selected in a range between 0.71 and 0.84. The minimum value 0.71 leads to a 75 percent reduction of the bias after one year.
- When the annual BI ratio shows persistent movements, it may be convenient to maintain (part of) the bias in extrapolation. A value of ϕ between 0.84 and 0.93 would serve this purpose. The maximum value 0.93 yields a 25 percent reduction of the bias after one year.

6.60 To sum up, the proportional Cholette–Dagum method with AR error method leads, on average, to more accurate extrapolation (and smaller revisions) than the Denton method when the indicator is an unbiased measurement of the ANA variable. Using the Cholette–Dagum solution, a local bias in the indicator arising in the most recent years can be adjusted through an AR convergence process from the last calculated quarterly error toward the historical BI ratio.

[20] For quarterly series, Dagum and Cholette (2006) suggest a range of values of ϕ between 0.343 and 0.729 (temporally consistent with the range [0.7; 0.9] suggested for monthly series). However, this range could lead to sizable differences between the short-term dynamics of the QNA series and the indicator.

The Cholette–Dagum method provides an automatic solution to overcome the shortcomings of the Denton method in extrapolation. Clearly, the relative performance of the Cholette–Dagum and Denton methods should be assessed on a continuous basis by comparing their QNA extrapolations with the new ANA benchmarks.

6.61 Ultimately, the choice between the Denton method (with or without adjustment for extrapolation) and Cholette–Dagum method could be a subjective call. Compilers may decide to use either of the two methods based on the properties of each benchmarking problem in the QNA. For the same variable, however, a definite choice between the two methods should be done. The same method should be used for calculating both the back series and forward series of ANA variables. Once a method is chosen for a variable, the method should be used consistently over time. Switching between Denton and Cholette–Dagum methods for the same variable may cause revisions that are difficult to explain. If a change in the method is warranted, it should be done at a time of a major revision of national accounts. The use of benchmarking methods in the QNA should be documented clearly in the metadata.

6.62 It is worth noting here that the regression-based temporal disaggregation method proposed by Chow and Lin (1971) and its variants[21] can also be considered particular cases of the Cholette–Dagum regression-based framework. The Chow–Lin method is used by some countries for the compilation of the QNA. Similar to the Cholette–Dagum solution described in this section, the Chow–Lin method assumes a first-order AR model to distribute smoothly the quarterly error and preserve as much as possible the movements of the indicator. However, this method requires that regression parameters are estimated from the data. Bad estimation of the parameters may lead to inaccurate QNA results, therefore a more careful investigation of the benchmarking results is required when using the Chow–Lin approach.[22]

6.63 When the Chow–Lin method is chosen, compilers should be aware that this approach requires expertise and statistical background to validate the results of the estimation process. Estimated parameters of the regression model should be validated using standard diagnostics (residual tests, correlation, etc.). The value of regression coefficient for the related indicator should be positive and statistically different from zero. Only one indicator should be used in the regression model, with a possible constant term to adjust for the different levels of the variables. Finally, the estimated value for the AR coefficient should be positive and sufficiently close to one to preserve the short-term dynamics of the indicator.

Specific Issues

Fixed Coefficient Assumptions

6.64 The benchmarking methodology can be used to avoid potential step problems in different areas of national accounts compilation. One important example is the frequent use of assumptions of fixed coefficients relating inputs (total or part of intermediate consumption or inputs of labor and capital) to output: input–output (IO) ratios. IO ratios or similar coefficients may be derived from annual supply and use tables, production surveys, or other internal information available. Fixed IO ratios can be considered a benchmark–indicator relationship, where the available series (usually output) is the indicator for the missing one (usually intermediate consumption) and the IO ratio (or its inverse) is the BI ratio. If IO ratios are changing from year to year but are kept constant within each year, a step problem is created. Accordingly, the Denton technique can be used to generate smooth time series of quarterly IO ratios based on annual (or less frequent) IO coefficients. The missing variable can be reconstructed by multiplying (or dividing) the quarterly IO ratios (derived by the Denton technique) by the available series. For instance, the derived quarterly IO ratios multiplied by quarterly output will provide an implicit estimate of quarterly intermediate consumption. Systematic trends can be identified to forecast IO ratios for the most recent quarters. Alternatively, the Cholette–Dagum method can be used to improve extrapolations of IO ratios based on historical behavior.

Seasonal Effects

6.65 It is possible to assign specific seasonal variations to a QNA variable when applying benchmarking. This solution may be needed when the true

[21] See Fernández (1981) and Litterman (1983).

[22] Further details on the Chow–Lin method are given in Annex 6.1.

underlying seasonal pattern in the QNA variable is not fully represented by the indicator. For example, an indicator may be available only in seasonally adjusted form, whereas the QNA variable is known to have a seasonal component. Specific seasonal effects may also be assumed in the distribution of annual coefficients, when the coefficients are subject to seasonal variations within the year. IO ratios may vary cyclically owing to inputs that do not vary proportionally with output, typically fixed costs such as labor, capital, or overhead (e.g., heating and cooling). Similarly, the ratio between income flows (e.g., dividends) and their related indicators (e.g., profits) may vary between quarters.

6.66 To incorporate a known seasonal pattern in the target QNA variable, without introducing steps in the series, the following multistep solution should be adopted:

1. Seasonally adjust the quarterly indicator. This step is needed to remove any unwanted seasonal effects in the indicator (if any) from the QNA series. Seasonal adjustment procedures should be applied using the guidelines provided in Chapter 7. Misguided attempts to correct the problem in the original data could distort the underlying trends. This step is not required if the indicator is already seasonally adjusted.
2. Multiply the seasonally adjusted indicator series by the known seasonal factors. The seasonal pattern can be fixed or variable over the years. It is convenient to impose quarterly seasonal factors that average to 1 in each year,[23] so that the underlying trend of the original indicator is not changed. Seasonal factors can also be extracted from another series through a seasonal adjustment procedure, when the seasonal behavior of that particular series is deemed to approximate the seasonality in the QNA variable.
3. Benchmark the quarterly series with superimposed seasonal effects derived at step 2 to the ANA target variable.

[23] As an example, quarterly seasonal coefficients that average to 1 are [0.97, 1.01, 0.99, 1.03]. This pattern would assume lower-than-average activity in the first (q1) and third (q3) quarters and higher-than-average activity in the second (q2) and fourth (q4) quarters.

Dealing with Difficult Benchmarking Problems

Short Series

6.67 For the back series, the Denton and Cholette–Dagum methods require a minimum of two years in the ANA variable and eight quarters in the indicator series. The results obtained with two years are in line with the stated objectives of benchmarking. For the forward series, however, two years of data may not be enough to appreciate the extrapolation accuracy of the methods. A longer period is needed to monitor the movements in the BI ratio, in order to identify possible divergence between the movements in the indicator and those in the ANA variable. When the Denton or Cholette–Dagum methods are used for extrapolation, a minimum of five years in both the ANA variable and the indicator series is recommended.

Series with Breaks

6.68 Benchmarking can produce inaccurate results when an annual variable contains a structural break in one year and the corresponding indicator does not include the same break (and vice versa).[24] The quarterly benchmarked series could indicate an incorrect timing of the start of the break and affect adjacent quarters that are not supposed to be affected. These situations typically happen when the ANA variable and the quarterly indicator have different coverage. For example, the national accounts data may include informal activities of a specific industry, while the quarterly indicator may only cover formal ones. If a break occurs in the informal sector only, the indicator will not show any change.

6.69 The first step to tackle this problem is to understand the nature of the break and verify the underlying reasons why the break does not show up consistently in the two measurements. When the break is in the ANA variable but not in the indicator, the quarterly indicator should be adjusted to match the corresponding shift in the ANA variable. The best possible measurement of the timing of the break should be done in the quarterly pattern of the adjusted indicator. When the break is in the indicator and not in the ANA variable, compilers should investigate whether the indicator is

[24] In this context, a structural break is defined as a sizeable (upward or downward) change in the level of a variable. The break can be either permanent or transitory.

still a good proxy of the ANA variable. If not, a better indicator should be identified. On the other hand, it may turn out that the break in the indicator is correct and the ANA variable is not showing the break due to a measurement error. In that case, the break should be accounted for in the compilation of the annual accounts. Compilers should also verify whether the break is permanent or transitionary, and extend the necessary adjustments to the periods affected.

Zeroes and Negative Values in the Indicator

6.70 The Denton method provides a solution to a benchmarking problem when the indicator contains nonzero values only.[25] When an indicator contains zeroes, penalty function (6) is undefined and there is no minimum satisfying the constrained minimization problem (equations (6) and (7)). For series with zeroes, the problem can be circumvented by simply replacing the zeroes with values infinitesimally close to zero (e.g., 0.001). The benchmarked series will present zeroes (or approximate zeroes) in the corresponding periods. However, the nature of the zeroes in the indicator should be investigated. If a benchmarked series is zero in a particular period, it means that the underlying national accounts transaction is either absent or zero by definition. In the former case, this result should be verified in contrast with other national accounts variables and indicators. Furthermore, movements in the neighbor quarters may be overadjusted as a result of this assumption. When the benchmarked series can only assume strictly positive values, the zeroes in the indicator could be adjusted (upward) before benchmarking to generate a strictly positive benchmarking series. Finally, the Cholette–Dagum regression-based model could be used to impose the zero values as quarterly benchmarks.

6.71 The proportional Denton method generally keeps the sign of the original value in the indicator. This feature may be considered a positive outcome of benchmarking from compilers when both positive and negative values are acceptable in the QNA series. However, for series with both negative and positive values, the Denton method may introduce spurious movements in the benchmarked series nearby the change of sign and amplify the original movements shown by the indicator. This may be seen as undesirable when the annual movements are smooth and the national accounts variable is required to be positive. A numerical illustration of this problem is given in Example 6.4 and Figure 6.4.

6.72 To overcome such problem, the indicator should be transformed in such a way that it shows strictly positive values only and its additive changes are all maintained. The following transformation procedure can be used:

a. Calculate the quarterly additive bias of the indicator in relation to the annual series: that is, the average difference between the sum of the quarterly values of the indicator and the sum of the annual benchmarks.

b. Derive a bias-adjusted indicator by subtracting the quarterly additive bias from the original values.

c. If the bias-adjusted indicator still presents negative values, remove the negative values by adding to the series the minimum value in absolute terms multiplied by two. This step makes the transformed indicator strictly positive. The minimum value of the transformed indicator will correspond to the minimum value of the bias-adjusted indicator taken in absolute terms. This transformation modifies the percentage growth rates, but maintains the same additive changes in all the quarters.

An example of this solution is shown in Example 6.4 and Figure 6.4. The best approach for dealing with series with negative and positive values is to compare the proportional Denton benchmarking results using the original indicator and the transformed indicator, and select the solution which seems more sensible in the national accounts and guarantees better consistency with other variables of the QNA system.

6.73 For series with negative and positive values that are derived as differences between two nonnegative series, the problem can be avoided by applying the proportional Denton method to the nonnegative components of the difference rather than to the difference itself. One possible example is changes in inventories, where benchmarking can be applied to the opening and closing of inventory levels rather than to the change.

[25] Annual benchmarks can contain zeroes.

Example 6.4 Benchmarking Series with Positive and Negative Values: Use of Strictly Positive Indicators

	Indicator		Proportional Denton Method		Transformed Indicator		Proportional Denton Method using the Transformed Indicator	
	Level	Quarter-to-Quarter Rate of Change	Benchmarked Series	Quarter-to-Quarter Rate of Change	Level	Quarter-to-Quarter Rate of Change	Benchmarked Series	Quarter-to-Quarter Rate of Change
q1 2010	20.0		107.8		94.6		67.8	
q2 2010	15.0	–25.0	64.5	–40.2	89.6	–5.3	63.6	–6.3
q3 2010	10.0	–33.3	23.9	–62.9	84.6	–5.6	58.8	7.5
q4 2010	–60.0	–700.0	3.7	–84.5	14.6	–82.8	9.8	–83.3
2010	–15.0		200.0		283.3		200.0	
q1 2011	10.0	–116.7	7.6	104.4	84.6	480.0	55.1	460.8
q2 2011	20.0	100.0	29.8	294.5	94.6	11.8	61.2	11.0
q3 2011	45.0	125.0	92.8	211.1	119.6	26.4	79.0	29.2
q4 2011	75.0	66.7	169.8	82.8	149.6	25.1	104.7	32.4
2011	150.0		300.0		448.3		300.0	
q1 2012	90.0	20.0	166.1	–2.1	164.6	10.0	126.6	21.0
q2 2012	100.0	11.1	151.8	–8.6	174.6	6.1	143.7	13.5
q3 2012	110.0	10.0	141.8	–6.6	184.6	5.7	158.7	10.4
q4 2012	120.0	9.1	140.3	–1.0	194.6	5.4	171.0	7.7
2012	420.0		600.0		718.3		600.0	

Negative Values in the Indicator and Growth Rates

In column 1, the indicator presents a negative value in q4 2010 (–60). The growth rate for q1 2011

[10–(–60)]/–60 = –1.167 ⇒ – 116.7%

is misleading because it would signal negative growth while the series increases from –60 to 10.

Derive a Bias-Adjusted, Strictly Positive Indicator

The following procedure produces a bias-adjusted indicator with strictly positive values:

1. Calculate the quarterly additive bias of the indicator in relation to the annual series, that is, the average difference between the sum of the quarterly values of the indicator and the sum of the annual benchmarks:

Sum of quarterly values: 20 + 15 + 10 – 60 + … + 120 = 555
Sum of annual benchmarks: 200 + 300 + 600 = 1,100
Quarterly additive bias: (555 – 1,100)/12 = –45.4.

2. Derive a bias-adjusted indicator by subtracting the quarterly additive bias from the original values:

q1 2010: 20 – (–45.4) = 65.4
q2 2010: 15 – (–45.4) = 60.4
q3 2010: 10 – (–45.4) = 55.4
q4 2010: –60 – (–45.4) = –14.6, and so forth.

3. If the bias-adjusted indicator still contains negative values, transform the series by adding the minimum value in absolute terms multiplied by two, that is,

q1 2010: 65.4 + (2 × 14.6) = 94.6
q2 2010: 60.4 + (2 × 14.6) = 89.6
q3 2010: 55.4 + (2 × 14.6) = 84.6
q4 2010: –14.6 + (2 × 14.6) = 14.6, and so forth.

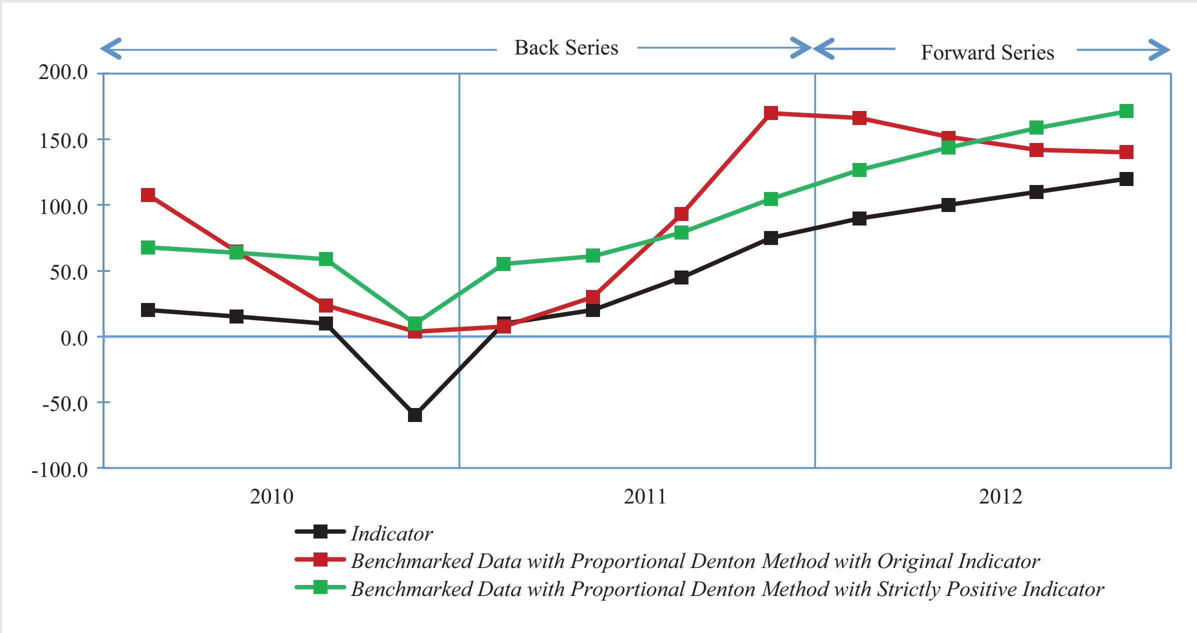
The minimum value in the transformed indicator (column 3) is the minimum value of the bias-adjusted indicator taken in absolute terms (14.6 in q4 2010). Note that the transformation modifies the growth rates, but the additive changes of the transformed indicator are equal to those of the original indicator in all quarters.

Annual Benchmarks with Strictly Positive Values

In this example, the annual benchmarks are positive and all distant from zero (200 in 2010, 300 in 2011, and 600 in 2012). It is reasonable to assume that the quarterly values are also strictly positive. Applying the proportional Denton method with the original indicator (column 2) would force the quarterly benchmarked series to change the movements around q4 2010 (see Figure 6.4). Conversely, the proportional Denton method with the bias-adjusted, strictly positive indicators (column 4) produces a benchmarked series that correctly reproduce the additive changes and is consistent with the patterns of the original indicator.

(These results are illustrated in Figure 6.4. Rounding errors in the table may occur.)

Figure 6.4 Solution to Positive and Negative Values: Use of Strictly Positive Indicators



6.74 Solutions for negative values may work under certain circumstances, but may fail in others. No matter how good the method is, a new combination of negative and positive values may appear in the data that can create discontinuity in the series. Benchmarking problems with negative and positive values should always be treated with care.

Benchmarking Without a Related Indicator

6.75 Quarterly values may have to be derived by using mathematical techniques that distribute the annual values into quarters without using a related quarterly indicator. These techniques should be avoided as much as possible in the compilation of QNA series because they do not reflect the true movements in the economy. These situations should be prevented when the QNA system is put in place by defining an appropriate level of detail of the ANA variables, taking into account the quarterly sources available from data providers. Benchmarking without a related indicator is acceptable only for series that move smoothly from one quarter to the next. Moreover, the size of the variable should be contained in order to reduce its impact on the levels of GDP and other main aggregates. A possible example of a stable series is consumption of fixed capital (when capital formation is fairly stable). In such cases, the ANA series should be interpolated in a way such that the quarterly values provide movements that are as stable as possible. This approach minimizes the impact of these items on the dynamics arising from the rest of the accounts.

6.76 The optimal method is provided by the interpolation technique suggested by Boot, Feibes and Lisman (1967). The Boot–Feibes–Lisman method looks for the quarterly values that minimize the sum of squares of the difference between successive quarters:

$$\min_{X_t} \sum_{t=2}^{4y} \left[X_t - X_{t-1}\right]^2 \tag{16}$$

subject to the annual constraints

$$\sum_{t=4n-3}^{4n} X_t = A_n \qquad \text{for } n = 1, \ldots, y.$$

6.77 Conveniently, the Boot–Feibes–Lisman solution can be derived by applying the proportional

Denton method with a constant indicator. If we assume $I_t = C$, penalty function (6) becomes

$$\min_{X_t} \sum_{t=2}^{4y} \left[\frac{X_t}{C} - \frac{X_{t-1}}{C} \right]^2 \Leftrightarrow \frac{1}{C^2} \min_{X_t} \sum_{t=2}^{4y} \left[X_t - X_{t-1} \right]^2,$$

which corresponds to the penalty function minimized by the Boot–Feibes–Lisman shown in equation (16) multiplied by a constant factor (which does not change the solution of the minimization problem). When extrapolations are needed, the quarterly variable can be extrapolated based on time-series models (see Chapter 10). Alternatively, an annual forecast of the next benchmark could be included in the benchmarking process. In both cases, because the variable is expected to be highly predictable, revisions to QNA variables would be very limited in future releases.

Benchmarking and Compilation Procedures

6.78 Benchmarking should be an integral part of the compilation process and should be conducted at the most detailed compilation level. In practice, this may imply benchmarking different series in stages, where data for some series—which have already been benchmarked—are used to estimate other series, followed by a second or third round of benchmarking. The actual arrangements will vary depending on the particularities of each case.

6.79 As an illustration, annual data may be available for all products, but quarterly data are available only for the main products. If it is decided to use the sum of the quarterly data as an indicator for the other products, the ideal procedure would be first to benchmark each of the products for which quarterly data are available to the annual data for that product, and then to benchmark the quarterly sum of the benchmarked estimates for the main products to the total. Of course, if all products were moving in similar ways, this would give similar results to directly benchmarking the quarterly total to the annual total.

6.80 In other cases, a second or third round of benchmarking may be avoided and compilation procedure simplified. For instance, a current price indicator can be constructed as the product of a quantity indicator and a price indicator without first benchmarking the quantity and price indicators to any corresponding annual benchmarks. Similarly, a volume indicator can be constructed as a current price indicator divided by a price indicator without first benchmarking the current price indicator. Also, if output at constant prices is used as an indicator for intermediate consumption, the (unbenchmarked) constant price output indicator can be benchmarked to the annual intermediate consumption data directly. It can be shown that the result is identical to first benchmarking the output indicator to annual output data, and then benchmarking the resulting benchmarked output estimates to the annual intermediate consumption data.

6.81 To derive quarterly constant price data by deflating current price data, the correct procedure would be first to benchmark the quarterly current price indicator and then to deflate the benchmarked quarterly current price data. If the same price indices are used in the annual and quarterly accounts, the sum of the four quarters of constant price data should be taken as the annual estimate, and a second round of benchmarking is unnecessary. As explained in Chapter 8, annual deflators constructed as unweighted averages of monthly or quarterly price data can introduce an aggregation over time error in the annual deflators and subsequently in the annual constant price data that can be significant if there is quarterly volatility. Moreover, if, in those cases, quarterly constant price data are derived by benchmarking a quarterly constant price indicator derived by deflating the current price indicator to the annual constant price data, the aggregation over time error will be passed on to the implicit quarterly deflator, which will differ from the original price indices. Thus, in those cases, annual constant price data should in principle be derived as the sum of quarterly or even monthly deflated data if possible. If quarterly volatility is insignificant, however, annual constant price estimates can be derived by deflating directly and then benchmarking the quarterly constant price estimates to the annual constant price estimates.

6.82 Finally, benchmarking can be performed before or after seasonal adjustment. When benchmarking is applied on the unadjusted data only, seasonal adjustment is performed on the results of benchmarking (i.e., the benchmarked series). On the other hand, seasonal adjustment can be done prior to benchmarking when the seasonal adjustment method is applied to the short-term indicators (monthly or quarterly). In this case, the seasonally adjusted indicator should be benchmarked to the annual accounts. Chapter 7 discusses in more details about benchmarking of seasonally adjusted data.

Benchmarking and Revisions

6.83 To avoid introducing distortions in the series, incorporation of new annual data for one year will generally require revision of previously published quarterly data for several years. Benchmarking methods with movement preservation (like the Denton method and the Cholette–Dagum method) minimize the impact of revisions on the historical movements of the QNA series. In principle, previously published QNA estimates for all preceding and following years may have to be adjusted to maximally preserve the short-term movements in the indicator, if the errors in the indicator are large. In practice, however, with most benchmarking methods, the impact of new annual data will gradually be diminishing and zero for sufficiently distant periods.

6.84 Ideally, revisions to quarterly indicators should be incorporated in the QNA series as soon as possible to reflect the most up-to-date short-term information available. This is particularly relevant for the forward series, which should immediately incorporate revisions to preliminary values of the indicators for the previous quarters on the basis of more up-to-date and comprehensive source data. If revisions to preliminary information in the current year are disregarded, the QNA may easily lead to biased extrapolations for the next years. For the back series, revisions to previous years of the indicator should be reflected in the QNA series at the time when revisions to new or revised ANA benchmarks are incorporated.

6.85 Revisions to some previously published QNA estimates can be avoided by freezing the quarterly values for those periods. This practice should be defined clearly in the revision policy of QNA data and not be changed from one quarter to the next without advance communication to users. To avoid introducing significant distortions to the benchmarked series, however, at least two to three years preceding (and following) years should be allowed to be revised each time new annual data become available. In general, the impact on more distant years will be negligible.

Reconciliation of QNA Series

6.86 The benchmarking methods discussed in this chapter adjust one indicator at a time to generate quarterly values in line with corresponding ANA benchmarks. The benchmarking adjustment process is applied individually to each variable and does not take into account any accounting relationship between the QNA series. Consequently, the benchmarked quarterly series may not automatically form a consistent set of accounts. For example, the independently derived quarterly estimates of GDP from the production side may differ from the independently derived quarterly estimates of GDP from the expenditure side, even though the annual data are consistent. Another example is when quarterly totals derived from estimates by institutional sector differ from the same quarterly totals derived from estimates by economic activity. Finally, quarterly discrepancies may arise when seasonal adjustment is applied directly to both QNA components and aggregates (see Chapter 7 for more details on the direct versus indirect seasonally adjusted approaches).

6.87 Quarterly inconsistencies between QNA series should be addressed and resolved at the various stages of QNA compilation. Discrepancies can be minimized by using coherent (when not equal) quarterly indicators for production, expenditure, and income flows pertaining to the same industry or product. Large discrepancies indicate that there are large inconsistencies between the short-term movements of interconnected QNA series. Some discrepancies in the accounts can also be eliminated in the compilation stage by benchmarking (or seasonally adjusting) different parts of the accounts at the most detailed level and building aggregates from the benchmarked (or seasonally adjusted) components. The discrepancies that remain after this careful investigation process should be eliminated using automatic adjustment procedures.

6.88 This section presents statistical methods to transform a set of quarterly indicators into a consistent system of QNA series that satisfy both annual constraints and quarterly constraints. These methods are called reconciliation methods. The annual constraints are those from the ANA system and correspond to the same ANA totals considered for benchmarking. The quarterly constraints are linear, contemporaneous aggregations[26] of the QNA series. These can be of two different types:[27]

- *Endogenous constraints.* In the national accounts there are endogenous accounting restrictions that should be met by the variables at any frequency: for example, the sum of gross output and imports of a product should be equal to the sum of final and intermediate uses of that product (net of valuation and adjustment items) or the difference of gross output and intermediate consumption is equal to gross value added. These identities can be added as quarterly accounting restrictions between the variables involved in the constrained minimization problem.
- *Exogenous constraints.* These are usually QNA aggregates that are independently derived from the system under adjustment. For example, quarterly estimates of value added by institutional sectors can be adjusted so that their sum is equal to quarterly gross value added for the total economy derived by economic activity. It has to be noted that exogenous constraints must satisfy the set of annual constraints. In the example above, the annual total gross value added by industry must be equal to the annual total gross value added by institutional sector. A numerical illustration of a three-variable QNA system with an independently derived quarterly sum is shown in Example 6.5.

6.89 In the QNA, the main objectives of reconciliation are as follows:

- to provide quarterly data that are (i) temporally consistent with the ANA data that is such that the sum (or the average) of the quarterly data is equal to the annual benchmark and, at the same time, (ii) consistent with (endogenous and exogenous) quarterly constraints that is such that linear combinations of the quarterly adjusted data are equal to given values available in every observed quarter; and
- to preserve as much as possible the quarterly movements in the indicator under the restrictions provided by the ANA data and the quarterly aggregation constraints.

6.90 Differently from benchmarking, reconciliation methods have to satisfy quarterly constraints in extrapolation. The forward series return quarterly values that are consistent with the quarterly extrapolated constraints. When there are exogenous constraints, they should always include estimates for the extrapolated quarters (either derived with the enhanced Denton method or the Cholette–Dagum method with AR error). The variables of the system will be extrapolated in accord with the quarterly extrapolated constraints. When there are endogenous constraints only, the individual variables of the system should be first extrapolated using the preferred univariate method for extrapolation. The extrapolated QNA variables can then be used as input series of the reconciliation methods.

6.91 Given the stated objectives of reconciliation, the multivariate proportional Denton method is the best solution for deriving QNA series subject to both annual and quarterly constraints (see paragraph 6.93). The penalty function is a multivariate extension of the univariate proportional Denton method to include all the quarterly series in the system. In addition, the constrained minimization problem is augmented to include the endogenous and exogenous quarterly constraints of the QNA system.

6.92 When the dimension of the system is too large, it may become difficult to apply the multivariate Denton approach using standard algorithms. For large QNA systems, a convenient two-step reconciliation procedure could be used to approximate the results of the optimal multivariate Denton method. This two-step procedure is based on the application of the proportional Denton method for each individual series at the first step, and a least-squares adjustment of the system of benchmarked series one year at a time as the second step (paragraph 6.97).

[26] Contemporaneous means that the quarterly constraints refer to the current quarter only (no lead or lagged relationships). It is also assumed that these quarterly relationships are linear combination of the variables. Nonlinear restrictions between the variables may also be useful in the adjustment process (e.g., between price and volume measures, or unadjusted and seasonally adjusted series), but they are not dealt with in this presentation for the sake of simplicity.

[27] This manual considers only quarterly binding constraints. Quarterly constraints are nonbinding when they are subject to changes in the reconciliation process.

Example 6.5 A Small Reconciliation Problem

		QNA Components			Sum QNA Components	QNA Aggregate	*Quarterly Discrepancies (%)*
		(a)	(b)	(c)	(5)	(6)	*[(6) – (5)]/(6)*
q1 2010		7.0	18.0	1.5	26.5	**27.1**	*2.2*
q2 2010		7.2	19.5	1.8	28.5	**29.8**	*4.3*
q3 2010		8.1	19.0	2.0	29.1	**29.9**	*2.7*
q4 2010		7.5	19.7	2.5	29.7	**31.2**	*4.9*
2010 QNA	(1)	29.8	76.2	7.8	113.8	118.0	
2010 ANA	**(2)**	**30.0**	**80.0**	**8.0**	118.0	118.0	
Annual Discrepancies (%)	*[(1) – (2)]/(2)*	*–0.7*	*–4.8*	*–2.5*	*–3.6*	*0.0*	
q1 2011		8.5	18.5	2.0	29.0	**29.3**	*1.1*
q2 2011		7.8	19.0	1.5	28.3	**27.9**	*–1.3*
q3 2011		8.1	20.3	1.7	30.1	**30.9**	*2.6*
q4 2011		8.4	20.0	2.0	30.4	**31.7**	*4.2*
2011 QNA	(3)	32.8	77.8	7.2	117.8	119.9	
2011 ANA	**(4)**	**30.6**	**81.2**	**8.1**	119.9	119.9	
Annual Discrepancies (%)	*[(3) – (4)]/(4)*	*7.2*	*–4.2*	*–11.1*	*–1.8*	*0.0*	

Reconciliation Problem

The example consists of three QNA components a, b, and c that have to be reconciled with their corresponding annual benchmarks and an independent quarterly sum. The quarterly sum is considered a more accurate estimate of the total than the sum of the individual components. The annual and quarterly series are available for the years 2010 and 2011. Note the relative size of the three variables, with the largest variable (b) being about 10 times larger than the smallest variable (c).

The preliminary QNA components show both annual and quarterly discrepancies. For example, the sum of the quarterly values for component b in 2010 (76.2) is 4.8 percent lower than the ANA benchmark for 2010 (80.0). At the same time, the contemporaneous sum of the quarterly components differs from the quarterly values of the independent sum. For 2010,

q1 2010:	7.0 + 18.0 + 1.5 = 26.5	≠	27.1
q2 2010:	7.2 + 19.5 + 1.8 = 28.5	≠	29.8
q3 2010:	8.1 + 19.0 + 2.0 = 29.1	≠	29.9
q4 2010:	7.5 + 19.7 + 2.5 = 29.7	≠	31.2

Note also that the QNA aggregate is in line with the sum of the ANA benchmarks. For example, the sum of the quarterly total and the sum of the ANA benchmarks are both 118.0 in 2010 and 119.9 in 2011. This consistency is a prerequisite for running any reconciliation methods. Low-frequency variables should satisfy any high-frequency relationships defined for the variables.

The Multivariate Proportional Denton Method

6.93 The multivariate proportional Denton method[28] derives the quarterly values that keep the ratio of the reconciled series to the indicators as constant as possible subject to the given annual and quarterly constraints. In mathematical terms, the multivariate proportional Denton method minimizes the constrained minimization problem:

$$\min_{X^R_{j,t}} \sum_{j=1}^{m} \sum_{t=2}^{4y} \left[\frac{X^R_{j,t}}{I_{j,t}} - \frac{X^R_{j,t-1}}{I_{j,t-1}} \right]^2 \qquad (17)$$

subject to both ANA constraints

$$\sum_{t=4n-3}^{4n} X^R_{j,t} = A_{j,n} \qquad \text{for } n = 1,\ldots,y \text{ and } j = 1,\ldots,m \quad (18)$$

and quarterly contemporaneous constraints

$$\sum_{j=1}^{m} c_{h,j} X^R_{j,t} = T_{h,t} \qquad \text{for } h = 1,\ldots,k \text{ and } t = 1,\ldots,4y \quad (19)$$

[28] The multivariate extension of the proportional Denton method (and its solution in matrix notation) is presented in Di Fonzo and Marini (2011).

where

m is the number of QNA series in the system to be adjusted,

j is the generic index for a QNA series,

k is the number of quarterly relationships between the QNA series,

h is the generic index for a quarterly relationship,

$X^R_{j,t}$ is the level of the QNA reconciled series j for quarter t,

$I_{j,t}$ is the level of the quarterly indicator j for quarter t,

$A_{j,n}$ is the level of the ANA benchmark j for year n,

$c_{h,j}$ is the coefficient of component j in the quarterly constraint h,

$T_{h,t}$ is the level of the quarterly constraint h for quarter t, and

t, n, and y are defined in equation (2).

6.94 The target values of the constrained minimization problem (equations (17)–(19)) are the quarterly values of the m series of the QNA system (specifically a total of $4y \cdot m$ values to be determined). The penalty function is designed to preserve the overall movement in the indicators used in the QNA system. The minimization problem allows for as many quarterly relationships as are established between the QNA series (for a single quarterly relationship, $k = 1$).

6.95 Coefficients $c_{h,j}$ and the constraint values $T_{h,t}$, for $h = 1,...,k$, define the type of quarterly relationships between the variables. For example, when the sum of QNA components (e.g., value added by economic activity) matches an independently derived aggregate estimate (e.g., value added by institutional sector), the values $c_{h,j}$ are equal to 1 for any j and $T_{h,t}$ is the value of the aggregate estimate for quarter t. For national accounts applications, the values of $c_{h,j}$ can be 1 (addition to the aggregate), −1 (subtraction to the aggregate), or 0 (not included in the aggregate).

6.96 As for benchmarking, the reconciled series $X^R_{j,t}$ are derived as the solution of the constrained minimization problem (equations (17)–(19)). The multivariate Denton method is illustrated in Example 6.6.

Example 6.6 The Multivariate Proportional Denton Method

	Reconciled QNA Components			Sum QNA Components	QNA Aggregate	*Quarterly Discrepancies (%)*
	(a)	(b)	(c)	(5)	(6)	*[(6) – (5)]/(6)*
q1 2010	7.1	18.5	1.5	27.1	**27.1**	*0.0*
q2 2010	7.3	20.6	1.8	29.8	**29.8**	*0.0*
q3 2010	8.1	19.8	2.0	29.9	**29.9**	*0.0*
q4 2010	7.4	21.1	2.6	31.2	**31.2**	*0.0*
2010 QNA	30.0	80.0	8.0	118.0	118.0	
2010 ANA	**30.0**	**80.0**	**8.0**	118.0	118.0	
q1 2011	8.1	19.1	2.2	29.3	**29.3**	*0.0*
q2 2011	7.2	19.1	1.7	27.9	**27.9**	*0.0*
q3 2011	7.5	21.4	1.9	30.9	**30.9**	*0.0*
q4 2011	7.8	21.6	2.3	31.7	**31.7**	*0.0*
2011 QNA	30.6	81.2	8.1	119.9	119.9	
2011 ANA	**30.6**	**81.2**	**8.1**	119.9	119.9	

Solution with the Multivariate Proportional Denton Method

The multivariate proportional Denton method adjusts the QNA components to meet both temporal and cross-sectional benchmarks in one step. The ratios between the reconciled QNA components and the preliminary QNA indicators (reconciled-to-indicator ratios) are presented in Example 6.9. The annual discrepancies are removed in a way so that the overall movement in the preliminary estimates of the QNA components is preserved. The quarterly discrepancies are distributed in proportion to the size of the preliminary QNA variables. These characteristics are more visible by looking at the results of the two-step reconciliation procedure (presented in Examples 6.7. and 6.8), which is an approximation of the multivariate proportional Denton method.

A Two-Step Reconciliation Procedure

6.97 When the dimension of the system is too large, it could become time consuming, or even inefficient, to solve the constrained minimization problem (equations (17)–(19)). A convenient approximation of the multivariate Denton method can be achieved using the following two-step procedure:[29]

- Benchmarking each of the m indicators to the corresponding ANA benchmarks using the univariate proportional Denton method. The first step provides temporally consistent QNA series, but it is likely to leave inconsistency in the quarterly benchmarked series toward the quarterly accounting constraints.
- For each year separately, balancing the quarterly benchmarked series obtained at the first step to both annual and quarterly constraints relevant to the year. The balancing procedure is performed using a least-square adjustment. The second step splits the full system observed over the available span of years into y small systems covering one year at a time.

6.98 The first step is straightforwardly achieved by applying the univariate Denton method to the m variables in the system: that is, by solving the m constrained minimization problems:

$$\min_{X^B_{j,t}} \sum_{t=2}^{q} \left[\frac{X^B_{j,t}}{I_{j,t}} - \frac{X^B_{j,t-1}}{I_{j,t-1}} \right]^2 \quad \text{for } j = 1,\ldots,m \tag{20}$$

subject to

$$\sum_{t=4n-3}^{4n} X^B_{j,t} = A_{j,n} \qquad \text{for } n = 1,\ldots, y\,. \tag{21}$$

where

$X^B_{j,t}$ is the level of the QNA benchmarked series j for quarter t to the corresponding ANA benchmarks.

6.99 The second step is needed to restore the contemporaneous consistency in the benchmarked series $X^B_{j,t}$ obtained at the first step. Because they are derived using the Denton method, movements in the indicator are already preserved in the $X^B_{j,t}$. Therefore, in the second step, there is no need to preserve again movements in the objective function. A simple least-squares adjustment of the $X^B_{j,t}$ values is sufficient to fulfill both the annual and quarterly constraints. Moreover, this adjustment can be done for each year separately, because the movement between one year and the next is already preserved by the benchmarked series.

6.100 Taking a generic year n, the second step is given by the least-squares solution of the constrained minimization:

$$\min_{X^R_{j,t}} \sum_{j=1}^{m} \sum_{t=4n-3}^{4n} \left[\frac{X^R_{j,t} - X^B_{j,t}}{X^B_{j,t}} \right]^2 \tag{22}$$

subject to

$$\sum_{t=4n-3}^{4n} X^R_{j,t} = A_{j,n} \qquad \text{for } n = 1,\ldots, y \tag{23}$$

and

$$\sum_{j=1}^{m} c_{h,j} X^R_{j,t} = T_{h,t}$$
$$\text{for } h = 1,\ldots,k \text{ and } t = 4n-3,\ldots,4n \tag{24}$$

where

$X^R_{j,t}$ is the level of the QNA reconciled series j for quarter t that satisfy both the corresponding ANA benchmarks $A_{j,n}$ and the quarterly accounting relationships.

6.101 Penalty function (22) shows that the discrepancies $(X^R_{j,t} - X^B_{j,t})$ are distributed in proportion to the level of the benchmarked series.[30] The relative size of the variables determines the amount of discrepancy to be distributed. The largest variables are

[29] Two-step reconciliation procedures are discussed in Quenneville and Fortier (2012). The approximation of the multivariate Denton method of the proposed two-step solution is illustrated with real-life examples in Di Fonzo and Marini (2011).

[30] From a statistical viewpoint, taking the level of the benchmarked series at the denominator in function corresponds to assuming equal reliability of all variables (notwithstanding their relative size). An alternative solution for the second step has been suggested in Quenneville and Rancourt (2005), which takes the square root of the benchmarked series as normalizing factor of the discrepancy $(X^R_{j,t} - X^B_{j,t})$. This assumption assumes that large variables are relatively more reliable than small variables, and therefore are touched less in the second step of the procedure.

Example 6.7 Two-Step Reconciliation Procedure: Univariate Benchmarking Step

	Benchmarked QNA Components			Sum QNA Components	QNA Aggregate	*Quarterly Discrepancies (%)*
	(a)	(b)	(c)	(5)	(6)	*[(6) – (5)]/(6)*
q1 2010	7.2	18.9	1.5	27.6	**27.1**	*–1.8*
q2 2010	7.3	20.5	1.8	29.6	**29.8**	*0.5*
q3 2010	8.1	19.9	2.1	30.1	**29.9**	*–0.8*
q4 2010	7.4	20.6	2.6	30.7	**31.2**	*1.8*
2010 QNA	30.0	80.0	8.0	118.0	118.0	
2010 ANA	**30.0**	**80.0**	**8.0**	118.0	118.0	
q1 2011	8.1	19.3	2.2	29.7	**29.3**	*–1.1*
q2 2011	7.3	19.8	1.7	28.8	**27.9**	*–3.2*
q3 2011	7.5	21.2	1.9	30.6	**30.9**	*1.1*
q4 2011	7.7	20.8	2.3	30.8	**31.7**	*2.8*
2011 QNA	30.6	81.2	8.1	119.9	119.9	
2011 ANA	**30.6**	**81.2**	**8.1**	119.9	119.9	

Example 6.8 Two-Step Reconciliation Procedure: Balancing Step

	Reconciled QNA Components			Sum QNA Components	QNA Aggregate	*Quarterly Discrepancies (%)*
	(a)	(b)	(c)	(5)	(6)	*[(6) – (5)]/(6)*
q1 2010	7.1	18.5	1.5	27.1	**27.1**	*0.0*
q2 2010	7.3	20.6	1.8	29.8	**29.8**	*0.0*
q3 2010	8.1	19.7	2.0	29.9	**29.9**	*0.0*
q4 2010	7.4	21.1	2.6	31.2	**31.2**	*0.0*
2010 QNA	30.0	80.0	8.0	118.0	118.0	
2010 ANA	**30.0**	**80.0**	**8.0**	118.0	118.0	
q1 2011	8.1	19.1	2.2	29.3	**29.3**	*0.0*
q2 2011	7.2	19.1	1.7	27.9	**27.9**	*0.0*
q3 2011	7.5	21.5	1.9	30.9	**30.9**	*0.0*
q4 2011	7.8	21.6	2.3	31.7	**31.7**	*0.0*
2011 QNA	30.6	81.2	8.1	119.9	119.9	
2011 ANA	**30.6**	**81.2**	**8.1**	119.9	119.9	

Solution with the Two-Step Reconciliation Procedure

In the first step (Example 6.7), each QNA component is benchmarked to the 2010 and 2011 annual benchmarks using the univariate proportional Denton method. This step removes the temporal discrepancies, but still leaves difference between the sum of the quarterly benchmarked series and the QNA aggregate.

In the second step (Example 6.8), the benchmarked series are adjusted to comply with both the annual constraints and the QNA aggregate values for each year separately. This adjustment is performed using a least-squares procedure which takes the value of the temporally benchmarked series as a normalizing factor of the discrepancy to be distributed.

Example 6.9 Results from Multivariate Denton Method and Two-Step Procedure

	Multivariate Denton Method			Two-Step Reconciliation Procedure								
	Reconciled-to-Indicator Ratios			Reconciled-to-Indicator Ratios			Benchmarking Step (BI Ratios)			Balancing Step (Reconciled-to-Benchmark Ratios)		
	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
q1 2010	1.016	1.027	0.998	1.015	1.027	0.999	1.024	1.051	1.002	0.992	0.977	0.998
q2 2010	1.020	1.057	1.009	1.020	1.058	1.009	1.017	1.051	1.009	1.003	1.006	1.000
q3 2010	1.000	1.040	1.024	1.001	1.039	1.024	1.004	1.050	1.026	0.997	0.990	0.998
q4 2010	0.993	1.073	1.055	0.993	1.073	1.055	0.984	1.048	1.052	1.009	1.024	1.002
q1 2011	0.950	1.031	1.090	0.951	1.031	1.089	0.957	1.046	1.091	0.994	0.985	0.998
q2 2011	0.920	1.004	1.116	0.923	1.003	1.115	0.936	1.044	1.120	0.986	0.961	0.996
q3 2011	0.929	1.057	1.140	0.928	1.057	1.141	0.923	1.043	1.140	1.005	1.014	1.001
q4 2011	0.932	1.080	1.153	0.929	1.081	1.155	0.916	1.042	1.150	1.014	1.037	1.004

Reconciled-to-Indicator Ratios

The reconciled-to-indicator ratios of the multivariate Denton method and of the two-step reconciliation procedure are presented in the table. It can be seen that the ratios of the two-step procedure are very close to those from the multivariate Denton approach.

The table also presents the ratios of the benchmarked series to the indicator series obtained at the first step (i.e., the BI ratio) and the ratios of the reconciled series obtained at the second step and the benchmarked series obtained at the first step (reconciled-to-benchmark ratios). As seen in the benchmarking section, the BI ratios obtained using the Denton method move smoothly between the quarters. Instead, the reconciled-to-benchmark ratios show that the quarterly discrepancies—reported in the last three columns of Example 6.9—are distributed in proportion to the size of the variable. In fact, most of the quarterly discrepancy for each quarter is assigned to component b, which is the largest variable in the system, while component c gets the smallest portion.

those receiving the highest portion of contemporaneous discrepancy.

6.102 The solutions to systems (equations (22)–(24)) for all the available years (i.e., $n=1,\dots,y$) generate quarterly reconciled series $X^R_{j,t}$ that are close approximations of the optimal solution provided by the multivariate Denton proportional method. An illustration of the two-step procedure is given in Examples 6.7 and 6.8. The results from the multivariate Denton method and the two-step procedure are compared in Example 6.9 using the ratios between the reconciled series $X^R_{j,t}$, the benchmarked series $X^B_{j,t}$, and the indicators $I_{j,t}$.

Summary of Key Recommendations

- *When quarterly indicators are of inferior quality than annual data, benchmarking methods should be used to derive QNA series that (i) are temporally consistent with the ANA benchmarks, (ii) preserve as much as possible the quarterly movements in the indicators, and (iii) provide accurate extrapolations for the current year.*
- *The pro rata method is not an appropriate method for benchmarking QNA series, because it may distort the quarter-to-quarter movement in the first quarter of each year.*
- *The preferred option for benchmarking QNA series is the proportional Denton method. The enhanced Denton formula for extrapolation could be used in place of the basic Denton method to improve the QNA estimates for the current year. This method requires a forecast of the next annual BI ratio, which should be determined externally by the user looking at the development of the annual BI ratio series.*
- *As an alternative to the Denton method, the proportional Cholette–Dagum method with first-order AR error could be used to obtain bias-adjusted QNA extrapolations based on historical behavior. The recommended value of the AR parameter is 0.84, or alternatively chosen in a range between 0.71 and 0.93, depending on the*

movements in the BI ratio. These values guarantee that movements in the indicator are adequately preserved for the back series.

- *The Denton method and Cholette–Dagum method should be tested on the specific benchmarking cases in the QNA. The method providing the most accurate results should be chosen. Ultimately, the choice between the two methods could be a subjective call. The same method should be used for calculating both the back series and the forward series of the same variable. Once a method is chosen for a variable, the method should be used consistently over time.*
- *For reconciliation problems, the multivariate proportional Denton method should be used for deriving a system of QNA series subject to both annual and quarterly constraints.*
- *When the dimension of the QNA system is too large to be solved efficiently in one step, the following two-step procedure may be used to approximate the optimal results of the multivariate Denton method:*
  - *benchmarking each quarterly indicator to the corresponding ANA benchmarks using the proportional Denton method and*
  - *for each year separately, balancing the quarterly benchmarked series obtained at the first step using a least-squares procedure that proportionally adjusts the original values to realign them with both annual and quarterly constraints relevant to the year.*

Annex 6.1 Benchmarking Methods

A6.1 Benchmarking refers to the procedures used to maintain consistency among the time series available at different frequencies for the same target variable. In the QNA, benchmarking usually consists of adjusting quarterly data to match annual (or quinquennial) benchmarks. [31] Quarterly values of indicators are modified so that the annual sums (or average) of the adjusted values are equal to the corresponding ANA benchmarks, which are considered the more comprehensive and accurate measurement in level of national accounts variables.

A6.2 Benchmarking methods can be grouped into two main approaches: the numerical approach and the model-based approach. Numerical methods determine the target values as the solution of an ad hoc constrained optimization problem, where an objective function is defined to preserve some characteristics of the original information available. Examples of numerical methods preserving the movements in the indicator are the benchmarking methods proposed by Denton (1971) and Monsour and Trager (1979). This group also includes mathematical solutions to decompose annual data into consistent quarterly data without the use of a quarterly related indicator, such as the methods by Lisman and Sandee (1964) and Boot, Feibes and Lisman (1967).

A6.3 Model-based benchmarking methods perform the adjustment under the assumption of a statistical model for the unknown values to be determined. Model-based benchmarking methods encompass ARIMA[32] model-based methods of Hillmer and Trabelsi (1987), regression-based methods proposed by Cholette and Dagum (1994), and state space models of Durbin and Quenneville (1997). In addition, Chow and Lin (1971) proposed a multivariable general least-squares regression approach for interpolation, distribution, and extrapolation of time series. [33] While not a benchmarking method in a strict sense, the Chow–Lin method is related to the regression-based model developed by Cholette and Dagum (as explained later in this annex).

A6.4 This annex provides a brief review of benchmarking methods for compiling QNA. The annex is not intended to provide an extensive survey of all alternative benchmarking methods proposed in the literature.[34] The aim of this annex is to offer a more technical discussion of the two benchmarking methods identified in the chapter as suitable for QNA purposes: namely,

- The benchmarking method proposed by Denton (1971), with its enhancement for extrapolation. The Denton proportional method is the preferred option for benchmarking. The enhanced version should be used for extrapolation when a forecast of the next annual BI ratio is available.
- The regression-based benchmarking method proposed by Cholette and Dagum (1994). An alternative solution to the Denton approach is the proportional Cholette–Dagum method with AR extrapolation, which preserves the movements in the indicator for the back series and automatically adjusts QNA extrapolations for a temporary bias in the indicator.

A6.5 This annex illustrates the two benchmarking methods mentioned above using a standardized formal notation. Each method (including the Cholette–Dagum approach) can be interpreted as the solution to a constrained minimization problem under a specific objective (or penalty) function. Further details for each method will be highlighted in both distribution and extrapolation steps. Finally, solutions of both methods are presented in matrix notation. Conveniently, a matrix representation permits to express the constrained minimization problem as a linear system and derive the benchmarked series as (part of) its solution using simple algebra operations. The technical presentation provided in this annex is intended to facilitate the implementation of these benchmarking methods in any preferred programming language with matrix capabilities.

[31] The term "benchmarking" was first introduced in Helfand, Monsour, and Trager (1977) to describe the historical revision of monthly survey data to incorporate census benchmarks every five years.

[32] Autoregressive-integrated moving average.

[33] Related works to the Chow–Lin solution are Fernández (1981), Litterman (1983), and Wei and Stram (1990).

[34] For further reference, see Dagum and Cholette (2006).

A6.6 The annex presents briefly the regression-based benchmarking (or temporal disaggregation) method proposed by Chow and Lin (1971). The Chow–Lin approach is presently used in many countries for compiling QNA variables. The annex explains how the Chow–Lin method relates to the Denton and Cholette–Dagum methods.

The Denton Benchmarking Method

A6.7 Denton (1971) proposed a method to adjust quarterly (or monthly) series so that the annual sums of the adjusted values are equal to independent annual totals and the resulting quarterly series be free of artificial discontinuities between the years. The adjustment method proposed by Denton (later became known as benchmarking) is grounded on a principle of movement preservation, whereby the adjusted values are sought to preserve maximally the movement in the original series. The adjustment follows thus a purely mechanical scheme, with no explicit statistical models or assumption describing the behavior of the series involved. The Denton benchmarking method has become popular in the QNA and in other areas of official statistics for its easy implementation and its flexibility and robustness to handle different kinds of benchmarking problems.

A6.8 Denton formulated the benchmarking problem as a constrained quadratic minimization of a penalty function, designed to minimize the impact of the adjustment on the movements in the original values. Denton proposed two penalty functions: an additive solution and a proportional solution.[35] They are shown below with the modifications proposed by Cholette (1984) to deal with the starting condition:[36]

- **Additive First Difference (AFD) Function**

$$\min_{X_t} \sum_{t=2}^{4y} [(X_t - I_t) - (X_{t-1} - I_{t-1})]^2 \Leftrightarrow \quad \min_{X_t} \sum_{t=2}^{4y} [(X_t - X_{t-1}) - (I_t - I_{t-1})]^2 \tag{A1}$$

- **Proportional First Difference (PFD) Function**

$$\min_{X_t} \sum_{t=2}^{4y} \left[\frac{X_t - I_t}{I_t} - \frac{X_{t-1} - I_{t-1}}{I_{t-1}} \right]^2 \Leftrightarrow \quad \min_{X_q} \sum_{t=2}^{4y} \left[\frac{X_t}{I_t} - \frac{X_{t-1}}{I_{t-1}} \right]^2 \tag{A2}$$

where

X_t is the quarterly series to be calculated (i.e., the QNA series),[37]
I_t is the quarterly series available (i.e., the indicator),
A_n is the annual series to be fulfilled (i.e., the ANA benchmarks),
$t = 1,..., 4y$ is the temporal index for the quarters, and
$n = 1,..., y$ is the index for the years.

Quarterly observations are available for each year. As shown later, the method can be extended easily to cover the case of extrapolation in quarters beyond the last available annual benchmark.

A6.9 Formulas (A1) and (A2) are minimized under the same restrictions, which for flow series correspond to

$$\sum_{t=4n-3}^{4n} X_t = A_n, \quad n = 1,..., y \tag{A3}$$

that is, the sum of the quarters must be equal to annual benchmarks available for each year. Annual benchmarks A_n are binding (or "hard") constraints in the system, as they cannot vary in the adjustment process. The Denton approach does not allow nonbinding (or "soft") benchmarks, a distinguished feature of the Cholette–Dagum regression-based model that is illustrated later in the annex.

A6.10 The PFD variant (equation (A2))—indicated in this chapter as proportional Denton method—is generally preferred over the AFD formula (A1) because it preserves seasonal and other short-term fluctuations in the series better when these fluctuations are multiplicatively distributed around the trend of the series. Multiplicatively distributed short-term fluctuations seem to be characteristic of most seasonal macroeconomic series. By the same token, it seems most

[35] Denton also proposed additive and proportional solutions that minimize the impact on second or higher-order differences in the original series. The proportional second difference solution is particularly convenient with stock variables, as discussed in Dagum and Cholette (2006).

[36] The original proposal by Denton assumed that the value for the first period of the series was predetermined. For more details on the original Denton method and the modified solution for the starting condition, see Dagum and Cholette (2006, chapter 6).

[37] The present formulation assumes that both the annual and quarterly observations are contiguous (no missing values) and that each annual benchmark is covered by the corresponding quarterly figures of the indicator.

reasonable to assume that the errors are generally multiplicatively, and not additively, distributed, unless anything to the contrary is explicitly known. The additive formula results in a smooth additive distribution of the errors in the indicator, in contrast to the smooth multiplicative distribution produced by the proportional formula. Consequently, the additive adjustment tends to smooth away some of the quarter-to-quarter rates of change in the indicator series. As a result, the additive formula can seriously disturb that aspect of the short-term movements for series that show strong short-term variations. This can occur particularly if there is a substantial difference between the level of the indicator and the target variable. In addition, the AFD formula may in a few instances result in negative benchmarked values for some quarters (even if all original quarterly and annual data are positive) if large negative adjustments are required for data with strong seasonal variations.

A6.11 The proportional variant of the Denton method does not preserve explicitly the quarterly rates of change of the indicator, which are commonly taken by users to analyze the short-term dynamics of economic series. A more explicit penalty function based on quarterly rates of change can be defined as follows:

$$\min_{X_t} \sum_{t=2}^{4y} \left[\frac{X_t - X_{t-1}}{X_{t-1}} - \frac{I_t - I_{t-1}}{I_{t-1}} \right]^2 \Leftrightarrow \min_{X_t} \sum_{t=2}^{4y} \left[\frac{X_t}{X_{t-1}} - \frac{I_t}{I_{t-1}} \right]^2, \qquad \text{(A4)}$$

which is known in the literature as *growth rates preservation* (GRP) principle. The PFD function proposed by Denton, however, is a very close approximation of the GRP,[38] in particular when the BI ratio does not present sudden jumps from one year to the next and the indicator is not too volatile. Furthermore the GRP function (A4) is a (quadratic) nonlinear function of the objective values (because X_{t-1} appears at the denominator of the ratio) and therefore its first-order conditions do not give rise to an explicit algebraic solution for the linear system. Nonlinear optimization procedures are required to find the benchmarked values minimizing the GRP function. Modern technology may consent an efficient implementation[39] of a GRP-based benchmarking procedure; however, performance of nonlinear solvers depends on the particular benchmarking problem faced and it is not possible to exclude slow convergence rates and inaccurate results in finding the actual minimum of the GRP function. For this reason, the proportional Denton method represents the most convenient solution for QNA compilers to preserve the quarter-to-quarter growth rates in the indicator.

A6.12 As shown by formula (A2), the proportional Denton solution amounts to minimizing the sum of the squared first differences of the quarterly BI ratio: that is, the ratio between the (unknown) benchmarked series X_t and the (known) indicator I_t. This chapter notes that the BI framework allows a useful interpretation of the proportional Denton method. The proportional technique implicitly constructs from the annual observed BI ratios a time series of quarterly BI ratios that are as smooth as possible. In the case of flow series, quarterly BI ratios for the back series $(n = 1, \ldots, y)$ are derived as weighted average of the annual BI ratios for each year n: that is,

$$\sum_{t=4n-3}^{4n} \frac{X_t}{I_t} w_t = \frac{A_n}{\bar{I}_n}$$

with

$\bar{I}_n = \sum_{t=4n-3}^{4n} I_t$ the annual sums of the quarterly observations and

$w_t = \dfrac{I_t}{\sum_{4n-3}^{4n} I_t}$ the indicator's weight for each quarter of the year,

for $t = 4n-3, \ldots, 4n$.

A6.13 The original method proposed by Denton (1971) did not consider the problem of extrapolating quarterly values for the year(s) following the last available annual observation. However, this extension is straightforward. Formulas (A1) and (A2) still work

[38] It can be shown that the term of the PFD function is equal to the term of the GRP function multiplied by the ratio $(X_{t-1}/I_t)^2$ (see Di Fonzo and Marini, 2013).

[39] Causey and Trager (1981) and Brown (2010) used gradient-based algorithms to minimize the growth rate preservation (GRP). Di Fonzo and Marini (2012a) proposed an interior point-based procedure, which makes use of second-order derivative information to increase robustness and efficiency in achieving the minimum value of the GRP function.

when the indicator I_t is observed for $t = 4y+1, \ldots$. No additional constraints is needed for the quarterly values of the year $y+1$, since the annual benchmark from the ANA is yet unknown. To minimize the PFD function, the extrapolated quarters are derived by assuming that the BI ratio is constant and equal to the last available quarterly BI ratio: that is, the fourth quarter of the year y in the current notation

$$\frac{X_{4y+k}}{I_{4y+k}} = \frac{X_{4y}}{I_{4y}}, \text{ for } k \geq 1.$$

A6.14 Forwarding the last available quarterly BI ratio using the proportional Denton method may lead to inaccurate extrapolation. It is possible to improve the estimates for the most recent quarters (i.e., the forward series) and reduce the size of later revisions by incorporating information on past systematic movements in the annual BI ratio. It is important to improve the estimates for these quarters, because they are typically of the keenest interest to users. Carrying forward the quarterly BI ratio from the last quarter of the last year is an implicit forecast of the annual BI ratio, but a better forecast may be derived observing the development of the annual BI ratio for the available years.

A6.15 To produce extrapolations that are consistent with a forecast of the next annual BI ratio, the same principles of constrained minimization used in the Denton formula can be used. Since the benchmark value is unavailable, the annual constraint is formulated in a way such that the weighted average of the quarterly BI ratios is equal to the forecast of annual BI ratio.

6.16 Denote with b_{y+1} the annual BI ratio of the year to extrapolate,

$$b_{y+1} = \frac{A_{y+1}}{\overline{I}_{y+1}}$$

where $\overline{I}_{y+1} = \sum_{t=4(y+1)-3}^{t=4(y+1)} I_t$.

Suppose the indicator's quarterly values are available for the year $y+1$: namely, $I_{4y+1}, I_{4y+2}, I_{4y+3}, \ldots, I_{4(y+1)}$. In mathematical terms, the enhanced proportional Denton method becomes the solution to the following constrained minimization problem:

$$\min_{X_t} \sum_{t=2}^{4(y+1)} \left[\frac{X_t}{I_t} - \frac{X_{t-1}}{I_{t-1}} \right]^2 \tag{A5}$$

subject to the annual benchmarks for the years $n = 1, \ldots, y$

$$\sum_{t=4n-3}^{4n} X_t = A_n$$

and, for the next year $y+1$, to the forecast of the annual BI ratio

$$\sum_{t=4(y+1)-3}^{4(y+1)} \frac{X_t}{I_t} w_{t-4} = \hat{b}_{y+1}$$

where

$w_t = I_t \Big/ \sum_{t=4n-3}^{4n} I_t$ are the indicator's quarterly shares of a year and

$\hat{b}_{y+1}$ is the annual forecast of the BI ratio for the year $y+1$.

Matrix Solution of the Proportional Denton Method

A6.17 The Denton benchmarking problem can be rewritten in matrix notation. This representation is convenient to calculate the benchmarked series with simple matrix operations. Assume there are no extrapolations ($q = 4y$). In matrix form, the minimization problem defined by equation (A2) under the constraint equation (A3) can be expressed as

$$\min_{\mathbf{X}} (\mathbf{X} - \mathbf{I})' \mathbf{M} (\mathbf{X} - \mathbf{I}) \tag{A6}$$

subject to

$$\mathbf{JX} = \mathbf{A}, \tag{A7}$$

where

X is the $(4y \times 1)$ vector containing the values X_t of the benchmarked series;

I is the $(4y \times 1)$ vector with the values I_t of the indicator;

A is the $(y \times 1)$ vector with the annual benchmarks A_t;

J is the $(y \times 4y)$ matrix aggregating $4y$ contiguous quarterly data into the corresponding y annual data,

$$\mathbf{J} = \begin{bmatrix} 1 & 1 & 1 & 1 & \dots & 0 & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & \dots & 1 & 1 & 1 & 1 \end{bmatrix};^{40} \qquad \text{(A8)}$$

$$\mathbf{M} = \hat{\mathbf{I}}^{-1}(\mathbf{D}'\mathbf{D})\hat{\mathbf{I}}^{-1};$$

$\hat{\mathbf{I}}$ is the $(4y \times 4y)$ diagonal matrix containing the values of the indicator in the main diagonal,

$$\hat{\mathbf{I}} = \begin{bmatrix} I_1 & 0 & \dots & 0 \\ 0 & I_2 & \dots & 0 \\ \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \dots & I_{4y} \end{bmatrix}; \text{ and}$$

$\mathbf{D}$ is the $(4y-1 \times 4y)$ matrix calculating the first difference from q-dimensional vectors,

$$\mathbf{D} = \begin{bmatrix} -1 & 1 & 0 & \dots & 0 \\ 0 & -1 & 1 & \dots & \dots \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & 1 \end{bmatrix}.$$

A6.18 Constrained quadratic minimization problem (A6) is solved by calculating the first-order conditions for a minimum, namely by equating to zero the partial derivatives of (A2) with respect to X_t and the Lagrange multipliers of the system. The two equations generate the following linear system:

$$\begin{bmatrix} \mathbf{M} & \mathbf{J}' \\ \mathbf{J} & \mathbf{0}_y \end{bmatrix} \begin{bmatrix} \mathbf{X} \\ \boldsymbol{\lambda} \end{bmatrix} = \begin{bmatrix} \mathbf{MI} \\ \mathbf{A} \end{bmatrix}$$

where $\mathbf{0}_y$ is the zero matrix of dimension y.

The solution is achieved by simple inverse and multiplication operations of the matrices involved:

$$\begin{bmatrix} \hat{\mathbf{X}} \\ \hat{\boldsymbol{\lambda}} \end{bmatrix} = \begin{bmatrix} \mathbf{M} & \mathbf{J}' \\ \mathbf{J} & \mathbf{0} \end{bmatrix}^{-1} \begin{bmatrix} \mathbf{MI} \\ \mathbf{A} \end{bmatrix}. \qquad \text{(A9)}$$

The $(q \times 1)$ vector $\hat{\mathbf{X}}$ in the left-hand side of equation (A9), which is (part of) the solution to the linear system (equation (A6)), contains the benchmarked values of the proportional Denton method.[41]

A6.19 To obtain extrapolations (case $q \geq 4y$), the only adjustments to the above formulation are to extend matrix $\mathbf{J}$ with as many zero columns as the number of extrapolations required and include the values of the indicator up to the last quarterly observation available. For example, for the extrapolation of q1 of the next year ($q = 4y + 1$),

$$\mathbf{J} = \begin{bmatrix} 1 & 1 & 1 & 1 & \dots & 0 & 0 & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \ddots & \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & 0 & 0 & \dots & 1 & 1 & 1 & 1 & 0 \end{bmatrix} \text{ and}$$

$$\hat{\mathbf{I}} = \begin{bmatrix} I_1 & 0 & \dots & 0 & 0 \\ 0 & I_2 & \dots & 0 & 0 \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ 0 & 0 & \dots & I_{4y} & 0 \\ 0 & 0 & \dots & 0 & I_{4y+1} \end{bmatrix}.$$

The Cholette–Dagum Regression-Based Method

A6.20 Cholette and Dagum (1994) proposed a benchmarking method based on the generalized least-squares regression model. The Cholette–Dagum model takes into account (i) the presence of bias in the indicator and (ii) the presence of autocorrelation and heteroscedasticity errors in the original data. In addition, it allows for nonbinding benchmarks. These characteristics make the Cholette–Dagum approach a very flexible benchmarking framework. The Denton method can be seen as a particular (approximated) case of the Cholette–Dagum regression model.

6.21 The benchmarking method proposed by Cholette and Dagum (1994) is based on the following two equations[42]:

$$I_t = a_t + X_t + e_t \qquad \text{for } t = 1,\dots,q \qquad \text{(A10)}$$

$$A_n = \sum_{t=4n-3}^{4n} X_t + w_n \qquad \text{for } n = 1,..,y \qquad \text{(A11)}$$

[40] For flow series with regularly spaced years and quarters, matrix $\mathbf{J}$ can be derived as $\mathbf{I}_y \otimes \mathbf{1}$, where $\mathbf{I}_y$ is the identity matrix of dimension y, 1 is a 1×4 row vector of ones, and $\otimes$ is the Kronecker product.

[41] The matrix solution of the enhanced Denton proportional solution can be found in Di Fonzo and Marini (2012b).

[42] This presentation of the Cholette–Dagum model assumes that both the annual and quarterly observations are contiguous (no missing values) and that each annual benchmark is covered by the corresponding quarterly figures of the indicator.

where

I_t is the quarterly series available (i.e., the QNA indicator),

a_t is a (combined) deterministic effect,

X_t is the true quarterly series,

e_t is a quarterly autocorrelated and heteroscedastic[43] error, and

w_n is an annual heteroscedastic error in the annual series A_n, uncorrelated with e_t,

with

$$E(e_t) = 0,\ E(e_t e_{t-h}) \neq 0$$
$$E(w_n) = 0,\ E(w_n^2) = \delta_n^2$$
$$E(e_t w_n) = 0.$$

A6.22 The proportional Cholette–Dagum method with AR error can be used to improve QNA extrapolations. This annex shows the assumptions that define this specific option from the general Cholette–Dagum regression-based framework defined by equations (A10) and (A11), and provides the solution in matrix notation for its implementation.

A6.23 Equation (A10) describes the values of the quarterly indicator I_t as a measure of variable X_t contaminated with deterministic effect a_t and quarterly error e_t. Equation (A11) relates the annual benchmark A_n to the annual sum of the quarterly values X_t with a possible measurement error w_n. The Cholette–Dagum regression-based method varies according to the assumptions for the deterministic effect a_t, the quarterly error e_t, and the annual error w_t.

A6.24 The annual error w_t is needed to account for situations whether the benchmark is also subject to error. These benchmarks are called nonbinding, because they are also subject to changes in the benchmarking process. In the QNA, however, the annual benchmarks are usually binding constraints for the quarterly values (i.e., $E(w_n^2) = 0$).

A6.25 The deterministic effect a_t is usually calculated from a set of deterministic regressors $r_{t,h}$ multiplied by their corresponding regression coefficients β_h: that is,

$$a_t = \sum_{h=1}^{s} r_{t,h}\beta_h,$$

where s is the number of deterministic effects considered. A constant is a typical deterministic effect used to capture a level bias difference between the annual and the quarterly level. As explained in the chapter, a constant bias can also be modeled implicitly by rescaling the original indicator with the historical BI ratio. This transformation is convenient because it requires no parameter estimation of the level bias. A deterministic trend could also be used to catch a diverging path between the indicator and the objective variable. However, deterministic trend may cause biased extrapolations at both ends of the series and should be used with caution.

A6.26 The error e_t is the quarterly discrepancy between the target variable X_t and the quarterly indicator I_t. Because a key objective of benchmarking is to keep the movements in X_t as close as possible to the movements in I_t, the error e_t needs to have two characteristics:

- It has to be proportional to the value of the indicator I_t. This property is necessary to distribute the errors around the level of the indicator, similar to the proportional Denton solution.
- It has to present smooth movements from one quarter to the next. A smooth distribution of e_t make the movements of X_t and I_t very close to each other.

A6.27 To obtain a proportional adjustment, the error e_t is standardized by the value of the indicator I_t,

$$e_t' = \frac{e_t}{I_t}. \tag{A12}$$

By doing so, the standard deviation of e_t is assumed to be equal to I_t.[44] To obtain a smooth distribution, the standardized error e_t' is assumed to follow a first-order (stationary) autoregressive model, or AR(1) model:

$$e_t' = \phi e_{t-1}' + v_t \tag{A13}$$

[43] Autocorrelation refers to the correlation of the error with its own past and future. Heteroscedasticity means that the variance of the error varies across observations.

[44] This assumption implies constant coefficient of variations: that is, $\sigma_t / I_t = 1$ for any quarter t.

with $|\phi| < 1$, where the v_t's are assumed to be independent and identically distributed innovations: that is,

$$E(v_t) = 0,\ E(v_t^2) = 1,\ E(v_t, v_{t-h}) = 0 \text{ for any } t \text{ and } h.$$

A6.28 The proportional Cholette–Dagum method with AR error entails the minimization of an objective function that is closely related to the proportional criterion (equation (A2)) minimized by Denton. It can be shown that the benchmarked series of the proportional Cholette–Dagum model with AR error model (A13) minimizes the objective function[45]:

$$\min_{X_t} \left\{ \left(\frac{1}{1-\phi^2} \right) \left(\frac{X_1}{I_1^a} \right)^2 + \sum_{t=2}^{q} \left[\frac{X_t}{I_t^a} - \phi \frac{X_{t-1}}{I_{t-1}^a} \right]^2 \right\}. \quad \text{(A14)}$$

A6.29 Function (A14) clarifies that, besides extrapolation, the AR parameter ϕ plays a crucial role in preserving the short-term dynamics of the indicator series. When ϕ is very close to 1 (e.g., 0.999), function (A14) converges to function (A2),[46] which is minimized by the proportional Denton method. As ϕ moves away from 1, the quarterly BI ratios are adjusted according to a criterion that offers weaker movement preservation than the Denton solution. For the reasons explained in the chapter, the value of ϕ should be chosen in a range between 0.71 and 0.93.

Matrix Solution of the Proportional Cholette–Dagum Method with AR Error

A6.30 The solution to the Cholette–Dagum proportional benchmarking with AR error is given by the expression

$$\mathbf{X} = \mathbf{I}^a + \mathbf{V}\mathbf{J}'(\mathbf{J}\mathbf{V}\mathbf{J}')^{-1}\left[\mathbf{A} - \mathbf{J}\mathbf{I}^a\right],$$

where

$\mathbf{X}$, $\mathbf{A}$, and $\mathbf{J}$ are defined in equation (A6),

$\mathbf{I}^a$ is the $(q \times 1)$ vector with the bias-adjusted indicator I_t^a calculated in equation (A11),

$\mathbf{V} = \hat{\mathbf{I}}^a(\mathbf{\Omega}^{-1})\hat{\mathbf{I}}^a$ is the $(q \times q)$ variance–covariance matrix of the quarterly error e_t,

$\hat{\mathbf{I}}^a$ is the $(q \times q)$ diagonal matrix containing the values of the bias-adjusted indicator I_t^a in the main diagonal,

$\mathbf{\Omega} = \mathbf{W}'\mathbf{W}$ is the autocorrelation matrix of the AR(1) model with parameter ϕ, where

$$\mathbf{W} = \begin{bmatrix} \sqrt{1-\phi^2} & 0 & 0 & \dots & 0 \\ -\phi & 1 & 0 & \dots & 0 \\ 0 & -\phi & 1 & & 0 \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & 0 & \dots & 1 \end{bmatrix}.$$

The Chow–Lin Regression-Based Method

A6.31 Chow and Lin (1971) proposed a method for interpolating, distributing, and extrapolating time series based on a regression model using related indicators. The Chow–Lin method is presently used by many statistical agencies for compiling QNA. Given its widespread use in the QNA, this annex provides a brief description of this approach. In particular, this section illustrates the main features of the Chow–Lin method and relates this approach to the benchmarking methods proposed by Denton (1971) and Cholette and Dagum (1994).

A6.32 The Chow–Lin method assumes a regression model between the true (unobserved) quarterly observations X_t and a set of p quarterly related series $I_{1,t}, \dots, I_{p,t}$:

$$X_t = \sum_{j=1}^{p} \beta_j I_{j,t} + u_t, \qquad \text{for } t = 1, \dots, q \qquad \text{(A15)}$$

with

$$u_t = \rho u_{t-1} + v_t, \qquad \text{(A16)}$$

where

X_t is the quarterly (unknown) target value (i.e., the QNA series);

β_j is the regression coefficient for the j-th indicator;

$I_{j,t}$ is the j-th quarterly indicator;

u_t is a random error assumed to follow the AR(1) model (A16), with the v_t's independently and identically distributed innovations;

q is the number of quarters, possibly including extrapolations ($q \geq 4y$); and

ρ is the autoregressive coefficient.

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[45] Dagum and Cholette (2006, pp. 87–92).

[46] The Denton method provides the same results whether the original indicator or the bias-adjusted indicator is used.

A6.33 Because X_t is unobserved (and its values are the target values of the method), model (A15) cannot be estimated. However, Chow and Lin assumes that the same relationship between X_t and the quarterly indicators holds true at the annual frequency. Therefore, model (A15) is temporally aggregated:

$$A_n = \sum_{j=1}^{p} \beta_j \bar{I}_{j,n} + u_n^a, \quad \text{for } n = 1, \ldots, y \qquad \text{(A17)}$$

where

$A_n = \sum_{t=4n-3}^{4n} X_t$ is the (known) annual variable that needs to be distributed and extrapolated into quarters (i.e., the ANA benchmarks),

β_j is the regression coefficient for the j-th indicator (assumed constant across frequencies),

$\bar{I}_{j,n}$ is the j-th annually aggregated indicator, and

u_n^a is an annual ARMA(1,1) error derived from the quarterly AR(1) model.[47]

A6.34 Chow and Lin derives the best linear unbiased estimator (BLUE) of X_t by estimating the regression coefficients $\hat{\beta}_j$ and the AR coefficient $\hat{\rho}$ from model (A17). The estimated series $\hat{X}_t$ (which corresponds to the benchmarked series) consists of two components: one from the regression effects $\sum_{j=1}^{p} \hat{\beta}_j I_{j,t}$ and one from the estimated quarterly residual $\hat{u}_t$. Regression effects may include deterministic effects (constant, trend, etc.) and related indicators. In the QNA, the most frequent combination of regressor is a constant term plus an indicator. The estimate $\hat{\rho}$ can be done by maximum likelihood or by weighted least squares. Similar to the AR error in the Cholette–Dagum method, the estimated value of $\hat{\rho}$ should be positive in order to preserve the original movements from the regression component.

A6.35 Dagum and Cholette (2006) shows that the Chow–Lin model is a particular case of their regression-based additive model with one related series. The AR(1) assumption for u_t[48] is needed to distribute the quarterly errors smoothly, similar to the Cholette–Dagum method with AR error. However, in the Chow–Lin approach, the AR coefficient ρ is estimated from the data observed and not chosen by the user (as for the AR coefficient ϕ in the Cholette–Dagum model). Although this can be considered a good theoretical property of the model, the maximum likelihood estimation process may lead to negative estimates of ρ, and when this happens, the error component may dominate the short-term movements of the benchmarked series.

[47] When temporally aggregated, an AR(1) model results in an ARMA (1,1) model.

[48] Other assumptions for the quarterly error are the random walk model by Fernández (1981) and the AR(1)-plus-random walk model by Litterman (1983).

Bibliography

Barcellan, R., and R. Buono (2002), "Temporal Disaggregation Techniques – ECOTRIM Interface (Version 1.01)," User Manual, Eurostat.

Boot, J.C.G., W. Feibes, and J.H.C. Lisman (1967), "Further Methods of Derivation of Quarterly Figures from Annual Data," *Applied Statistics*, 16(1): 65–75.

Brown, I. (2010), "An Empirical Comparison of Constrained Optimization Methods for Benchmarking Economic Time Series," in *Joint Statistical Meetings 2009 Proceedings*, Business and Economic Statistics Section, pp. 2131–2143, Washington, DC: American Statistical Association.

Causey, B., and M.L. Trager (1981), "Derivation of Solution to the Benchmarking Problem: Trend Revision," Unpublished Research Notes, U.S. Census Bureau.

Cholette, P. A. (1984), "Adjusting Sub-annual Series to Yearly Benchmarks," *Survey Methodology*, 10: 35–49.

Cholette, P.A. (1994), "Users' Manual of Programme BENCH," Working Paper Time Series Research and Analysis Division, TSRA-90-009, Ottawa: Statistics Canada.

Cholette, P.A., and E.B. Dagum (1994), "Benchmarking Time Series with Autocorrelated Survey Errors," *International Statistical Review*, 62(3): 365–377.

Chow, G.C., and A. Lin (1971), "Best Linear Unbiased Interpolation, Distribution, and Extrapolation of Times Series by Related Series," *The Review of Economic and Statistics*, 53(4): 372–375.

Dagum, E.B., and P.A. Cholette (2006), *Benchmarking, Temporal Disaggregation, and Reconciliation Methods for Time Series*, Springer edition, New York: Springer.

Denton, F. (1971), "Adjustment of Monthly or Quarterly Series to Annual Totals: An Approach based on Quadratic Minimization," *Journal of the American Statistical Association*, 66(333): 99–102.

Di Fonzo, T., and M. Marini (2011), "Simultaneous and Two-Step Reconciliation of Systems of Time Series: Methodological and Practical Issues," *Journal of Royal Statistical Society: Series C*, 60(2): 143–164.

Di Fonzo, T., and M. Marini (2012a), "Benchmarking Time Series According to a Growth Rates Preservation Principle," *Journal of Economic and Social Measurement*, 37(3): 225–252.

Di Fonzo, T., and M. Marini (2012b), "On the Extrapolation with the Denton Proportional Benchmarking Method," IMF Working Paper Series, WP/12/169.

Di Fonzo, T., and M. Marini (2013), "Benchmarking and Movement Preservation: Evidences from Real-Life and Simulated Series," in N. Torelli and others (eds), *Advances in Theoretical and Applied Statistics*, pp. 499–509, Heidelberg: Springer-Verlag.

Durbin, J., and B. Quenneville (1997), "Benchmarking by State Space Models," *International Statistical Review*, 65(1): 23–48.

Fernández, R.B. (1981), "A Methodological Note on the Estimation of Time Series," *The Review of Economics and Statistics*, 63(3): 471–476.

Helfand, S.D., N.J. Monsour, and M.L. Trager (1977), "Historical Revision of Current Business Survey Estimates," in *Proceedings of the Business and Economic Statistics Section*, American Statistical Association, Washington, DC, United States, pp. 246–250.

Hillmer, S.C., and A. Trabelsi (1987), "Benchmarking of Economic Time Series," *Journal of the American Statistical Association*, 82(400): 1064–1071.

Lisman, J.H.C., and J. Sandee (1964) "Derivation of Quarterly Figures from Annual Data," *Applied Statistics*, 13(2): 87–90.

Litterman, R.B. (1983), "A Random Walk, Markov Model for the Distribution of Time Series," *Journal of Business and Economic Statistics*, 1(2): pp. 169–173.

Monsour, N.J., and M.L. Trager (1979), "Revision and Benchmarking of Business Time Series," in *Proceedings of the Business and Economic Statistics Section*, American Statistical Association, Washington, DC, United States, pp. 333–337.

Quenneville, B., and S. Fortier (2012), "Restoring Accounting Constraints in Time Series: Methods and Software for a Statistical Agency," in ed. T.S. McElroy, *Economic Time Series: Modeling and Seasonality*, Boca Raton: Chapman and Hall, pp. 231–253.

Quenneville, B., and E. Rancourt (2005), "Simple Methods to Restore the Additivity of a System of Time Series," presented at the workshop *Frontiers in Benchmarking Techniques and Their Application to Official Statistics*, Eurostat, Luxembourg, April 2005.

Wei, W.W.S., and D.O. Stram (1990), "Disaggregation of Time Series Models," *Journal of the Royal Statistical Society: Series B*, 52(3): 453–467.

7 Seasonal Adjustment

The purpose of seasonal adjustment is to identify and estimate the different components of a time series, and thus provide a better understanding of the underlying trends, business cycle, and short-run movements in the series. Seasonal adjustment offers a complementary view on the current developments of macroeconomic series, allowing comparisons between quarters without the influence of seasonal and calendar effects. This chapter introduces the main principles of seasonal adjustment. Next, it outlines the main steps of the most commonly used seasonally adjustment procedures adopted by data producer agencies. Practical guidance is provided on how to evaluate and validate the quality of seasonally adjusted data. Finally, some specific issues arising from the application of seasonal adjustment in the framework of national accounts are considered, such as the direct versus indirect adjustment of quarterly national accounts (QNA) aggregates and the temporal consistency with annual benchmarks.

Introduction

7.1 Seasonal adjustment of the QNA allows a timely assessment of the current economic conditions and identification of turning points in key macroeconomic variables, such as quarterly gross domestic product (GDP). Economic variables are influenced by systematic and recurrent within-a-year patterns due to weather and social factors, commonly referred to as the seasonal pattern (or seasonality). When seasonal variations dominate period-to-period changes in the original series (or seasonally unadjusted series), it is difficult to identify nonseasonal effects, such as long-term movements, cyclical variations, or irregular factors, which carry the most important economic signals for QNA users.

7.2 Seasonal adjustment is the process of removing seasonal and calendar effects from a time series. This process is performed by means of analytical techniques that break down the series into components with different dynamic features. These components are unobserved and have to be identified from the observed data based on a priori assumptions on their expected behavior. In a broad sense, seasonal adjustment comprises the removal of both within-a-year seasonal movements and the influence of calendar effects (such as the different number of working days or moving holidays). By removing the repeated impact of these effects, seasonally adjusted data highlight the underlying long-term trend and short-run innovations in the series.

7.3 In trend-cycle estimates, the impact of irregular events in addition to seasonal variations is removed. Adjusting a series for seasonal variations removes the identifiable, regularly repeated influences on the series but not the impact of any irregular events. Consequently, if the impact of irregular events is strong, seasonally adjusted series may not represent a smooth, easily interpretable series. Standard seasonal adjustment packages provide an estimate of the trend-cycle component, representing a combined estimate of the underlying long-term trend and the business-cycle movements in the series. It should be noted, however, that the decomposition between the trend-cycle and the irregular components is subject to large uncertainty at the endpoint of the series, where it may be difficult to distinguish and allocate the effects from new observations.

7.4 A common solution to deal with seasonal patterns is to look at annual rates of change: that is, compare the current quarter to the same quarter of the previous year. Over-the-year comparisons present the disadvantage, however, of giving signals of outdated events.[1] Furthermore, these rates of change do not fully exclude all calendar-related effects (e.g., Easter

[1] Quenneville and Findley (2012) found analytically that year-on-year changes present 5.5 months of delay with respect to month-to-month growth rates. For quarterly series, this corresponds to a delay of almost two quarters.

may fall in the first or second quarter, and the number of working days of a quarter may differ between subsequent years). Finally, these year-on-year rates of change will be influenced by any eventual change in the seasonal pattern caused by institutional, climatic, or behavioral changes.

7.5 Several methods have been developed to remove seasonal patterns from a series.[2] Broadly speaking, they can be divided into two groups: moving average (MA) methods and model-based methods. Methods in the first group derive the seasonally adjusted data by applying a sequence of MA filters to the original series and its transformations. These methods are all variants of the X-11 method, originally developed by the U.S. Census Bureau (Shiskin and others, 1967).[3] The current version of the X-11 family is X-13ARIMA-SEATS (X-13A-S), which will often be referred to in this chapter. Model-based methods derive the unobserved components in accord with specific time series models, primarily autoregressive integrated moving average (ARIMA) models. The most popular model-based seasonal adjustment method is TRAMO-SEATS,[4] developed by the Bank of Spain (Gomez and Maravall, 1996). Box 7.1 illustrates the main characteristics of the X-13A-S and TRAMO-SEATS programs. Other available seasonal adjustment methods include, among others, BV4, SABLE, and STAMP.

7.6 Current seasonal adjustment packages offer built-in functionality to select between alternative modeling options in an automatic manner (e.g., ARIMA model, calendar effects, and additive versus multiplicative model). The selection process mostly relies on statistical tests or heuristic rules based on the seasonal adjustment results. These automatic features are very helpful when seasonal adjustment is to be applied to many time series at a time (hundreds, or even thousands), avoiding a series-by-series, time-consuming manual selection process. However, compilers should use these automatic features with care. Steps performed by the seasonal adjustment procedure used in the QNA should be assessed and comprehended, as with every other method applied in the national accounts. Seasonal adjustment options, at least for the most relevant QNA series, should always be tested for adequacy and monitored over time.

7.7 Seasonally adjusted data should not replace the original QNA data. Some users prefer to base their economic analysis on unadjusted data, as they treat seasonality as an integrated part of their modeling work. In this regard, seasonal adjustment adopted by statistical agencies is sometimes seen as a potentially dangerous procedure that may compromise the intrinsic properties of the original series. In fact, there is always some loss of information from seasonal adjustment, even when the seasonal adjustment process is properly conducted. For this reason, producers of seasonally adjusted data should employ sound and internationally accepted methodology for seasonal adjustment. More importantly, they should implement a transparent communication strategy, indicating the method in use and integrating seasonally adjusted figures with appropriate metadata that allow the results to be replicated and understood by the general public.

7.8 Countries that are yet to produce QNA in seasonally adjusted form may follow an evolutionary approach to seasonal adjustment. In a first stage, seasonal adjustment should be applied to the most important aggregates of the QNA (such as the GDP). For some time, these seasonally adjusted series may be used internally or published as experimental data. Next, seasonal adjustment could be expanded to the full set of QNA series once compilers gain more experience and confidence in the seasonal adjustment work. Albeit not published, seasonal adjustment of QNA data should at least be done internally; in effect, seasonally adjusted data often facilitate the identification of issues in the unadjusted data as seasonality may hide errors and inconsistencies in the original estimates.

7.9 This chapter is structured as follows. The next section illustrates the main principles of seasonal

[2] For a history of seasonal adjustment methods, see Ladiray and Quenneville (2001, chapter 1).

[3] The X-11 program was the first procedure designed for a large-scale application of seasonal adjustment. It emerged from decades of research originated in the early 1930s by researchers at the NBER. Subsequent improvements to the original X-11 program were implemented in the X-11-ARIMA program, developed by Statistics Canada (Dagum, 1980), and in the X-12-ARIMA program, developed by the U.S. Census Bureau (Findley and others, 1998). For further details on the history of X-11, see Box 7.1 in this chapter and Ghysels and Osborn (2001).

[4] TRAMO is the acronym for Time series Regression with Autoregressive integrated moving average (ARIMA) errors and Missing Observations. SEATS stands for Signal Extraction for ARIMA Time Series.

Box 7.1 Software for Seasonal Adjustment

Statistical agencies and international organizations have developed programs to facilitate the production process of seasonally adjusted and trend-cycle data. This box provides a brief overview of the three most used seasonal adjustment programs available at the time of writing:

- X-13-ARIMA-SEATS (U.S. Bureau of the Census),
- TRAMO-SEATS (Bank of Spain), and
- JDemetra+ (National Bank of Belgium, in cooperation with Deutsche Bundesbank and Eurostat).

X-13-ARIMA-SEATS (U.S. Bureau of the Census). The U.S. Bureau of the Census currently promotes and supports the X-13ARIMA-SEATS (X-13A-S) program. X-13A-S implements the two most widely used seasonal adjustment methods: the moving average X-11 method and the ARIMA model-based SEATS method. It also offers a module for selecting preadjustment effects using regARIMA models. X-13A-S produces basic and advanced diagnostics to evaluate the quality of the seasonal adjustment results. The program runs under DOS and Unix. A Windows interface, Win X-13, is also available. X-13A-S is the result of a series of developments of the original X-11 program developed by the U.S. Bureau of the Census in the late 1950s to early 1960s. Statistics Canada later developed X-11 ARIMA, which introduced ARIMA methods for backcasts and forecasts. The program, manual, and further reference can be found at https://www.census.gov/srd/www/x13as/.

TRAMO-SEATS (Bank of Spain). The TRAMO-SEATS program implements the ARIMA model-based seasonal adjustment method developed by Gomez and Maravall (1996). It is promoted and maintained by the Bank of Spain. The SEATS decomposition is based on the signal extraction method proposed by Burman (1980) and Hillmer and Tiao (1982). The preadjustment module (TRAMO) is similar to the one incorporated in the X-13A-S program. The software can be launched in both DOS and UNIX. A Windows interface, TRAMO-SEATS for Windows (TSW), is also available. The program, manual, and further reference can be found at http://www.bde.es/bde/en/secciones/servicios/Profesionales/Programas_estadi/Programas.html.

JDemetra+ (National Bank of Belgium, Deutsche Bundesbank, and Eurostat). JDemetra+ is a tool for seasonal adjustment developed by the National Bank of Belgium in cooperation with the Deutsche Bundesbank and Eurostat. It offers both X-11 and SEATS filters, and a common methodology for preadjustment. It allows to seasonally adjust large-scale sets of time series and provides user-friendly tools for checking the quality of the results. J-Demetra+ includes enhanced features and standardized outputs for comparing results from X-11 and SEATS. It also includes a plug-in for benchmarking (see Chapter 6).

The program, manual, and further reference can be found at https://ec.europa.eu/eurostat/cros/content/jdemetra-seasonal-adjustment-software_en.

adjustment. The third section "Seasonal Adjustment Procedure" outlines the two stages of seasonal adjustment procedures: preadjustment and time series decomposition. It also provides a brief illustration of the X-11 (MA) filter and SEATS (model-based) filter. The fourth section "Seasonal Adjustment and Revisions" stresses the importance of revisions in seasonal adjustment and how to handle and communicate them properly in a production context. Quality assessment tools for analyzing seasonal adjustment results are described in "Quality Assessment of Seasonal Adjustment" section. The sixth section "Particular Issues" addresses a set of critical issues on seasonal adjustment specifically related to QNA issues, such as preservation of accounting identities, seasonal adjustment of balancing items and aggregates, and the relationship between annual data and seasonally adjusted quarterly data. Finally, the last section "Status and Presentation of Seasonally Adjusted and Trend-Cycle QNA Estimates" discusses the presentation and status of seasonally adjusted and trend-cycle data.

Main Principles of Seasonal Adjustment

7.10 For seasonal adjustment purposes, a time series is generally assumed to be made up of four main components: (i) the trend-cycle component, (ii) the seasonal component, (iii) the calendar component, and (iv) the irregular component. These components are unobserved and have to be identified (and estimated) from the observed time series using a signal extraction technique.

7.11 The trend-cycle component (T_t) is the underlying path of the series. It includes both the long-term trend and the business-cycle movements in the data.

The long-term trend can be associated with structural changes in the economy, such as population growth and progress in technology and productivity. Business-cycle variations are related to the periodic oscillations of different phases of the economy (i.e., recession, recovery, growth, and decline), which generally repeat themselves with a period between two and eight years.

7.12 The seasonal component (S_t) includes those seasonal fluctuations that repeat themselves with similar annual timing, direction, and magnitude.[5] Possible causes of seasonal movements relate to climatic factors, administrative or legal rules, and social/cultural traditions and conventions—including calendar effects that are stable in annual timing (e.g., public holidays or other national festivities). Each of these causes (or a combination of them) can affect expectations in such a way that seasonality is indirectly induced. Similarly, changes in any of these causes may change the properties of the seasonal pattern.

7.13 The calendar component (C_t) comprises effects that are related to the different characteristics of the calendar from period to period. Calendar effects are both seasonal and nonseasonal. Only the "nonseasonal" part should be included in the calendar component and treated separately, as the "seasonal" one is already caught by the seasonal component.[6] The most used calendar effects include the following:

a. *Trading-Day or Working-Day Effect.* The trading-day effect detects the different number of each day of the week within a specific quarter relative to the standard weekday composition of a quarter. The working-day effect catches the difference between the number of working days (e.g., Monday through Friday) and the number of weekend days (e.g., Saturday and Sunday) in a quarter. The trading-day effect assumes an underlying pattern associated with each day of the week; the working-day effect postulates different behavior between the groups of weekdays and weekends.[7] Both the trading-day and working-day effects should incorporate the effects of national holidays (e.g., when Christmas falls on Monday, that Monday should not be counted as a trading/working day).

b. *Moving Holiday Effect.* A moving holiday is associated with events of religious or cultural significance within a country that change date from year to year (e.g., Easter or Ramadan).

c. *Leap Year Effect.* This effect is needed to account for the extra day in February of a leap year, which may generate a four-year cycle with a peak in the first quarter of leap years.

7.14 The irregular component (I_t) captures all the other fluctuations that are not part of the trend-cycle, seasonal, and calendar components. These effects are characterized by the fact that their timing, impact, and duration are unpredictable at the time of their occurrence. The irregular component includes the following effects:

a. *Outlier Effects.* These effects manifest themselves with abrupt changes in the series, sometimes related to unexpected weather or socioeconomic effects (such as natural disasters, strikes, or economic and financial crises). Such effects are not part of the underlying linear data generation process assumed for the original series. For these reasons, outlier effects are also called nonlinear effects. In the seasonal adjustment process, outliers should be removed by means of predefined intervention variables. Three main types of outliers are often used for economic time series:

   i. *additive outlier*, which relates to only one period;

   ii. *level shift*, which changes the level of a series permanently;[8] and

   iii. *transitory change*, whose effects on a series fade out over a number of periods.

   Other effects are seasonal outliers (which affect only certain quarters/months of the year), ramp outliers (which allow for a linear increase or decrease in the level of a series), or temporary level

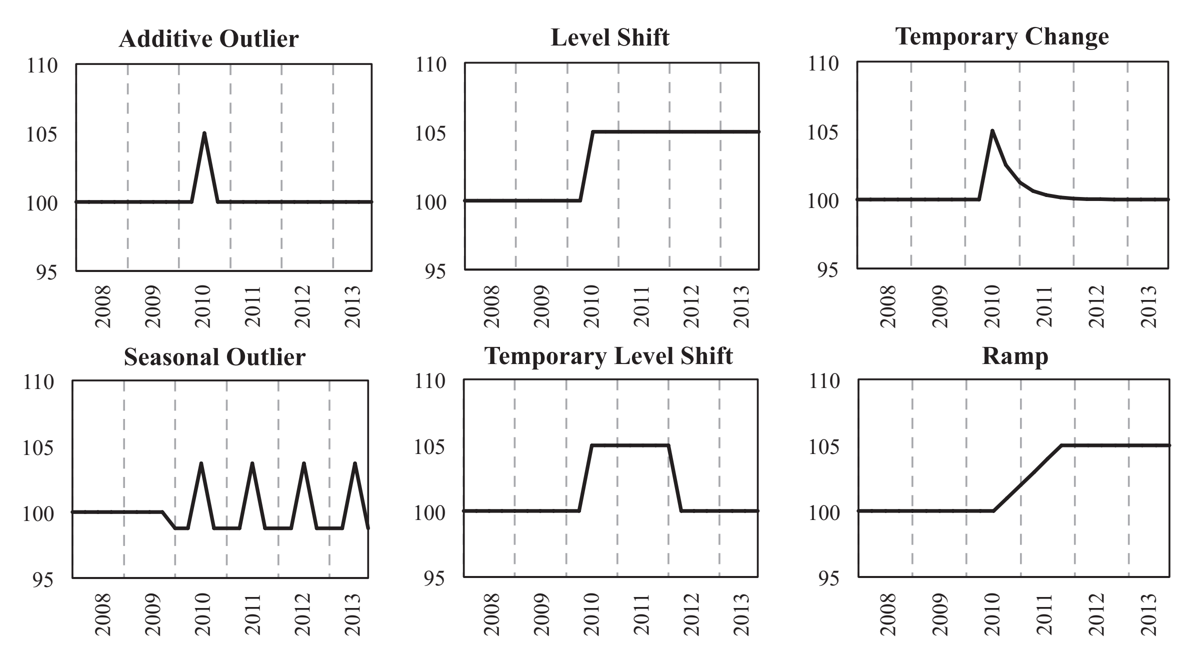
[5] Seasonality may be gradually changing over time. This phenomenon is called "moving seasonality."

[6] For example, the effect due to the different average number of days in each quarter is part of the seasonal effects.

[7] Trading-day effect is less important in quarterly data than in monthly data. Only quarters 3 and 4 contain different numbers of working days over time (excluding the leap year effect). The working-day effect is most commonly used for quarterly series.

[8] For seasonal adjustment purposes, outliers producing structural breaks in the series (such as a level shift or a seasonal outlier) may actually be allocated to the trend or seasonal components. Further details on the allocation of outliers is given in "Preadjustment" section.

Figure 7.1 Types of Outliers



shifts. These effects are modeled through specific intervention variables. The different types of outliers are shown in Figure 7.1. Further details on the treatment of outlier effects is given in "Preadjustment" section.

b. *White Noise Effects*. In the absence of outliers, the irregular component is assumed to be a random variable with normal distribution, uncorrelated at all times with constant variance. In statistical terms, such a variable is called a white noise process. Differently from outlier effects, a white noise process is assumed to be part of the underlying linear data generation process of the series.

7.15 The purpose of seasonal adjustment is to identify and estimate the different components of a time series, and thus provide a better understanding of the underlying trends, business cycle, and short-run movements in the series. The target variable of a seasonal adjustment process is the series adjusted for seasonal and calendar effects (or seasonally and calendar adjusted series). As mentioned before, both seasonal and calendar effects should be removed from the original series to allow for a correct analysis of the current economic conditions.

7.16 A fundamental prerequisite for applying seasonal adjustment procedures is that the processed series should present clear and sufficiently stable seasonal effects. Series with no seasonal effects, or series with seasonal effects that are not easy to identify from the original series, should not be seasonally adjusted. As discussed in the next section, the original series should always be tested for the presence of identifiable seasonality. At the same time, the series should also be tested for the presence of calendar effects. Calendar effects are usually less visible than seasonal effects, therefore their identification relies on statistical tests that reveal when their contribution to the series is statistically different from zero.

7.17 Two observations on the limits of seasonal adjustment are worth noting here. First, seasonal adjustment is not meant for smoothing series. A seasonally adjusted series[9] is the sum of the trend-cycle component and the irregular component. As a consequence, when the irregular component is strong, the seasonally adjusted series may not present a smooth pattern

[9] Unless otherwise specified, we indicate hereafter with seasonally adjusted series a series adjusted for both seasonal and calendar effects (if they are present).

over time. To extract the trend-cycle component, the irregular component should be further removed from the seasonally adjusted series. Trend-cycle extraction is a difficult exercise and subject to greater uncertainty than seasonal adjustment, especially in the final period of a series.

7.18 Second, seasonal adjustment and trend-cycle estimation represent an analytical processing of the original data. As such, the seasonally adjusted data and the estimated trend-cycle component complement the original data, but they can never replace the original data for the following reasons:

a. Unadjusted data are useful in their own right. The nonseasonally adjusted data show the actual economic events that have occurred, while the seasonally adjusted data and the trend-cycle estimate represent an analytical elaboration of the data designed to show the underlying movements that may be hidden by the seasonal variations. Compilation of seasonally adjusted data, exclusively, represents a loss of information.

b. No unique solution exists on how to conduct seasonal adjustment.

c. Seasonally adjusted data are subject to revisions as future data become available, even when the original data are not revised.

d. When compiling QNA, balancing and reconciling the accounts are better done on the original unadjusted QNA estimates. While errors in the source data may be more easily detected from seasonally adjusted data, it may be easier to identify the source for the errors and correct the errors working with the unadjusted data.

7.19 Figure 7.2 shows a quarterly time series spanning 20 years of data. This series has been simulated using a well-known seasonal ARIMA model with calendar effects (see the figure for details). The series shows an evident upward trend, stable seasonal effects (high in quarters 3 and 4, low in quarters 1 and 2), plus other nonsystematic, random movements. This series will be used throughout this chapter to illustrate the different stages of a seasonal adjustment process, which are described in the following section. Seasonal adjustment results using X-11 of this series are shown in Example 7.1.

Seasonal Adjustment Procedure

7.20 A seasonal adjustment procedure follows a two-stage approach (see the diagram in Box 7.2). The first stage is called *preadjustment*. The objective of preadjustment is to select a regression model with ARIMA errors that best describes the characteristics of the original series. The chosen model is used to adjust the series for deterministic effects (from which the name "preadjustment" is taken) and to extend the series with backcasts and forecasts to be used in the time series decomposition process. The preadjustment stage comprises mainly the choice of (i) how the unobserved components are related to each other (additive,

Figure 7.2 A Simulated Series with Trend, Seasonal, Calendar, and Irregular Effects

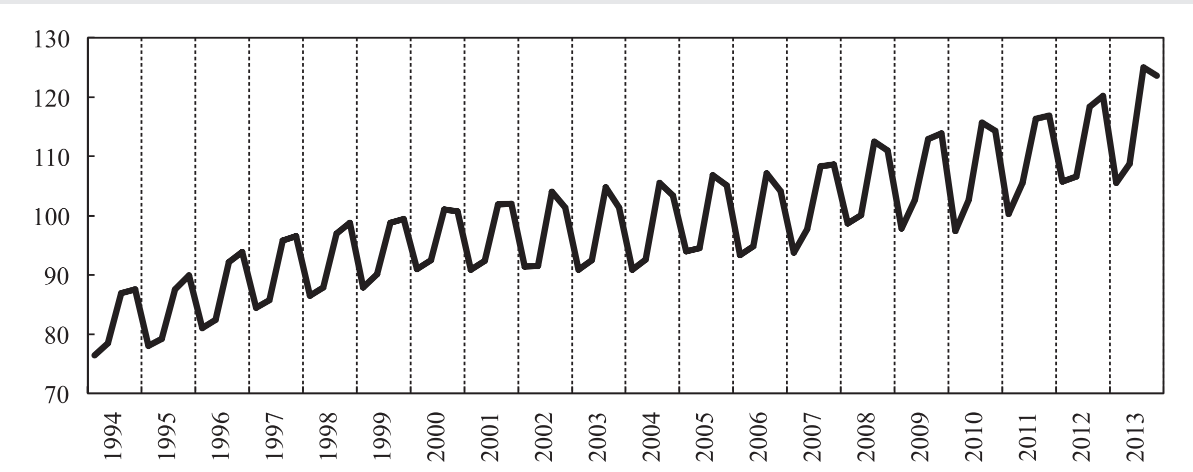


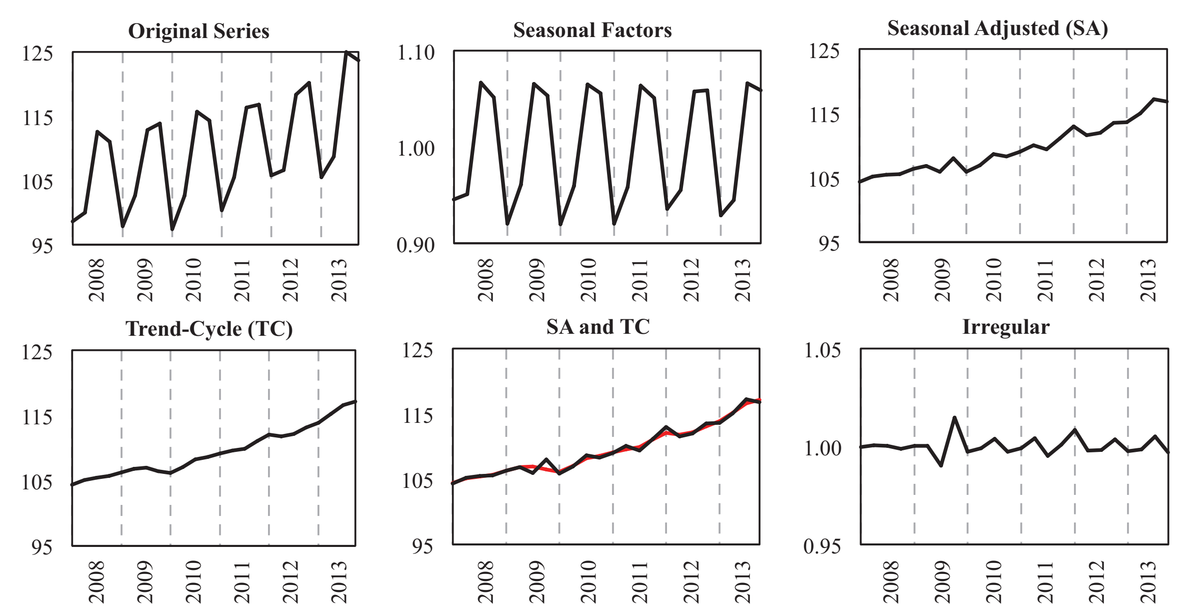
Figure 7.2 A Simulated Series with Trend, Seasonal, Calendar, and Irregular Effects (continued)

Quarter	Value	Quarter	Value	Quarter	Value	Quarter	Value	Quarter	Value
q1 1994	76.42	q1 1998	86.43	q1 2002	91.43	q1 2006	93.37	q1 2010	97.37
q2 1994	78.49	q2 1998	87.89	q2 2002	91.54	q2 2006	94.86	q2 2010	102.64
q3 1994	86.87	q3 1998	96.92	q3 2002	103.98	q3 2006	107.07	q3 2010	115.67
q4 1994	87.51	q4 1998	98.80	q4 2002	101.33	q4 2006	104.08	q4 2010	114.31
q1 1995	78.05	q1 1999	87.90	q1 2003	90.83	q1 2007	93.78	q1 2011	100.32
q2 1995	79.25	q2 1999	90.11	q2 2003	92.51	q2 2007	97.75	q2 2011	105.47
q3 1995	87.54	q3 1999	98.75	q3 2003	104.72	q3 2007	108.32	q3 2011	116.31
q4 1995	89.85	q4 1999	99.46	q4 2003	101.38	q4 2007	108.63	q4 2011	116.83
q1 1996	80.97	q1 2000	90.98	q1 2004	90.88	q1 2008	98.65	q1 2012	105.77
q2 1996	82.46	q2 2000	92.52	q2 2004	92.60	q2 2008	100.02	q2 2012	106.61
q3 1996	92.12	q3 2000	101.01	q3 2004	105.51	q3 2008	112.52	q3 2012	118.39
q4 1996	93.88	q4 2000	100.67	q4 2004	103.36	q4 2008	111.02	q4 2012	120.23
q1 1997	84.42	q1 2001	90.83	q1 2005	93.96	q1 2009	97.86	q1 2013	105.53
q2 1997	85.70	q2 2001	92.38	q2 2005	94.46	q2 2009	102.67	q2 2013	108.70
q3 1997	95.82	q3 2001	101.85	q3 2005	106.84	q3 2009	112.86	q3 2013	124.98
q4 1997	96.52	q4 2001	101.97	q4 1994	105.08	q4 2009	113.83	q4 2013	123.65

The series shown in Figure 7.2 was simulated using a seasonal ARIMA model $(0,1,1)(0,1,1)_4$. The series includes a composite deterministic effects proportional to the Easter period and the number of working days.

Example 7.1 Seasonally Adjusted Series, Seasonal, Irregular, and Trend-Cycle Components

Multiplicative decomposition approach using X-11

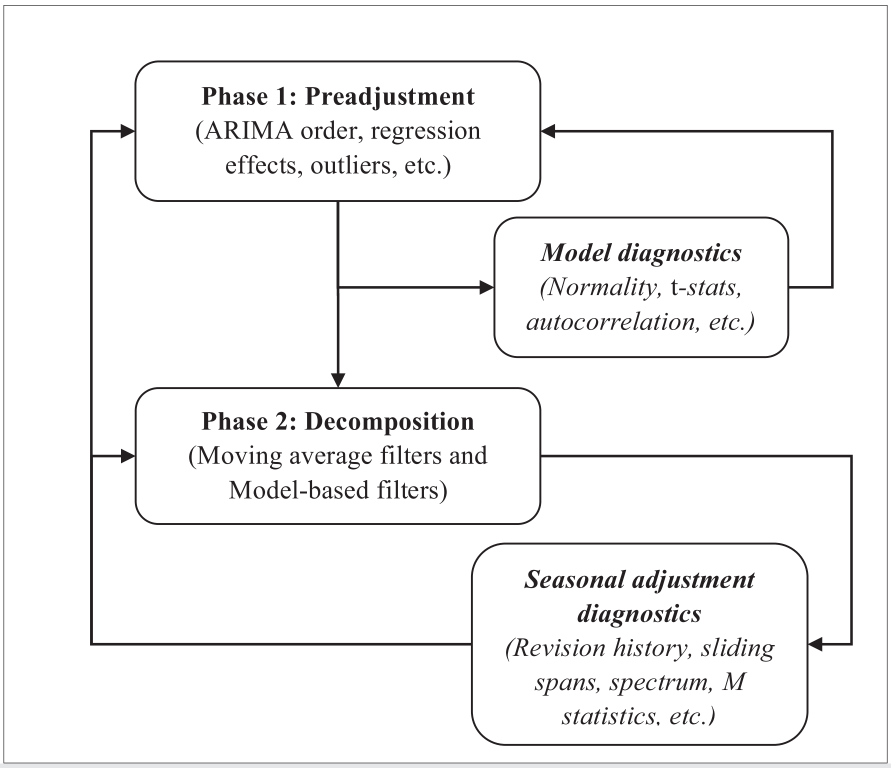


Example 7.1 Seasonally Adjusted Series, Seasonal, Irregular, and Trend-Cycle Components (continued)

	Original	Seasonal	Irregular	SA	TC
	(1)	(2)	(3)	(4)=(1) /(2)	(5)=(4) /(3)
q1 2009	97.9	0.920	1.000	106.3	106.3
q2 2009	102.7	0.961	1.000	106.9	106.8
q3 2009	112.9	1.066	0.990	105.9	106.9
q4 2009	113.8	1.054	1.015	108.0	106.5
q1 2010	97.4	0.920	0.997	105.9	106.1
q2 2010	102.6	0.960	0.999	106.9	107.0
q3 2010	115.7	1.065	1.004	108.6	108.2
q4 2010	114.3	1.056	0.997	108.3	108.6
q1 2011	100.3	0.920	0.999	109.0	109.1
q2 2011	105.5	0.958	1.004	110.1	109.6
q3 2011	116.3	1.063	0.995	109.4	109.9
q4 2011	116.8	1.051	1.001	111.2	111.1
q1 2012	105.8	0.936	1.008	113.0	112.1
q2 2012	106.6	0.955	0.998	111.6	111.8
q3 2012	118.4	1.057	0.998	112.0	112.2
q4 2012	120.2	1.059	1.004	113.5	113.1

The table and charts show the seasonal adjustment results for the simulated series shown in Figure 7.2. This decomposition has been obtained by the X-13A-S program, using the X-11 filter with default parameters and automatic identification of preadjustment effects.

Box 7.2 Main Elements of Seasonal Adjustment Procedures



[1] Diagram based on Findley and others (1998).

multiplicative, or other mixed forms), (ii) the order of the ARIMA model, (iii) calendar effects,[10] and (iv) outliers and other intervention variables.

7.21 The second stage performs a *decomposition* of the preadjusted series into unobserved components. The series adjusted for deterministic effects is decomposed into three unobserved components: trend-cycle, seasonal, and irregular. This section illustrates the two most applied decomposition methods for seasonal adjustment: the X-11 filter and the SEATS filter. After unobserved components are estimated, the adjustment factors identified in the first stage (calendar effects, outliers, etc.) are allocated to their respective component so to end up with a full decomposition of the original series into final trend-cycle, seasonal, calendar, and irregular components. The seasonally adjusted series is obtained as the series without seasonal and calendar effects.

7.22 Although the two steps are treated separately, they should be considered fully integrated in any seasonal adjustment procedure. Different choices in the preadjustment phase lead to different decomposition results. Also, results from the time series decomposition may point to changes in the preadjustment stage. A careful analysis of the diagnostics in the two stages (as discussed in "Quality Assessment of Seasonal Adjustment" section) is fundamental to determine whether the seasonal adjustment results are of acceptable quality.

7.23 The X-13A-S program implements this two-stage procedure. This software allows the user the choice between the X-11 and the SEATS filters within the same environment.[11] Because the same diagnostics are produced for the two filters, a comparative assessment between the two methods is now feasible for any series. Thanks to this flexibility, X-13A-S is (at the time of writing) the recommended seasonal adjustment procedure for producing seasonally adjusted QNA data.[12]

7.24 The rest of this chapter briefly presents the main elements of the preadjustment and decomposition steps.

Preadjustment

Model Selection

7.25 The first step in the preadjustment stage is to determine the decomposition model assumed for the series. For the X-11 decomposition, two main models are usually selected: the additive model and the multiplicative model.[13] In the additive model, the original series X_t can be thought of as the sum of unobserved components: that is,

$$X_t = T_t + S_t + C_t + I_t, \tag{1}$$

where

T_t is the trend-cycle component,

S_t is the seasonal component,

C_t is the calendar component, and

I_t is the irregular component.

The additive model assumes that the unobserved components are mutually independent from one another. The seasonal and calendar adjusted series for the additive model is derived by subtracting the seasonal and calendar components from the original series:

$$\begin{aligned} X_t^a &= X_t - (S_t + C_t) \\ &= T_t + I_t . \end{aligned} \tag{2}$$

7.26 In the multiplicative model, the series X_t is decomposed as the product of the unobserved components:

$$X_t = T_t \cdot S_t \cdot C_t \cdot I_t. \tag{3}$$

[10] The X-13A-S program offers an alternative method to estimate trading-day effects from the irregular component, inherited from the original X-11 method. However, the regression framework is the preferred approach for identifying and estimating calendar effects.

[11] X-13A-S implements a version of the SEATS procedure originally developed by Gomez and Maravall (1998). The X-13A-S manual cautions that "possible delays in the updating of versions may cause slight differences between the X-13A-S version of SEATS and the one at the Bank of Spain website." (U.S. Census Bureau, 2013).

[12] This chapter provides hints on how to set options in the X-13A-S input specification file. The input specification file contains a set of specifications (or "specs") that give information about the data and desired seasonal adjustment options. For more details on the theory and practice of seasonal adjustment, see the X-13A-S guide (U.S. Census Bureau, 2013) and the literature therein cited.

[13] In some cases, a mixed model may be chosen. In particular, X-13A-S includes a pseudo-additive model $X_t = T_t(S_t + I_t - 1)$ for series that show a multiplicative decomposition scheme but whose values are zero in some periods.

The multiplicative model assumes that the magnitude of the unobserved components is proportional to the level of the series. For the seasonal component, for example, a multiplicative model implies that seasonal peaks increase as the level of the series increases. Because the trend-cycle component determines the overall level of the series, the other unobserved components are expressed as percentages of T_t (usually called factors). The seasonal and calendar adjusted series for the multiplicative model is the ratio between the original series and the seasonal and calendar factors:

$$\begin{aligned} X_t^a &= X_t / (S_t \cdot C_t) \\ &= T_t \cdot I_t. \end{aligned} \tag{4}$$

7.27 With SEATS, the multiplicative model cannot be used directly because the model-based decomposition assumes that the unobserved components are additive. The multiplicative adjustment is approximated through the log-additive model:

$$\begin{aligned} \log(X_t) &= \log(T_t \cdot S_t \cdot C_t \cdot I_t) \\ &= \log(T_t) + \log(S_t) + \log(C_t) + \log(I_t). \end{aligned} \tag{5}$$

After an additive decomposition of the logged series is completed, the seasonally adjusted series is derived taking the exponential of the logged trend-cycle and irregular components:

$$\begin{aligned} X_t^a &= \exp[\log(T_t) + \log(I_t)] \\ &= T_t \cdot I_t. \end{aligned} \tag{6}$$

7.28 Sometimes, a graphical inspection of the series can give some clues about the best decomposition model for the series. If the variation of seasonal pattern increases with the level of the series, then the relationship between components is expected to be multiplicative and a multiplicative (or a log-additive) adjustment is recommended. Such a transformation allows stabilizing the evolution of the seasonal pattern and controlling for possible heteroscedasticity in the irregular component (and in the regression residuals). Alternatively, if the seasonal pattern appears to be stable over time and does not evolve in accordance with the movements of the trend, then no transformation is to be performed and the decomposition should follow an additive approach.

7.29 A visual inspection of the series may not be enough to determine the underlying relationship between components. In addition to the expert knowledge about the series, X-13A-S implements an automatic selection procedure to decide whether the series should be log transformed or not.[14] This automatic tool should be used when seasonal adjustment is applied for a large number of time series. However, the automatic choice from the X-13A-S should always be validated individually for important time series.

7.30 If the multiplicative approach is chosen, final components have the nature of multiplicative factors: that is, the seasonal and irregular components will be ratios centered around 1. On the other hand, if the additive approach is selected, seasonal and irregular components will have the form of addends and will be centered around 0 (additively neutral).

7.31 The next step in the preadjustment phase is to identify an ARIMA model for the series. The ARIMA selection process should be seen in conjunction with the choice of regression effects. In effect, using certain regression variables may change the order of the ARIMA model. An ARIMA with regression effects is called regARIMA model. For the sake of clarity, however, ARIMA model and regression effects are treated separately in this presentation.

7.32 Using the same notation of the X-13A-S manual, an ARIMA model for seasonal time series can be written as follows:

$$\phi(B)\Phi(B^s)(1-B)^d(1-B^s)^D Y_t = \theta(B)\Theta(B^s)\varepsilon_t, \tag{7}$$

where

Y_t is the original series (possibly preadjusted for deterministic effects);

B is the lag operator, which is defined by $Y_{t-1} = BY_t$;

s is the seasonal frequency, 4 for quarterly series and 12 for monthly series;

$\phi(B) = 1 - \phi_1 B - \ldots - \phi_p B^p$ is the regular autoregressive (AR) operator of order p;

$\Phi(B) = 1 - \Phi_1 B^4 - \ldots - \Phi_P B^{4P}$ is the seasonal AR operator of order P;

$\theta(B) = 1 - \theta_1 B - \ldots - \theta_q B^q$ is the regular MA operator of order q;

[14] The spec TRANSFORM enables the automatic transformation selection procedure. TRANSFORM can also be used to select automatically between the additive and multiplicative models for X-11.

$\Theta(B) = 1 - \Theta_1 B^Q - \ldots - \Theta_Q B^{4Q}$ is the seasonal MA operator of order Q; and

ε_t is a white noise process.

7.33 Identifying an ARIMA model consists in determining the orders of the AR operators (p for nonseasonal and P for seasonal), the MA operators (q and Q), as well as establishing the nonseasonal and seasonal integration orders (d and D). [15] A seasonal ARIMA model for a quarterly series is usually indicated as $(p,d,q)(P,D,Q)_4$. In X-13A-S, the following automatic selection procedure is implemented to identify the ARIMA order:[16]

- A default model is estimated. The default model for quarterly series is $(0,1,1)(0,1,1)_4$, also known as the "airline" model. This model is parsimonious (only two parameters are estimated) and usually fits very well-economic time series. Regression effects are also identified and removed using the default model.
- The differencing orders d and D are estimated by performing a series of unit root tests.
- The ARMA[17] order $(p,q)(P,Q)_4$ is selected by comparing values of a statistical information criterion[18] of a number of models, up to a maximum order for the regular and seasonal ARMA polynomial which can be specified by the user.
- Diagnostics on the residuals for the chosen ARIMA model are compared with those from the default model. Based on these tests, the final model is selected and validated.

7.34 Selecting the correct ARIMA model has important consequences in the seasonal adjustment process.

a. The chosen order of the ARIMA model may affect the automatic selection process of calendar effects and outliers.

b. The ARIMA model is used to produce forecasts and backcasts that are necessary to address the asymmetry of filters at the endpoints of the series.

c. The ARIMA order chosen for the original series is central to the SEATS decomposition, because the seasonal and trend filters are derived from the coefficients of the estimated ARIMA model (as discussed later in this section).

7.35 In general, users should consider the ARIMA order automatically selected by the X-13A-S program as the baseline model. Changes to the baseline model should be done when the model statistics are not satisfactory. For example, the model should be changed when diagnostics on the residuals signal misspecification of the automatically identified model. Parsimonious models should always be preferred to complex models. In most cases, the differencing orders d and D are 0 (if the component is stationary) or 1 (if the component is nonstationary). Double differencing may occur for some series with persistent movements (e.g., price data or deflators). Mixed ARMA models, which are models where AR and MA operators are both present in the seasonal or nonseasonal parts, should usually be avoided. For most series, the default model $(0,1,1)(0,1,1)_4$ often works very well with seasonal economic time series and should be considered when no other model provides satisfactory results.

Calendar Effects

7.36 Calendar effects should be removed from the series because they could affect negatively the quality of decomposition into unobserved components. For example, consider the effect from a different number of working days in two periods. When a month contains more working days than usual, series measuring economic activities may present a spike in that particular month due to the fact that there is more time for production. This effect cannot be captured by any linear representation of the series (like an ARIMA model), and will be allocated in the time series decomposition process mostly to the irregular component. As a result, the seasonally adjusted series will present an increase that is merely attributable to the different number of working days in the two periods compared. To avoid such distortions, calendar effects

[15] Integrated series refers to nonstationary underlying processes that must be differentiated in order to turn the series into a stationary process. The order of integration (i.e., number of unit roots in the autoregressive polynomial) reflects the need for differentiation of the time series to become stationary.

[16] The automatic ARIMA model identification procedure implemented in X-13A-S is based on the one available in the TRAMO program (Gomez and Maravall, 1996). In X-13A-S, the reference spec is AUTOMDL. For more details on the procedure, refer to the X-13A-S manual (U.S. Census Bureau, 2013).

[17] ARMA stands for autoregressive moving average. In contrast with ARIMA models, ARMA processes are stationary and do not require differentiation.

[18] X-13A-S uses the Bayesian information criterion (BIC) for selecting the ARMA order. The best model is the one with the minimum BIC value.

should be estimated and eliminated from the original series before the time series decomposition process.

7.37 All calendar effects are captured through specific deterministic effects that are meant to reproduce the changes in the calendar structure over time. These deterministic effects are called calendar regressors, as they are used as independent variables in the regARIMA model specified in the seasonal adjustment process. The most frequently used calendar regressors are formalized below.

7.38 The trading-days effect is defined by the following six regressors:[19]

$$\begin{aligned} td_t^1 &= (\#\,\text{Mondays} - \#\,\text{Sundays}) \\ td_t^2 &= (\#\,\text{Tuesdays} - \#\,\text{Sundays}) \\ &\dots \\ td_t^6 &= (\#\,\text{Saturdays} - \#\,\text{Sundays}) \end{aligned} \tag{8}$$

which calculate the difference between the number of each day of the week ($\#\,\text{Mondays},\ \#\,\text{Tuesdays}, \dots$) and the number of Sundays[20] ($\#\,\text{Sundays}$) in month t. The assumption is that each day of the week may influence the underlying phenomenon with different magnitude and direction.

7.39 The working-days effect is caught via a single regressor that compares the group of working days (e.g., Monday to Friday) with the group of weekend days (e.g., Saturday and Sunday) through the following equation:

$$wd_t = \left(\#\,\text{Weekdays} - \frac{5}{2}\#\,\text{Weekend days}\right). \tag{9}$$

The $5/2$ factor is needed to make the working-days regressor nil over a regular seven-day week composition. Any monthly deviation from the standard week will be reflected in the regressor (e.g., when wd_t is larger than zero, it means that month/quarter t has more working days than a standard week). This approach assumes that weekdays have similar effects (in sign and value) and are different from weekend-days effects.

7.40 The Easter date moves between March (q1) and April (q2).[21] The Easter regressor calculates the proportion of days before Easter falling in March (q1) and April (q2). After defining the length of the Easter effect, the regressor is calculated as follows:

$$e_t = \frac{W_t}{w} - \bar{W}, \tag{10}$$

where

W_t is the number of w days falling in month/quarter t and

$\bar{W}$ is the long-term proportion of days in month/quarter t.

Usually $\bar{W}$ can be approximated with 0.5 for both March (q1) and April (q2)[22]: that is, the number of days of the Easter effect is equally distributed between the two periods. In X-13A-S, the length w of the Easter effect can be provided by the user (from 1 to 25) or selected automatically by the program (lengths of 1, 8, and 15 are compared).

7.41 Finally, the leap year effect is captured as follows:

$$ly_t = \begin{cases} 0.75, & \text{if } t \text{ is February of a leap year} \\ -0.25, & \text{if } t \text{ is February of a non-leap year} \\ 0, & \text{otherwise.} \end{cases} \tag{11}$$

The regressor ly_t reproduces a deterministic four-year cycle with a peak in February of leap years; over a four-year period, the leap year effect is fully compensated by the negative effects in the subsequent non-leap years.

7.42 The adjustment for calendar effects should be performed only for those series for which there is both statistical evidence and economic interpretation of calendar effects. This assessment should be based on the statistical and economic significance of their regression coefficients. Statistically, a regression coefficient is said to be significantly different from zero

[19] The following presentation is based on the Monday-to-Friday workweek in place in most Western countries (the default one in X-13A-S). However, other countries have different workweeks (in particular, Sunday-to-Thursday in many Muslim countries). The groups of weekdays and weekend days should be defined according to the legal workweek in the country.

[20] National holidays should be considered non-working days. Therefore, the number of nonworking days should be increased by the number of national holidays and the number of working days should be decreased accordingly. The same holds true for the working-days regressor.

[21] Only the Catholic Easter is considered here. Orthodox Easter falls between April and May, thus it does not affect quarterly series.

[22] The Easter regressor may also be nonzero in February, but this happens very rarely.

Box 7.3 Test for Calendar Effects

A 1. Time Series Data (for the Span Analyzed)			
Regression Model			
Variable	Parameter Estimate	Standard Error	t-value
1-Coefficient trading day			
Weekday	0.0019	0.00065	2.97
**Saturday/Sunday (derived)	–0.0048	0.00162	–2.97
Leap year	0.0142	0.00384	3.71
Easter	0.0092	0.00250	3.66

Table A 1 from the X-13A-S output contains diagnostics on the estimated regression coefficients for the series presented in Figure 7.2. The first column shows the estimated values; the second column their standard errors; and the third column the *t*-statistics, which is the ratio between the parameter estimates and the standard errors. When the *t*-ratio (in absolute terms) is large enough (say, larger than 2), the regression effect is said to be significantly different from zero and should be kept in the model. In the above example, three calendar effects are estimated in the model: (i) the working-day regressor (called in X-13A-S "1-Coefficient trading day"), (ii) the leap year regressor, and (iii) the Easter regressor. All the effects are significantly different from zero (i.e., their *t*-values are larger than 2 in absolute terms). For calendar effects, it is also important to look at the sign of the estimated coefficients to validate them in economic terms. In most cases, calendar effects are expected to have a positive impact on national accounts transactions and should appear with positive sign; on the contrary, negative coefficients should be found when the effect is expected to reduce the activity (e.g., working days for tourism-related services).

when the associated *t*-statistic is higher (in absolute value) than a certain threshold (usually 2, but lower thresholds may be acceptable). Furthermore, the sign of the regression coefficient should be interpretable from an economic standpoint. For example, the leap year effect should always be positive, the working-days effect for economic activities where production is organized on a five-day week should be positive, the Easter effect should be positive for consumption of tourism-related services[23] and negative for other producing activities, etc. When the estimated coefficient for a calendar effect is not statistically significant (i.e., *t*-statistic lower than a chosen threshold) or is difficult to interpret in economic terms (i.e., implausible size or sign of the coefficient), the series should not be adjusted for that calendar effect. As an example, Box 7.3 shows the output returned by X-13A-S to evaluate the results on calendar effects.

7.43 Two compilation aspects concern the frequency of calculation of calendar effects. First, calendar effects are statistically more evident on monthly series than on quarterly series. The quarterly aggregation reduces (and sometimes eliminates) the variability of calendar regressors up to a level that makes them hardly detectable in the estimation process. For this reason, the adjustment for calendar effects should be preferably performed on monthly indicators and then the resulting effect aggregated at the quarterly level.

7.44 On the other hand, trading-days and working-days effects may also be relevant at the annual frequency. Adjacent years may contain up to three or four working days of difference, which may distort the comparison between annual observations. When such effects are significant on an annual basis, it may be necessary to calculate annual aggregates adjusted for calendar effects (mostly trading/working-days and leap year) and use these as annual benchmarks for the quarterly seasonally and calendar adjusted estimates.[24] When calendar effects are negligible on an annual basis, quarterly seasonally and calendar adjusted estimates can be benchmarked to the original annual national accounts (ANA) aggregates.

7.45 X-13A-S provides predefined calendar effects. Furthermore, the program allows user-defined regressors to be included in the regARIMA model. The user can prepare any specific calendar effect and test its economical and statistical significance from the results returned by the program. This functionality

[23] In some countries, Easter creates a peak in retail trade activity due to the increase in household spending; in other countries, however, most shops are closed during the Easter holiday.

[24] Annual data adjusted for calendar effects can be obtained by aggregating the quarterly calendar adjusted series returned by X-13A-S. When calendar adjustment is applied to monthly indicators, annual data of national accounts adjusted for calendar effects should be derived proportionally to the adjustment derived on the indicator or via a regression approach (Di Palma and Marini, 2004).

is important for adjusting QNA data for country-specific effects not included as a built-in option of X-13A-S (e.g., Chinese New Year, Ramadan, etc.). An automatic selection procedure of calendar effects (both built-in and user-defined) is available.[25] Similar to the ARIMA order, the automatic selection procedure should always be used when seasonal adjustment is applied to a large number of time series. However, the sign of each calendar effect accepted by X-13A-S should always be evaluated in economic terms. Moreover, regression coefficients associated with calendar effects should remain stable as new observations are incorporated in the series. Estimated calendar effects that are not supported by economic rationale should not be included in the adjustment.[26]

7.46 QNA series should not be adjusted for bridge days or extreme weather effects. Bridge days are working days that fall between a public holiday and the weekend. Because many employees take off bridge days for a long weekend, bridge days may result in lower output than on a normal working day. Extreme weather effects like heavy rain or snow days can affect the level of output in many industries, including construction and tourism activities. Nevertheless, their effects may be local rather than national. In some cases, the loss in production may be recovered in subsequent periods. Country experience shows that the estimation of bridge day and extreme weather effects is extremely uncertain.[27] Normal weather-related effects should be treated as part of the regular seasonal adjustment process, whereas extreme effects can be adjusted using outliers or ad hoc intervention variables.

Outliers and Intervention Variables

7.47 Unusual events cannot be predicted ex ante; but once they have manifested in the series, they should be understood and modeled in the seasonal adjustment process through specific regression variables. The reason is that leaving abnormal values in the series may lead to significant distortion in the decomposition of QNA series such as production, consumption, investment, etc. For instance, unexpected extreme weather conditions (droughts, floods, etc.) can seriously affect output of agricultural crops. The sudden fall in the agricultural activity should be allocated to the irregular component, without influencing the long-term trend or seasonality in agriculture. Other unusual events may be allocated to the trend (e.g., level shift) or seasonality (e.g., seasonal break). To achieve this, abnormal values (commonly known as outliers) should be taken out of the original series and reintroduced in the final components after the decomposition step has been applied to the series preadjusted for such events. Other known events that are supposed to have a significant impact on the series should be treated in the preadjustment step by means of intervention variables (e.g., strikes, temporal shutdowns, and quarantines).

7.48 X-13A-S contains a procedure for automatic identification of additive outliers, temporary change outliers, and level shifts (see Figure 7.1).[28] This procedure consists of including dummy-type variables in the regression model for all possible periods within a specified time span. The program calculates regression coefficients for each type of outlier specified and adds to the model all outliers with absolute *t*-statistics exceeding a critical value.[29] Furthermore, X-13A-S allows the use of predefined intervention variables.[30] As mentioned in "Main Principles of Seasonal Adjustment" section, three common intervention variables are temporary level shifts, seasonal outliers, and ramps (see Figure 7.1). Other intervention variables can be created from the user externally and given as input to the program.

7.49 Seasonal adjustment results are severely affected by outliers and intervention variables. A different combination of regression effects can produce significant changes in the estimation of trend and seasonal components. As for any other regression effects, outliers should be evaluated based on the statistical significance of their regression coefficients (through

[25] In X-13A-S, the spec name for the automatic identification of calendar effects is REGRESSION. The test is based on the Akaike Information Criterion.

[26] X-13A-S also provides another option for estimating trading-day and Easter effects based on ordinary least square (OLS) regression analysis from the final irregular component. The spec name for this option is X11REGRESSION. However, regARIMA models for estimating calendar effects are preferred because they usually provide better results than OLS regressions.

[27] See Deutsche Bundesbank (2012).

[28] In X-13A-S, the spec name for the automatic identification of outliers is OUTLIER.

[29] Default critical values for the outlier *t*-statistics depend on the series length.

[30] In X-13A-S, the spec name for including intervention variables in the regARIMA model is REGRESSION.

t-statistics) and their robustness. Outliers are particularly difficult to detect and interpret in real time, especially during periods of strong economic changes such as recessions.[31] When abnormal values first arise in a series, they should either be adjusted as additive outliers or left unadjusted. Level shifts or other transitory effects involving more than one period should be taken into consideration only when future observations of the series make clear the nature of the event.

Time Series Decomposition Methods

7.50 For seasonal adjustment of QNA data, a choice should be made between two alternative methods: the X-11 filter and the SEATS filter. These methods are well documented and have become standard methods for seasonal adjustment of official statistics. Furthermore, their use increases comparability of seasonally adjusted time series across countries.

7.51 Both methods give satisfactory results for most time series and are equally recommendable. Countries should choose their preferred method according to statistical and practical considerations. The fact that X-13A-S offers both filters in the same program allows an easy comparison on series with different characteristics using a common set of diagnostics.[32] However, the choice may also be grounded on past experience, internal expertise, and subjective judgment. Once the choice is made, the same method should be used to seasonally adjust all the QNA series (indicators or final results) and clearly communicated to the public. Mixing different seasonal adjustment methods in the same statistical domain may reduce the level of comparability of seasonally adjusted series and cause confusion in the users.

7.52 Both X-11 and SEATS apply symmetric filters to the preadjusted series to derive estimates of trend-cycle, seasonal, and irregular components. However, the nature of such filters differs significantly from one another. The following provides a brief description and highlights the main differences between the two methods.

[31] For a discussion on how to handle recession effects on seasonal adjustment, see the experiments in Ciammola and others (2010) and in Lytras and Bell (2013).

[32] The original version of SEATS, developed by Gomez and Maravall (1996), is implemented in the program TRAMO-SEATS (available at the Bank of Spain Web site). X-13A-S provides a close approximation of the SEATS decomposition results.

The X-11 Filter

7.53 The X-11 filter is derived as an iterative process, which consists in applying a sequence of predefined MA filters. After the series is preadjusted and extended with backcasts and forecasts, it goes through three rounds of filtering and extreme value adjustments called “B, C, and D iterations.”

7.54 The MA filtering procedure implicitly assumes that the irregular effect is approximately symmetrically distributed around their expected value (1 for a multiplicative model and 0 for an additive model) and thus can be fully eliminated by using a symmetric MA filter. Therefore, seasonality and trend-cycle components are isolated from the irregular components by means of a successive application of ad hoc MA filters.

7.55 The main steps of the X-11[33] multiplicative adjustment[34] for quarterly data in the B, C, and D iterations are reproduced as follows:

Iteration B. Initial Estimates

a. *Initial Trend Cycle* (T_t^1). The original series Y_t is filtered using a weighted 5-term (2×4)[35] centered MA, which extracts an initial trend component from the series.

b. *Initial Seasonal–Irregular (SI) Ratios* (SI_t^1). The original series is divided by T_t^1 to give an initial (joint) estimate of the seasonal and irregular components SI_t^1.

c. *Initial Preliminary Seasonal Factors*. Irregular effects from the initial SI ratios are removed by applying a weighted 5-term (3×3) centered seasonal MA so as to derive an initial preliminary estimate of the seasonal factors.

d. *Initial Seasonal Factors* (S_t^1). Preliminary seasonal factors are then normalized to ensure that the annual average of the initial seasonal factors is close to 1.

[33] The procedure described below is a summary of the detailed steps performed by the X-11 filter. For a more precise description of the X-11 filter, see Ladiray and Quenneville (2001, chapter 4).

[34] Multiplicative decomposition is the default X-11 method in X-13A-S. However, the decomposition method should be consistent with the type chosen in the preadjustment stage (automatically or manually). In the case of additive decomposition, subtractions are used instead of divisions. The spec to modify options of the standard X-11 filter is X11.

[35] An $N\times M$ centered moving average is obtained by applying simple moving averages of length N and M in succession. See Ladiray and Quenneville (2001) for a discussion of the properties of moving averages used in X-11.

e. *Initial Seasonally Adjusted Series* (A_t^1). The initial estimate of the seasonally adjusted series A_t^1 is derived by dividing the original series by the initial seasonal factors S_t^1: that is,

$$A_t^1 = \frac{Y_t^1}{S_t^1} = T_t^1 I_t^1 .$$

Iteration C. Final Seasonal–Irregular Ratios

a. *Intermediate Trend Cycle* (T_t^2). A revised estimate of the trend cycle is derived by applying a Henderson filter[36] to the initial seasonally adjusted series A_t^1. The Henderson filter is a (2*h*+1)-term symmetric filter whose values are designed to extract a trend component from the input series. For quarterly series, X-13A-S selects automatically a 5- or a 7-term Henderson MA based on the statistical characteristics of the data.

b. *Revised SI Ratios* (SI_t^2). Revised SI ratios are derived by dividing the original series Y_t by the intermediate trend cycle T_t^2.

c. *Revised Preliminary Seasonal Factors.* Revised preliminary seasonal factors are derived by applying a (3×5)-centered seasonal MA to the revised SI ratios SI_t^2.

Iteration D. Final Components

a. *Final Seasonal Factors* (S_t^2). As in stage B, preliminary seasonal factors are normalized to produce final seasonal factors.

b. *Final Seasonally Adjusted Series* (A_t^2). The original series is divided by the revised seasonal factors S_t^2 to derive the final seasonally adjusted series.

c. *Final Trend Cycle* (T_t^3). A final estimate of the trend-cycle component is derived by applying a Henderson MA to the final seasonally adjusted series A_t^2.

d. *Final Irregular* (I_t^3). A final estimate of the irregular component is derived by dividing the final seasonally adjusted series A_t^2 by the final trend cycle T_t^3.

7.56 In addition to the three-stage procedure described above, the X-11 filter implements an algorithm to reduce the impact of extreme values in the adjustment process. Based on a statistical analysis of SI ratios, extreme values are identified and temporarily replaced with average values in stages B and C, so as to eliminate their effects from seasonal factors.

7.57 One quick way to analyze the X-11 results is to look at the final SI ratios. X-13A-S produces a chart comparing the final seasonal factors with the SI ratios (see the example in Figure 7.3). Seasonality is expected to be stable over time. If SI ratios are too volatile relative to the seasonal factors, this indicates that the series contains a strong irregular component and the seasonal effects may absorb too much volatility. Shorter filters for extracting seasonal effects from SI ratios are warranted when the irregular component is large relative to the seasonal effects; longer filters are better to extract stable seasonal factors.[37]

The SEATS Filter

7.58 The SEATS filter is based on the ARIMA model-based (AMB) approach for seasonal adjustment. This approach consists of estimating an ARIMA model for the original (possibly preadjusted) series, deriving consistent ARIMA models for the unobserved components (trend-cycle, seasonality, and irregular), and estimating the components using an optimal signal extraction technique. An important property of the AMB approach is that the seasonal adjustment filter adapts itself to the particular structure of the series. Conversely, X-11 is an ad hoc seasonal adjustment filter that applies to every single series in the same manner regardless of the structure of the seasonal and nonseasonal components (although the filter length may be changed to better suit different characteristics).

7.59 The AMB approach implemented by SEATS is briefly illustrated below.[38] The following presentation of SEATS is informal, as a comprehensive illustration of the AMB approach for seasonal adjustment requires the use of advanced concepts of time-series analysis (such as spectral analysis and signal extraction theory) that go beyond the scope of this manual. The advantage of using seasonal adjustment programs such as X-13A-S[39] or TRAMO-SEATS is that they have been designed and equipped with automatic features that facilitate

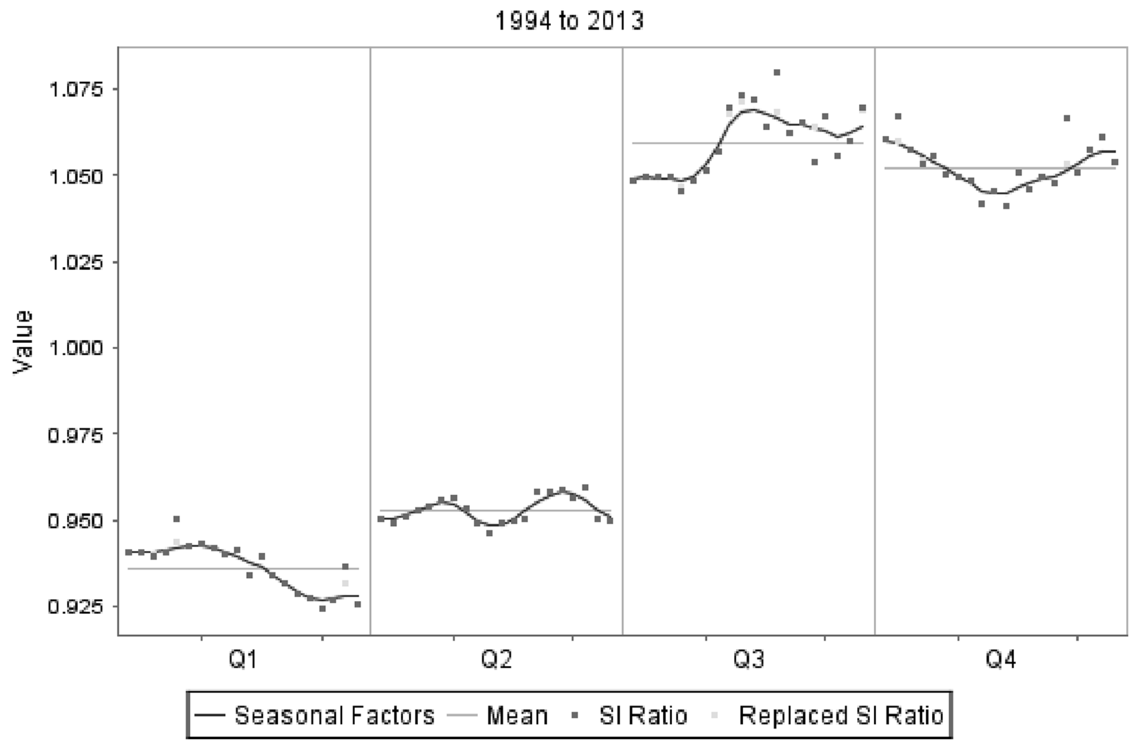
[36] A Henderson filter is a centered moving average whose weights are designed to extract a smooth trend cycle from series with noise.

[37] In X-13A-S, the spec name for modifying the length of the standard X-11 filter is X11.

[38] For an introduction to the AMB decomposition of time series and further reference, see Kaiser and Maravall (2000).

[39] In X-13A-S, the spec name for running SEATS is SEATS.

Figure 7.3 Seasonal Factors and Seasonal-to-Irregular Ratios



This chart is taken from the output of Win X-13, the windows interface of X-13A-S. The chart shows the seasonal factors by quarter, their average, and the seasonal-to-irregular (SI) ratios for the series presented in Figure 7.2.

the selection of seasonal adjustment options, making this task easy even for less experienced seasonal adjustment users. However, compilers who are interested in applying SEATS in the QNA should acquire a sound knowledge of the method, which will be necessary to help them evaluate and validate the results and be able to handle the adjustment of problematic series.

7.60 The ARIMA model (7) (see paragraphs 7.31–35), identified and estimated on the input series, is decomposed into ARIMA models for the trend-cycle, seasonal, and irregular components. A number of assumptions are made to derive an optimal decomposition (among infinite ones) of the estimated ARIMA model. First, components are assumed to be mutually independent (components are said to be orthogonal). This is not a harmless assumption, as it requires, for example, that the trend-cycle and seasonal components are independent from one another. However, this assumption is traditionally accepted in model-based seasonal adjustment methods. Second, the seasonal component captures all the seasonal movements in the series.[40] Finally, the variance of the irregular component is maximized over the variance of the other components.[41] This assumption implies that the trend-cycle and seasonal components estimated by SEATS tend to be stable, as most of the volatility is assigned to the irregular component.

7.61 The optimal estimator for a component[42] is derived by applying a specific symmetric filter to the input series:

$$
\begin{aligned}
A_t &= \ldots + v_2 Y_{t-2} + v_1 Y_{t-1} + v_0 Y_t + v_1 Y_{t+1} + v_2 Y_{t+2} + \ldots \\
&= v_0 Y_t + \sum_{j=1}^{\infty} v_j (B^j + F^j) Y_t = v(B,F)
\end{aligned}
\tag{12}
$$

[40] In the frequency domain, this means that peaks at the seasonal frequencies in the spectrum are allocated to the ARIMA model of the seasonal component.

[41] A decomposition where the innovation of the irregular is maximized is called canonical decomposition.

[42] The estimator is optimal because it is the minimum mean square error (MMSE) estimator of the components.

where B is the backward operator and F is the forward operator, such that $Y_{t-j} = B^j Y_t$ and $Y_{t+j} = F^j Y_t$. The filter $v(B,F)$ is called the Wiener–Kolmogorov (WK) filter. Its weights depend on the ARIMA models derived for the unobserved components and vary with the characteristics of the series. Likewise the X-11 filter, the WK filter uses backcasts and forecasts at both ends of the series calculated from the ARIMA model estimated for the series. Because the WK filter is a convergent filter, it can be truncated after a relatively large number of periods to yield a finite-sample approximation of the infinite filter.

7.62 Several empirical studies have been conducted to compare the seasonal adjustment results from the X-11 and SEATS filters.[43] In general, both methods give satisfactory results and the choice should be made based on practical considerations and subjective judgment. However, a few general points for guidance can be given. Because of the canonical decomposition, SEATS tends to produce more stable seasonal components than X-11. Consequently, seasonally adjusted series with SEATS are expected to be more volatile than seasonally adjusted series with X-11. Furthermore, the quality of the SEATS decomposition mainly depends on the quality of the estimated ARIMA model, as a poorly fit model is likely to lead to a bad-quality (or even inadmissible) decomposition. Finally, the SEATS results are more subject to the effect of parameter uncertainty than for X-11. A greater instability in the estimation process of the regARIMA model may be expected for short series (5–6 or less years), as parameters are estimated on a small number of observations, and long series (20 or more years), which may present evolving patterns.

Seasonal Adjustment and Revisions[44]

7.63 Seasonal effects may change over time. The seasonal pattern may gradually evolve as economic behavior, economic structures, and institutional and social arrangements change. The seasonal pattern may also change abruptly because of sudden institutional changes. Seasonal filters estimated using centered MAs (like the X-11 and SEATS filters) allow the seasonal pattern of the series to change over time and allow for a gradual update of the seasonal pattern. This results in a more correct identification of the seasonal effects influencing different parts of the series.

7.64 On the other hand, centered MA seasonal filters also imply that the final seasonally adjusted values depend on both past and future values of the series. Thus, to be able to seasonally adjust the earliest and latest observations of the series, either asymmetric filters have to be used for the earliest and latest observations of the series or the series has to be extended by use of backcasts and forecasts based on the pattern of the time series. While the original X-11 program used asymmetric filters at the beginning and end of the series, X-13A-S (and its predecessors X-11-ARIMA and X-12-ARIMA programs) use ARIMA modeling techniques to extend the series so that less asymmetric filters can be used at both ends of the series.

7.65 Studies have shown that using ARIMA models to extend the series before filtering generally significantly reduces the size of these revisions compared with using asymmetric filters.[45] These studies have shown that, typically, revisions to the level of the series as well as to the period-to-period rate of change are reduced. Use of regARIMA models, as offered by X-13A-S, may make the backcasts and forecasts more robust and thus further reduces the size of these revisions compared with using pure ARIMA models. The reason for this is that regARIMA models allow calendar effects and other effects captured by the regressors to be taken into account in the forecasts in a consistent way. Availability of longer time series should result in a more precise identification of the regular pattern of the series (the seasonal pattern and the ARIMA model) and, in general, also reduce the size of the revisions.

7.66 Consequently, new observations generally result in changes in the estimated seasonal pattern for the latest part of the series and subject seasonally adjusted data to more frequent revisions than the original nonseasonally adjusted series. This is illustrated in Example 7.2. Furthermore, revisions to one observation in the original series may lead to changes in some of the estimated parameters, which in turn results in revisions to more than one period in the seasonally

[43] For example, see Hood and Findley (1999) and Scott, Tiller, and Chow (2007).

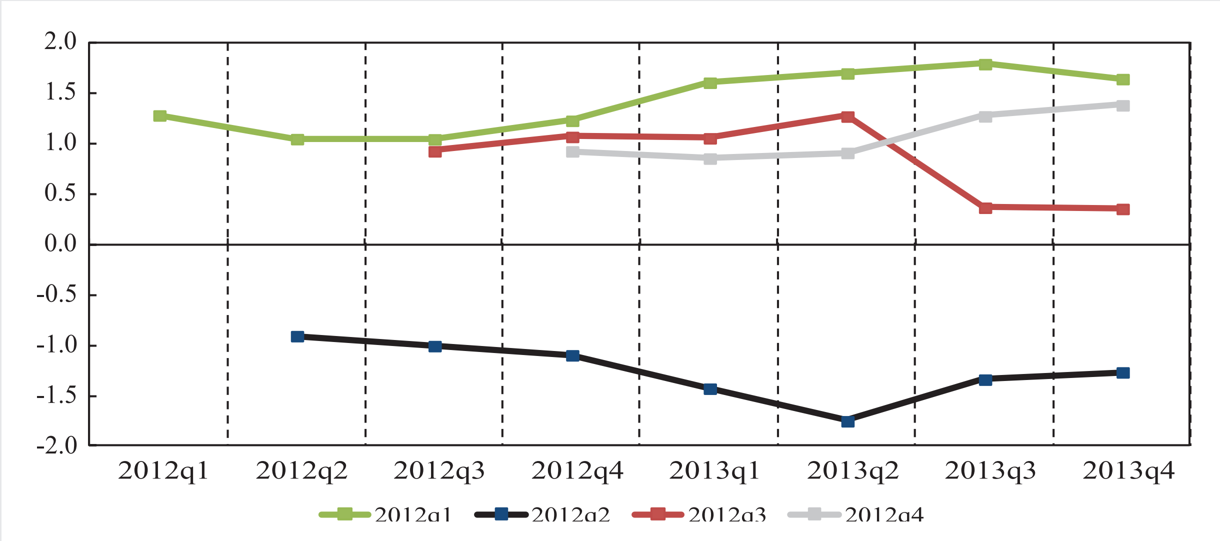
[44] This section focuses on revisions generated by seasonal adjustment. For more general considerations on the revision policy of QNA, see Chapter 12.

[45] See among others Bobbitt and Otto (1990), Dagum (1987), Dagum and Morry (1984), and Huyot and others (1986).

Example 7.2 Revisions to the Seasonally Adjusted Series

Revisions to the seasonally adjusted estimates by adding new observations

(Original unadjusted data in Figure 7.2)



Data Until

	q1 2012		q2 2012		q3 2012		q4 2012		q1 2013		q2 2013		q3 2013		q4 2013	
Quarter	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)
q1 2010	105.5	–2.4	105.6	–2.4	105.6	–2.3	105.7	–2.2	105.8	–2.1	105.9	–2.1	105.9	–2.0	105.9	–2.0
q2 2010	106.8	1.2	106.9	1.3	106.9	1.2	106.9	1.1	106.9	1.0	106.8	0.9	106.9	1.0	106.9	1.0
q3 2010	108.8	1.9	108.9	1.8	108.9	1.8	108.8	1.8	108.7	1.7	108.7	1.8	108.7	1.6	108.6	1.6
q4 2010	108.6	–0.2	108.5	–0.3	108.5	–0.3	108.4	–0.4	108.3	–0.4	108.4	–0.3	108.3	–0.4	108.3	–0.3
q1 2011	108.7	0.1	108.6	0.1	108.6	0.1	108.7	0.3	108.9	0.5	109.0	0.6	109.1	0.8	109.0	0.7
q2 2011	109.7	0.9	110.0	1.3	109.9	1.2	109.9	1.1	109.9	0.9	109.8	0.7	110.1	0.9	110.1	0.9
q3 2011	109.7	0.0	109.7	–0.3	109.7	–0.2	109.8	–0.2	109.7	–0.2	109.6	–0.1	109.4	–0.6	109.4	–0.6
q4 2011	111.5	1.6	111.3	1.5	111.4	1.5	111.2	1.4	111.1	1.3	111.2	1.4	111.1	1.6	111.2	1.7
q1 2012	112.9	1.3	112.5	1.0	112.5	1.0	112.6	1.2	112.9	1.6	113.0	1.7	113.1	1.8	113.0	1.6
q2 2012			111.5	–0.9	111.4	–1.0	111.4	–1.1	111.3	–1.4	111.1	–1.8	111.6	–1.3	111.6	–1.3
q3 2012					112.4	0.9	112.6	1.1	112.5	1.1	112.5	1.3	112.0	0.4	112.0	0.4
q4 2012							113.6	0.9	113.4	0.9	113.5	0.9	113.4	1.3	113.5	1.4
q1 2013									113.3	–0.2	113.5	0.0	113.7	0.2	113.6	0.1
q2 2013											114.3	0.7	115.1	1.2	115.0	1.3
q3 2013													117.2	1.9	117.2	1.9
q4 2013															116.8	–0.3

Note how the seasonally adjusted data (like the trend-cycle data presented in Example 7.3 but less so) for a particular period are revised as later data become available, even when the *unadjusted data for that period are not revised*. The chart shows how the seasonally adjusted estimates of the 2012 quarters that are revised as new observations are added in the adjustment. For example, adding q2 2012 results in a downward adjustment of the q1 2012 rate of change in the seasonally adjusted series (1.0% from 1.3%) and considering the data up to q3 2013 brings the rate of change to its highest level (1.8%).

adjusted series. Seasonal adjustment is a major source of revisions of quarterly seasonally adjusted data, as discussed in Chapter 12.

7.67 In particular, estimates of the underlying trend-cycle component for the most recent parts of the time series may be subject to relatively large revisions at the first updates.[46] However, theoretical and empirical studies indicate that the trend cycle converges much faster to its final value than the seasonally adjusted series. In contrast, the seasonally adjusted series may be subject to lower revisions at the first updates but not negligible revisions even after one to two years. There are two main reasons for slower convergence of the seasonal estimates. First, the seasonal MA filters are significantly longer than the trend-cycle filters.[47] Second, revisions to the estimated regression parameters for deterministic effects may affect the entire time series.

7.68 Trend-cycle estimates for the most recent parts of the series must be interpreted with care, because they may be subject to strong revisions. Outliers may be one of the causes of significant revisions to the trend-cycle endpoint estimates, since it is usually not possible to distinguish an outlier from a change in the underlying trend cycle from a single observation. In general, several observations are needed to verify if changes are due to changes in the cycle or should be part of the irregular. Second, trend filters used at the end of the series will implicitly be applied on the most recent observed series as well as on the forecasts (which in turn depend on the observed data). Consequently, when a turning point appears at the current end of the series, it is not possible to discern whether it is a change in the trend, so its initial estimate will most likely make it persist in function of the previous trend. It is only after a lag of several observations that the change in the trend comes to light. While the trend-cycle component may be subject to large revisions at the first updates, however, it typically converges relatively fast to its final value. An illustration of this can be found by comparing the data presented in Example 7.2 (seasonally adjusted estimates) with those in Example 7.3 (trend-cycle estimates).

7.69 Producing seasonally adjusted (and trend-cycle) data on a continuous basis makes necessary to develop a well-defined and coherent revision policy. A revision policy should aim at minimizing both (i) the size and (ii) the frequency of revisions of seasonally adjusted data. Moreover, it should avoid the publication of unnecessary revisions that may be reverted when new observations are added to the series, since this confuses the users by generating uncertainty in the seasonally adjusted estimates.

7.70 A revision policy comprises at least two elements: the update strategy and the revision period. The update strategy defines the way in which options and models for seasonally adjustment are modified as new observations become available (or past observations are revised). This strategy plays an important role in the calculation of seasonally adjusted data, while the revision period has to do with the dissemination stage as it establishes the number of periods to be revised and released to the public each time new QNA results are published. These two components of revision policy are discussed below.

Update Strategies

7.71 Seasonal adjustment can be carried out using different update strategies. Basically, these strategies differ in how often models and options[48] for seasonal adjustment are reidentified as new or revised observations are available. Two strategies with opposite characteristics are usually compared: the concurrent adjustment strategy and the current adjustment strategy. Broadly speaking, they can be described as follows:

- In the concurrent adjustment, models, options, and parameters of seasonal adjustment are identified and estimated every time new or revised observations are made available. A concurrent strategy generates the most accurate seasonally adjusted data as they incorporate all the

[46] As illustrated in Example 7.3.

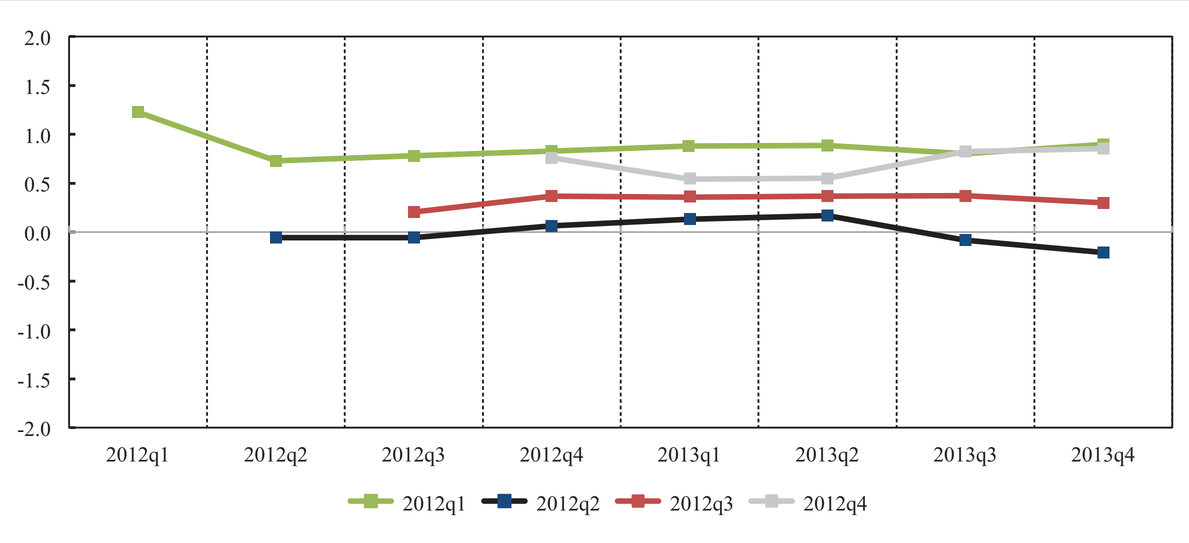
[47] For instance, the seasonal factors will be final after two years with the default 5-term (3×3) moving average seasonal filter (as long as any adjustments for calendar effects and outliers are not revised). In contrast, the trend-cycle estimates will be final after two quarters with the 5-term Henderson moving average trend-cycle filter (as long as the underlying seasonally adjusted series is not revised).

[48] Models and options correspond to the set of choices to be made in the preadjustment (i.e., calendar effects, outliers, etc.) and decomposition stages (i.e., filter length, allocation of autoregressive roots, etc.).

Example 7.3 Revisions to the Trend-Cycle Component

Revisions to trend-cycle estimates by adding new observations

(Original unadjusted data in Figure 7.2)



Data Until

	q1 2012		q2 2012		q3 2012		q4 2012		q1 2013		q2 2013		q3 2013		q4 2013	
Quarter	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)	Index	Rate of Change (%)
q1 2010	106.5	–0.1	106.4	–0.1	106.3	–0.1	106.2	–0.2	106.1	–0.3	106.1	–0.3	106.1	–0.2	106.1	–0.3
q2 2010	107.2	0.6	107.2	0.8	107.2	0.8	107.1	0.9	107	0.9	107.0	0.9	107.1	0.9	107.0	0.9
q3 2010	108.3	1.1	108.4	1.1	108.4	1.1	108.4	1.2	108.3	1.2	108.2	1.2	108.2	1.1	108.2	1.1
q4 2010	108.7	0.4	108.6	0.2	108.6	0.2	108.6	0.2	108.6	0.3	108.7	0.4	108.6	0.3	108.6	0.3
q1 2011	108.9	0.1	108.9	0.2	108.9	0.2	108.9	0.2	109	0.3	109.0	0.3	109.1	0.5	109.1	0.5
q2 2011	109.3	0.4	109.5	0.6	109.5	0.6	109.5	0.6	109.6	0.5	109.5	0.4	109.6	0.5	109.6	0.4
q3 2011	110.0	0.6	110.1	0.6	110.1	0.6	110.1	0.5	110	0.4	110.0	0.4	110.0	0.3	109.9	0.3
q4 2011	111.4	1.2	111.3	1.0	111.3	1.0	111.2	1.0	111.1	0.9	111.0	1.0	110.9	0.9	111.1	1.1
q1 2012	112.7	1.2	112.1	0.7	112.2	0.8	112.1	0.8	112	0.9	112.0	0.9	111.8	0.8	112.1	0.9
q2 2012			112.0	–0.1	112.1	–0.1	112.2	0.1	112.2	0.1	112.2	0.2	111.7	–0.1	111.8	–0.2
q3 2012					112.3	0.2	112.6	0.4	112.6	0.4	112.6	0.4	112.2	0.4	112.2	0.3
q4 2012							113.5	0.8	113.2	0.5	113.2	0.6	113.1	0.8	113.1	0.9
q1 2013									113.4	0.2	113.7	0.4	113.9	0.7	113.9	0.6
q2 2013											114.3	0.5	115.3	1.2	115.2	1.2
q3 2013													116.8	1.3	116.6	1.2
q4 2013															117.2	0.5

Large revisions may be expected to the initial estimates of the trend-cycle component. In this example, the q1 2012 rate of change is revised downward to 0.7 percent from 1.2 percent when the q2 2012 observation is added. However, the concurrent estimates of the trend cycle tend to converge faster to the final ones than the seasonally adjusted estimates. This appears evident in this example by noting the stability of the trend-cycle estimates in this chart in comparison with the revision pattern shown by the corresponding seasonally adjusted estimates in Example 7.2.

revisions to seasonal factors from current and updated observations. However, it may lead to more frequent revisions generated by (possible) changes in models and options.

- In the current adjustment, models, options, and parameters of seasonal adjustment are identified and estimated during specific review periods conducted, at a minimum, every year or every time a major revision in the original data occurs. Models, options, and parameters are kept fixed between two review periods. In-between review periods, seasonally adjusted data are obtained by dividing the original series by extrapolated seasonal and calendar factors (which implicitly means that models and options, including estimated parameters, are the same of the last review period). This strategy concentrates revisions to seasonally adjusted data during review periods, while revisions are not presented during non-review periods (unless past observations in the original data are revised). On the opposite, seasonally adjusted data during non-review periods may be less accurate as they do not incorporate all the up-to-date information in the calculation of seasonal and calendar factors.

7.72 From a purely theoretical point of view, and excluding the effects of outliers and revisions to the original unadjusted data, concurrent adjustment is preferable. New data carry new information about changes in the seasonal pattern, which should preferably be incorporated into the estimates as early as possible. Consequently, use of one-year-ahead forecasts of seasonal factors results in loss of information and, as empirical studies[49] have shown and as illustrated in Example 7.4, often in larger, albeit less frequent, revisions to the levels as well as the period-to-period rates of change in the seasonally adjusted data. Theoretical studies[50] support this finding.

7.73 Potential gains from concurrent adjustment can be significant but are not always. In general, potential gains depend on, among other things, the following factors:

- The stability of the seasonal component. A high degree of stability in the seasonal factors implies that the information gain from concurrent adjustment is limited and makes it easier to forecast the seasonal factors. On the contrary, rapidly moving seasonality implies that the information gain can be significant.
- The size of the irregular component. A high irregular component may reduce the gain from concurrent adjustment because there is a higher likelihood for the signals from the new observations about changes in the seasonal pattern to be false, reflecting an irregular effect and not a change in the seasonal pattern.
- The size of revisions to the original unadjusted data. Large revisions to the unadjusted data may reduce the gain from concurrent adjustment because there is a higher likelihood for the signals from the new observations about changes in the seasonal pattern to be false.

7.74 Furthermore, a concurrent adjustment strategy may not be ideal from the users' perspective. It is generally observed that most users of QNA data prefer a strategy where seasonally adjusted data are stable and not subject to frequent revisions. With a pure concurrent seasonal adjustment strategy, the risk of generating excessive noise in the revision process is very high. This is particularly true when options for seasonal adjustment are chosen on the basis of automatic selection procedures, which could modify previously selected choices on the basis of new or revised data. It is also not ideal from the producers' perspective. A concurrent adjustment requires human intervention to control and validate the results of seasonal adjustment, and this would have to be done during peak production times of QNA.

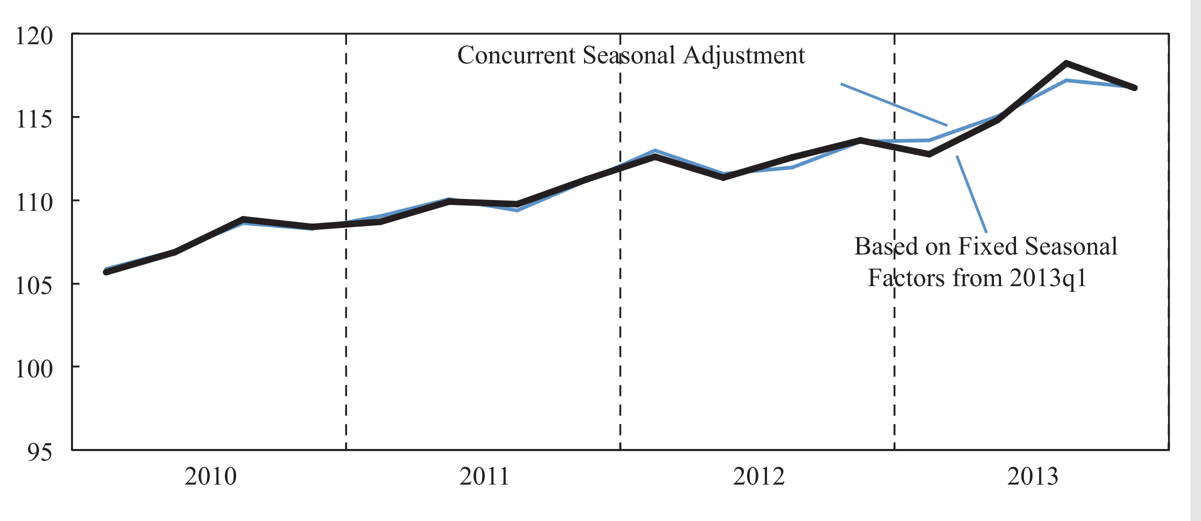
7.75 A more balanced alternative to the current and concurrent strategies is the so-called partial concurrent adjustment. Models and options are identified in every review period (once a year or anytime a major revision occurs) and are maintained up to the next review period. However, parameters are reestimated every time new observations are added to the series (i.e., parameters are concurrently estimated every time new data are available). Between two review periods, models and options should be checked for adequacy. Changes between review periods should be made only when exceptional events

[49] See among others Dagum and Morry (1984), Huyot and others (1986), Kenny and Durbin (1982), and McKenzie (1984).
[50] See among others Dagum (1982) and Wallis (1982).

Example 7.4 Concurrent Adjustment versus Current Adjustment

Concurrent adjustment versus current adjustment (one-year-ahead forecast of seasonal factors)

(Original unadjusted data in Figure 7.2)



Quarter	Concurrent Seasonal Adjustment (up to 2013q4)	Rate of Change (%)	Fixed Seasonal Factors from 2013q1	Rate of Change (%)
q1 2010	105.9	–2.0	105.7	–2.2
q2 2010	106.9	1.0	106.9	1.1
q3 2010	108.6	1.6	108.8	1.8
q4 2010	108.3	–0.3	108.4	–0.4
q1 2011	109.0	0.7	108.7	0.3
q2 2011	110.1	0.9	109.9	1.1
q3 2011	109.4	–0.6	109.8	–0.2
q4 2011	111.2	1.7	111.2	1.4
q1 2012	113.0	1.6	112.6	1.2
q2 2012	111.6	–1.3	111.4	–1.1
q3 2012	112.0	0.4	112.6	1.1
q4 2012	113.5	1.4	113.6	0.9
q1 2013	**113.6**	**0.1**	**112.8**	**–0.8**
q2 2013	**115.0**	**1.3**	**114.8**	**1.8**
q3 2013	**117.2**	**1.9**	**118.2**	**3.0**
q4 2013	**116.8**	**–0.3**	**116.7**	**–1.3**

The chart and table show the differences between concurrent adjustment (i.e., seasonal adjustment of data up to q4 2013) and current adjustment (i.e., fixed seasonal factors extrapolated from seasonal adjustment up to q4 2012). The latter series is taken from column "q4 2012" in Example 7.2 and extrapolated with the "Final adjustment ratio forecasts" provided by X-13A-S in table E 18.A. In this example, using one-year-ahead seasonal factors gives a decline of 1.3 percent in the seasonally adjusted series for q4 2013; instead, the concurrent adjustment, which incorporates the full sample of observations available, shows a much smaller reduction (–0.3%). However, the use of concurrent adjustment may produce significant revisions in the series. In this example, the seasonally adjusted rate of change of q3 2012 goes down to 0.4 percent from 1.1 percent.

occur and require special treatment in the adjustment. Otherwise, revisions to seasonally adjusted data are determined only by changes in the estimated parameters.

7.76 As an example of partial concurrent adjustment, consider the case of a review period scheduled for March of year T (when q4 of year $T-1$ is first released). ARIMA models, regression effects, outliers, and other intervention variables are identified including observations up to q4 of year $T-1$ (possibly using automatic selection features of seasonal adjustment programs). In the next estimation period (say, June), all the options selected in March are not changed (unless extraordinary revisions are done to the original series). Diagnostics on the residuals should be checked to evaluate if the new observation (i.e., q1 of year T) is an outlying observation. In that case, an additive outlier may be included in the model and tested for adequacy. The same approach should be taken for the following quarters until the next review period arrives (March of year $T+1$), where all models and options are reidentified and tested for adequacy.[51] This cycle then repeats every year.

7.77 A partial concurrent adjustment strategy represents the best compromise in the trade-off between preserving the accuracy of seasonally adjusted data and minimizing the size and frequency of revisions. An uncontrolled concurrent strategy should not be used in a production context, as changes in the seasonal adjustment options (especially if they rely on automatic procedures) may introduce large and unnecessary revisions from one quarter to the next. A current adjustment strategy could be an acceptable one for series with a stable seasonal component and low-variance irregular component.

Revision Period

7.78 The other element of revisions policy is to establish the revision period of QNA publications: that is, the number of previously published quarterly observations subject to revisions. In a concurrent approach (partial or full), the seasonally adjusted series changes in its entirety every time a new observation is added to the series (or an old observation is revised). The same happens in the review period when a current adjustment approach is adopted. Revisions may be sizeable up to four to five years before the last revised observation in the original series; for more distant observations, revisions tend to be rather small. This happens because seasonal adjustment filters assign larger weights to nearby observations than to distant ones.[52] However, reidentification of regression effects (e.g., outliers) or changes in the estimated regression coefficients may generate significant revisions in the whole seasonally adjusted series.

7.79 In a review period (i.e., when seasonal adjustment options are reidentified and models are reestimated), the best approach is to revise the entire seasonally adjusted series. At a minimum, revisions to seasonally adjusted data should be made for four or five completed years before the revision period of the original data. The revision period may be shortened when the reidentified models and options do not lead to long significant revisions to previously published seasonally adjusted data.

7.80 In a non-review period, the revision period should be selected on the basis of the update strategy:

a. In a partial concurrent adjustment strategy, seasonally adjusted series should be revised a minimum of two complete years before the revision period of the original data. Such a window permits the incorporation of the effects from reestimated regression coefficients and newly identified outliers in the seasonally adjusted data for the most recent periods. A minimum of two completed years is required to calculate quarter-to-quarter rates of change for the current year and the previous one using seasonally adjusted data coming from the same adjustment process. Previously published seasonally adjusted data before the two-year (or longer) revision period could be frozen provided there are no artificial breaks induced in the series. As an alternative, the entire seasonally adjusted series

[51] To preserve stability of seasonally adjusted series, previously identified models and options should be maintained as much as possible. Changes should be done only when they are supported by better statistical tests and diagnostics.

[52] For example, in the standard X-11 filter for quarterly series, zero weights are assigned to observations that are distant five or more years.

could be published when the size of historical revisions is within acceptable limits.

b. In a current adjustment strategy, the revision period of seasonally adjusted data should at least cover the revision period of the original data. When the original series is not revisable, this practice implies that the seasonally adjusted data for each current quarter (derived with extrapolated seasonal factors) is added to the previously published seasonally adjusted series until the next review period.

Quality Assessment of Seasonal Adjustment

7.81 The validation of seasonally adjusted results is an integral part of any seasonal adjustment procedure. Seasonal adjustment programs may return "seasonally adjusted" data even when the input data does not contain seasonal effects. On the other hand, they may provide seasonally adjusted series that still contain residual seasonal effects. Both situations can be avoided by looking at the output of seasonal adjustment programs.

7.82 Seasonally adjusted results should be evaluated and assessed on the basis of specific diagnostics on the preadjustment and decomposition results. "True" seasonally adjusted data do not exist, as the components are unobserved and can only be estimated from the original series. As a consequence, the quality of seasonally adjusted data should be judged upon the quality of the estimation process that has generated them and the dynamic features of the estimated components. The main diagnostics on the seasonal adjustment process are presented in this section. Furthermore, seasonally adjusted data in the QNA should also be viewed in the general framework of national accounts statistics. These other aspects of quality are discussed in "Particular Issues" section.

7.83 A key prerequisite for seasonal adjustment is that the original data should present clear and stable characteristic patterns. Without good-quality original data, there is no chance to get good-quality seasonally adjusted data. In particular, it is required that seasonal effects repeat themselves with similar pattern and intensity over time. Unstable seasonal effects increase the level of uncertainty in the decomposition, as it becomes more difficult to distinguish seasonal movements from other signals when they are not regular. The situation gets worse when the irregular component dominates the series' variability.

7.84 This section introduces both basic and advanced diagnostics on seasonal adjustment; all of them are produced by the X-13A-S program.[53] Basic diagnostics should include at a minimum tests for presence of identifiable seasonality in the original series, tests for residual seasonality in the seasonally adjusted series, significance tests of calendar effects and other regression effects identified in the preadjustment stage, and diagnostics on residuals from the estimated regARIMA model.

7.85 Advanced diagnostics of seasonal adjustment include sliding spans and revision history. Both of them look at the stability of the seasonal adjustment results as more observations are included in the estimation process. Because they require more time to be implemented and monitored than basic diagnostics, these tools should only be considered during review periods for the most relevant series in the QNA (or for series showing problematic issues).[54]

Basic Diagnostics

7.86 A visual inspection of the series to be processed is the first step when conducting seasonal adjustment. For most series, a simple visualization of observations against time highlights the most visible features of the series, such as an upward/downward trend, cyclical patterns, seasonal effects, outliers, and volatility. A seasonal plot[55] can also be used for a better understanding of the seasonal component. When the quarters move around different levels, this is a clear signal of seasonal effects in the series.

7.87 Seasonal adjustment should not be applied to series that do not present seasonal movements, or present seasonal movements that are hardly identifiable. X-13A-S calculates a combined test to check for

[53] X-13A-S provides a wide range of diagnostics to assess the seasonal adjustment results, both for the preadjustment and decomposition stages. Most of them apply equally to the X-11 and SEATS filters; therefore with X-13A-S, it is possible to compare alternative adjustments with a common set of quality measures.

[54] Both sliding spans and revisions history require a minimum length of the time series which depend on the length of the filters used in seasonal adjustment.

[55] A seasonal plot for quarterly series splits the series into four subseries by quarter and plots each quarter against the years. The average value for each quarter is usually shown in each subplot. Chart 7.3 is an example of seasonal plot of seasonal–irregular ratios.

Box 7.4 Test for the Presence of Seasonality in the Original Series

D 8. Final Unmodified SI Ratios

D 8.A. F-Tests for Seasonality

Test for the Presence of Seasonality Assuming Stability

	Sum of Squares	Degrees of Freedom	Mean Square	*F*-Value
Between quarters	2,509.7	3.0	836.6	1505.733[a]
Residual	42.2	76.0	0.6	
Total	2,551.9	79.0		

[a]*Seasonality present at the 0.1 percent level.*

Nonparametric Test for the Presence of Seasonality Assuming Stability

	Kruskal–Wallis Statistic	Degrees of Freedom	Probability Level
	70.2823	3	0.000%

Seasonality present at the 1 percent level.

Moving Seasonality Test

	Sum of Squares	Degrees of Freedom	Mean Square	*F*-Value
Between years	9.3038	20	0.465189	0.802
Error	34.8074	60	0.580123	

No evidence of moving seasonality at the 5 percent level.

Combined test for the presence of identifiable seasonality

Identifiable Seasonality Present

Table D 8.A informs the user whether stable seasonality is identified in the series. Three outcomes are possible: (i) identifiable seasonality present, (ii) possible identifiable seasonality present, and (iii) identifiable seasonality not present. The decision is made on the basis of the values of three tests: an *F*-test for the presence of seasonality assuming stability, the Kruskall and Wallis test (a nonparametric test for stable seasonality), and an *F*-test for moving seasonality (an *F*-test is a statistical test in which the test statistic has an *F*-distribution under the null hypothesis). Identifiable seasonality is shown when the first two tests signal the presence of stable seasonality, whereas the third test shows no evidence of moving seasonality. Table D 8.A should always be checked when a series is seasonally adjusted for the first time. When the program returns "identifiable seasonality not present," the series should not be seasonally adjusted.

the presence of identifiable seasonality (see Box 7.4). The decision is based on statistical tests that identify whether seasonality is present and, when present, look at whether the seasonal effects are sufficiently stable over the years. These tests are calculated on the preliminary SI ratios. Based on this combined test, X-13A-S returns in output one of the following outcomes: (a) identifiable seasonality is present, (b) identifiable seasonality is probably not present, or (c) identifiable seasonality is not present. In general, seasonal adjustment should not be performed when identifiable seasonality is not present (case c).[56]

7.88 After seasonal adjustment, an immediate check on results should be to verify that the seasonally adjusted series is free from seasonal effects. No residual seasonality or calendar effects should appear in the seasonally adjusted series. A statistical test is used in X-13A-S to check that there is no residual seasonality in the seasonally adjusted series (see Box 7.5). The test is similar to the one used to verify identifiable seasonality in the original series. A good seasonal adjustment process requires the test to be rejected, as this indicates that seasonal effects are not present in the seasonally adjusted series.[57]

7.89 The regARIMA model specified in the preadjustment phase should be assessed using standard

[56] The M7 statistic can also be helpful to determine whether identifiable seasonality is present, as explained later.

[57] Absence of seasonal and calendar effects can also be verified by looking at the spectrum diagnostics available in X-13A-S. For more details, see section 6.1 "Spectral Plots" of the X-13A-S reference manual (U.S. Census Bureau, 2013).

Box 7.5 Test for the Presence of Seasonality in the Seasonally Adjusted Series

D 11. Final Seasonally Adjusted Data

Test for the presence of residual seasonality

No evidence of residual seasonality in the entire series at the 1 percent level: *F* = 0.02

No evidence of residual seasonality in the last 3 years at the 1 percent level: *F* = 0.14

Table D 11 provides the results of the test for the presence of residual seasonality in the seasonally adjusted series. Residual seasonality in the seasonally adjusted series is a sign of misspecification of the seasonal adjustment model, and consequently a warning for users to modify the chosen specification. An *F*-test is calculated, similar to the one used in table D 8.A, to determine whether stable seasonality is present in the series. Differently from table D 8.A, a positive outcome is when the null of presence of seasonality is rejected. For the series of Figure 7.2, the program shows no evidence of seasonality in the entire series and in the last three years. The latter test is useful to identify a possible deterioration of the seasonal adjustment quality for the most recent periods.

regression diagnostics. Failures in the model specification may lead to incorrect seasonal adjustment results. Estimated residuals should be normally distributed and uncorrelated. X-13A-S provides normality tests and sample autocorrelation tests (the Ljung–Box Q tests) on the estimated residuals. If these tests indicate non-normality or autocorrelation in the residuals, actions should be taken in order to improve the fit of the regARIMA model. Non-normality may derive from large residuals not properly accounted for in the estimation process, which may be fixed using outliers or intervention variables. The presence of autocorrelation in the residuals may derive, in turn, from model misspecification.

7.90 Regression effects such as calendar effects, outliers, and any additional intervention variables should be retained in the model only when they are both statistically significant and economically meaningful. Standard *t*-statistics are used to assess the statistical significance of individual regressors; combined tests (such as *F*-tests) are used to assess the significance of a group of regressors (like the six-regressor trading-days effect). Particular care should be given to outliers, as different selections of outliers may generate large differences in the results. A regression effect is economically meaningful when the magnitude and sign of the estimated regression coefficient is in line with economic rationale. Box 7.3 provides an example on how to assess statistical significance and economic meaningfulness of calendar effects using the X-13A-S output.

7.91 The ARIMA order should be validated carefully, especially when it is automatically identified by the program. The ARIMA order is particularly relevant for SEATS adjustment, as the AMB decomposition implemented by SEATS completely relies on the specified ARIMA model; but it is also important for X-11 as the ARIMA model is used to calculate backcasts and forecasts needed to extend the series at both ends. In general, parsimonious models should be preferred as they are more likely to lead to admissible decompositions than models with many parameters. In this regard, the airline model $(0,1,1)(0,1,1)_4$ is a particularly suitable model because it only has two parameters to be estimated (the regular and the seasonal MA coefficients) and provides an admissible decomposition for a large region of the parameter space.[58]

7.92 Other useful diagnostics on seasonal adjustment are the 11 M diagnostics calculated by X-13A-S. All the M diagnostics (and the Q aggregate measure) take values between 0 and 3. Values higher than 1 indicate potential issues in the adjustment, while values between 0 and 1 are acceptable. The most important M diagnostics are the following:

- M7 measures the relation between moving and stable seasonality. High values of M7 may indicate an excessive amount of moving seasonality in relation to the stable seasonality. The M7 diagnostic may also be used as a test for existence of seasonality in the original series.
- M1 and M2 show how large is the irregular component in the series. M1 assesses the contribution of variance of the irregular to the original series in terms of lag 3 differences; M2 compares the irregular with the original series made stationary. High values of M1 and M2 may signal highly irregular series, which are more difficult to adjust.
- M6 compares the (annual) stability of seasonality with respect to changes in the irregular component. This diagnostic may suggest the use of filters with different lengths in order to split evolving seasonal patterns from irregular movements.

[58] The airline model may not provide an admissible decomposition when the seasonal MA parameter is large and positive.

- M8 and M9 deal with the stability of the seasonal component. High values of M8 and M9 may indicate high fluctuations in the seasonal pattern, which may reveal the existence of abrupt seasonal breaks. M10 and M11 are the same M8 and M9 diagnostics calculated using the last three years of data. They may be used to help identify problems at the end of the series.
- M3 and M5 calculate the significance of the irregular component in relation to the trend cycle. High values of M3 and M5 may indicate difficulty in extracting the trend-cycle component from the seasonally adjusted series. These diagnostics are relevant for trend-cycle estimation and interpretation of the results.

7.93 None of the M diagnostics can be used individually to assess the overall quality of seasonal adjustment, because each of them focuses on particular aspects of the results. Specific problems can be detected when monitoring these measures, which should be addressed as much as possible, but the quality of the whole process could still be deemed appropriate even when some of the M diagnostics are larger than one. Naturally, the adjustment should be considered unacceptable when all diagnostics fail. In order to give an overall assessment of the adjustment, the M diagnostics are aggregated in a single quality control indicator called Q (see Box 7.6).

Box 7.6 The M Diagnostics

	F 3. Monitoring and Quality Assessment Statistics	
No.	**Statistics**	**Value**
1.	The relative contribution of the irregular over one quarter span (from table F 2.B)	M1 = 0.020
2.	The relative contribution of the irregular component to the stationary portion of the variance (from table F 2.F)	M2 = 0.013
3.	The amount of quarter-to-quarter change in the irregular component as compared to the amount of quarter-to-quarter change in the trend cycle (from table F2.H)	M3 = 0.200
4.	The amount of autocorrelation in the irregular as described by the average duration of run (from table F 2.D)	M4 = 0.535
5.	The number of quarters it takes the change in the trend cycle to surpass the amount of change in the irregular (from table F 2.E)	M5 = 0.200
6.	The amount of year-to-year change in the irregular as compared to the amount of year-to-year change in the seasonal (from table F 2.H)	M6 = 0.482
7.	The amount of moving seasonality present relative to the amount of stable seasonality (from table F 2.I)	M7 = 0.056
8.	The size of the fluctuations in the seasonal component throughout the whole series	M8 = 0.242
9.	The average linear movement in the seasonal component throughout the whole series	M9 = 0.074
10.	Same as 8, calculated for recent years only	M10 = 0.233
11.	Same as 9, calculated for recent years only	M11 = 0.188
	ACCEPTED at the level 0.15	
	Q (without M2) = 0.17 ACCEPTED	

Table F 3 reports the M diagnostics and the aggregate Q measure. All the M diagnostics are defined in the range from 0 to 3, with an acceptance region from 0 to 1. The Q measure is a weighted average of the M diagnostics. In the above example (for the series from Figure 7.2), all the Ms are within the acceptance region.

Advanced Diagnostics

7.94 X-13A-S offers two advanced diagnostic tools for evaluating the reliability of seasonal adjustment results. The first tool is the sliding spans diagnostic. It measures how stable the seasonal adjustment estimates are when different spans of data in the original series are considered in the estimation process. When the sliding spans statistics signal instability of the seasonally adjusted data, this may indicate the presence of breaks in the series or moving seasonality. The second tool is the revisions history diagnostic. It looks at the revisions of seasonally adjusted data for the most recent quarters when new data points are introduced. Both tools are very useful for comparing alternative options for the same seasonal adjustment filter (either X-11 or SEATS) or for comparing the same options using two different filters (X-11 vs. SEATS).

7.95 When the sliding spans diagnostic is enabled,[59] the program selects four spans of data from the series. The span length is automatically chosen between 6 and 11 years, depending on the seasonal filter selected, the length of the series, and its frequency (monthly or quarterly). In the final span, the final observation is the last available period of the series. The other spans progressively exclude one year from the end and include one year at the beginning.[60] Seasonal adjustment is then performed on each span separately and the seasonally adjusted data are compared for the overlapping periods. Summary statistics are calculated to measure the stability of the estimates in the different spans. In particular, the sliding spans evaluation is carried out on the estimated seasonal factors and on quarter-to-quarter changes in the seasonally adjusted series. The program alerts the user when there is too much variation in the estimates for the same quarter and when the number of unstable seasonal factors or changes in the seasonally adjusted series exceeds recommended limits. Box 7.7 illustrates the sliding spans statistics.

7.96 The revision history diagnostic measures how much the seasonally adjusted figures change as new observations are introduced. A start date for the revisions history analysis is automatically selected by the program (or specified by the user). The program adjusts the series up to the start period of the revisions analysis; next, it adjusts the series including the next quarter; and so forth. The process is repeated until the whole series is seasonally adjusted. By default, the program calculates the differences between the concurrent estimates (first seasonal adjustment of a data point) and the final estimates (seasonal adjustment of the whole series) in the revision period. Other history analysis can be specified by the user. Summary statistics on the revisions to the seasonal adjusted and trend-cycle values (both in the levels and in percent changes) are calculated. This tool is particularly helpful when comparing different seasonal adjustment methods, with the method presenting the smaller statistics of revisions generally being preferable. Furthermore, revisions history can be useful when comparing direct and indirect seasonal adjustment of aggregates: the approach with the smallest amount of revisions should be preferred.[61] Conversely, it is less helpful when assessing the quality of adjustment of a single method as it is difficult to decide an acceptable level of revisions in absolute terms. Box 7.8 provides an example of revisions history.

Particular Issues

7.97 This section addresses a series of more QNA-specific issues related to seasonal adjustment. A first group of issues is related to how seasonal adjustment should be applied to maintain consistency in the framework of national accounts. Ideally, seasonally adjusted QNA variables should preserve the same accounting relationships existing between unadjusted variables. However, seasonal adjustment procedures may generate inconsistencies across variables and across frequencies because of existing nonlinearities in the estimation process. The issues considered here are the direct versus indirect calculation of seasonally adjusted aggregates; the relationship between price, volume, and value indices for seasonally adjusted series; and the temporal consistency between quarterly seasonally adjusted data with the annual benchmarks.

7.98 Further practical issues need consideration when producing seasonally adjusted QNA data. When the original series is too short (or too long),

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[59] In X-13A-S, the spec name for the sliding spans diagnostic is SLIDINGSPANS; the spec name for revisions history is HISTORY.

[60] For the series used in this chapter, the span length selected is eight years and the four spans are q1 2004–q4 2010, q1 2005–q4 2011, q1 2006–q4 2012, and q1 2007–q4 2013.

[61] For a discussion on the direct versus indirect adjustment in the QNA, see paragraph 134.

Box 7.7 Sliding Spans Tables

S 1. Quarterly Means of Seasonal Factors
(movements within a quarter should be small)

	Span 1		Span 2		Span 3		Span 4		Max Difference (%)	All Spans	
First	93.04	min	92.96	min	93.07	min	92.77	min	0.33	92.96	min
Second	95.48		95.70		95.74		95.61		0.27	95.64	
Third	106.62	max	106.25	max	106.17	max	106.32	max	0.43	106.33	max
Fourth	104.94		105.15		105.07		105.35		0.39	105.14	

S 2. Percentage of Quarters Flagged as Unstable				
Seasonal factors	0 out of 32	(0.0%)		
Quarter-to-quarter changes in seasonally adjusted series	0 out of 31	(0.0%)		
Recommended Limits for Percentages				
Seasonal factors	15% is too high.			
	25% is much too high.			
Quarter-to-quarter changes in seasonally adjusted series	35% is too high.			
	40% is much too high.			
Threshold Values Used for Maximum Percent Differences to Flag Quarters as Unstable				
Seasonal factors	Threshold = 3.0%			
Quarter-to-quarter changes in seasonally adjusted series	Threshold = 3.0%			

Table S 1 presents average seasonal factors for each quarter calculated from four spans of data. For stable seasonal adjustment, the seasonal factors should be similar in the different spans.

Table S 2 calculates statistics on the stability of seasonal factors and quarter-to-quarter changes in the seasonally adjusted series. A quarter is flagged "unstable" when the seasonal factor (or the quarter-to-quarter change in the seasonally adjusted series) deviates more than 3.0 percent (a default threshold) from the average. Recommended limits are given by the program. For stable seasonal adjustment, the number of unstable seasonal factors and quarter-to-quarter changes should not exceed 15 percent.

additional efforts are required to produce seasonally adjusted data with an acceptable level of quality. A decision should also be made as to whether to apply seasonal adjustment to indicators (monthly or quarterly) or to QNA series, considering the pros and cons of both solutions. Finally, some suggestions are given on how the responsibility for producing seasonally adjusted QNA data should be organized in the QNA.

Direct versus Indirect Seasonal Adjustment of Aggregates

7.99 Seasonally adjusted series of aggregates can be derived (i) directly by adjusting the aggregates or (ii) indirectly by aggregating seasonally adjusted data of the component series. A typical example in the QNA is a seasonally adjusted estimate for GDP derived either by seasonally adjusting GDP directly or as the sum of seasonally adjusted data of value added by economic activity (plus net taxes on products). The two approaches are also alternatives for deriving balancing items; value added, for instance, can be derived either by seasonally adjusting value added directly or as the difference between independently derived seasonally adjusted data of output and intermediate consumption. Generally, the results will differ, sometimes significantly.

7.100 Conceptually, neither the direct approach nor the indirect approach is optimal. There are arguments in favor of both approaches. It is convenient, and for some uses crucial, that accounting and aggregation relationships are preserved.[62] Studies,[63] however, have

[62] However, for chain-linked series, these accounting relationships are already broken (see Chapter 8 on nonadditivity of chain-linked measures in monetary terms).
[63] See, among others, Dagum and Morry (1984).

Box 7.8 Revisions History Tables

R 1 Percent revisions of the concurrent seasonal adjustments		R 2 Percent revisions of the quarter-to-quarter percent change of the adjustments		R 1.S Summary statistics : average absolute percent revisions of the seasonal adjustments		R 2.S Summary statistics : average absolute revisions of the quarter-to-quarter percent change of the adjustments	
Date	Concurrent - Final	Date	Concurrent - Final	Date	Concurrent - Final	Date	Concurrent - Final
2009		2009		Quarters		Quarters	
1st	0.50	1st	0.69	1st	0.20	1st	0.30
2nd	0.01	2nd	-0.38	2nd	0.22	2nd	0.37
3rd	-0.29	3rd	-0.57	3rd	0.24	3rd	0.37
4th	-0.13	4th	0.26	4th	0.11	4th	0.38
2010		2010					
1st	0.03	1st	-0.11	Years:		Years:	
2nd	0.24	2nd	0.21	2009	0.23	2009	0.47
3rd	0.32	3rd	0.42	2010	0.16	2010	0.30
4th	-0.04	4th	-0.45	2011	0.14	2011	0.27
2011		2011		2012	0.16	2012	0.44
1st	-0.10	1st	0.13	2013	0.32	2013	0.25
2nd	0.16	2nd	0.36				
3rd	0.14	3rd	-0.25	Total:	0.20	Total:	0.35
4th	0.18	4th	0.35				
2012		2012		Hinge Values:		Hinge Values:	
1st	0.09	1st	0.36	Min	0.01	Min	0.01
2nd	0.09	2nd	-0.36	25%	0.08	25%	0.23
3rd	-0.40	3rd	-0.57	Med	0.14	Med	0.36
4th	-0.08	4th	0.46	75%	0.29	75%	0.45
2013		2013		Max	0.61	Max	0.69
1st	0.29	1st	0.21				
2nd	0.61	2nd	0.54				
3rd	-0.04	3rd	-0.01				

Tables R 1 and R 2 show the differences between the final seasonally adjusted estimates and the concurrent seasonally adjusted estimates (i.e., the first seasonal adjustment of a data point) for the last five years of data (in levels and period-to-period changes). In other terms, these differences are the revisions to the concurrent estimates when the full sample of observations is considered. Revisions history tables are particularly helpful when comparing alternative seasonal adjustment models: the one with the smallest amount of revisions should be preferred.

shown that the quality of the seasonally adjusted series, and especially estimates of the trend-cycle component, may be improved, sometimes significantly, by seasonally adjusting aggregates directly or at least at a more aggregated level. Practice has shown that seasonally adjusting the data at a detailed level may leave residual seasonality in the aggregates, result in less smooth seasonally adjusted series, and provide series more subject to revisions. Which compilation level for seasonal adjustment gives the best results varies from case to case and depends on the properties of the particular series.

7.101 For aggregates, the direct approach may give the best results if the component series show similar seasonal patterns and the trend cycles are highly correlated. In such cases, aggregation often reduces the amplitude of the irregular in the component series, which at the most detailed level may be too dominant for proper seasonal adjustment. This effect may be particularly important for small economies where irregular events have a stronger impact on the data. Similarly, when trend cycles are highly correlated, aggregation reduces the impact of both the seasonal and irregular components of the component series.

7.102 Conversely, the indirect approach may give the best results when the component series show very different seasonal patterns. Aggregation may cause large, highly volatile seasonality overshadow stable seasonal effects, making it difficult or impossible to identify seasonality in the aggregate series. Moreover, it may be easier to identify breaks, outliers, calendar effects, and so on in detailed series than directly from the aggregates, because at the detailed level, these effects may display a simpler pattern and be more interpretable in economic terms.

7.103 For balancing items (such as value added), the indirect approach may give better results than the direct approach. Balancing items are often derived as the difference between two correlated component series (e.g., gross output and intermediate consumption of the same industry). Irregular effects estimated from two (or more) correlated series are also likely to be correlated. Correlated movements in the component series, when subtracted, will cancel each other out in the balancing item, resulting in a more regular seasonally adjusted series. For value added, however, the estimate of intermediate consumption at the quarterly level may be absent or subject to high uncertainty; in that case, a direct seasonal adjustment of value added should be followed.

7.104 In practice, the choice between direct and indirect seasonal adjustment may be guided by the expected uses of seasonally adjusted data. For some uses, preserving accounting and aggregation relationships in the data may be crucial, and the smoothness and stability of the derived series secondary. For other uses, the time-series properties of the derived estimates may be crucial, while accounting and aggregation relationships may be less important. If the differences are insignificant, accounting and aggregation relationships in the seasonally adjusted data should be guaranteed. When the indirect approach is preferred, seasonally adjusted aggregates should be checked to exclude the presence of residual seasonality using the *F*-test available in X-13A-S (see Box 7.4).

7.105 Countries' practices vary with respect to the choice between direct and indirect seasonal adjustment. Many countries obtain the seasonally adjusted QNA aggregates as the sum of adjusted components, while others prefer to adjust the totals independently, showing discrepancies between the seasonally adjusted total and the sum of the seasonally adjusted component series. Allocating discrepancies on components to achieve consistency should be avoided.

7.106 X-13A-S offers a diagnostic tool to evaluate the direct and indirect adjustment of aggregates.[64] The program calculates seasonally adjusted aggregates using the direct and indirect approaches and provides in output a set of statistics to compare the results (M diagnostics, measures of smoothness, frequency spectrum diagnostics, etc.). Furthermore, sliding spans and revision history diagnostics can be requested to assess which of the two approaches provides more stable and reliable seasonally adjusted results.

Relationship among Price, Volume, and Value

7.107 As for balancing items and aggregates, seasonally adjusted estimates for national accounts price indices, volume measures, and current price data can be derived either by seasonally adjusting the three series independently or by seasonally adjusting two of them and deriving the third as a residual, if all three show seasonal variations.[65] Again, because of nonlinearities in the seasonal adjustment procedures, the alternative methods will give different results; however, the differences may be minor. Preserving the relationship among the price indices, volume measures, and the current price data is convenient for users.[66] Thus, it seems reasonable to seasonally adjust two of them and derive the seasonally adjusted estimate of the third residually.

7.108 Choosing which series to derive residually should be determined on a case-by-case basis,

[64] In X-13A-S, the spec name for comparing direct and indirect adjustment is COMPOSITE.
[65] Experience has shown that the price data may not always show identifiable seasonal variations.
[66] Note that chain-linking preserves this relationship (V = P • Q).

depending on which alternative seems to produce the most reasonable result. Theoretically, seasonality in current price data is generated by seasonality from price and volume effects. Therefore, the best approach is to apply seasonal adjustment to price and volume series and derive seasonally adjusted data in current prices indirectly. However, seasonal adjustment of data in current prices should be preferred when the main data source is available in nominal terms. In any case, the residual item should always be tested because indirect adjustment may induce residual seasonality.

Temporal Consistency with the Annual Accounts

7.109 Annual totals based on the seasonally adjusted data will not automatically—and often should not conceptually—be equal to the corresponding annual totals based on the original unadjusted data. The number of working days, the impact of moving holidays, and other calendar effects vary from year to year. Similarly, moving seasonality implies that the impact of seasonal effects will vary from year to year. Thus, conceptually, for series with significant calendar effects or moving seasonality effects, the annual totals of a seasonally adjusted series should differ from the unadjusted series.

7.110 Seasonal adjustment based on the additive model (1) without calendar effects or moving seasonality will produce seasonally adjusted data that add up to the corresponding unadjusted annual totals. In the case of multiplicative seasonal adjustment with no significant calendar or moving seasonality effects, the difference between the annual totals of the adjusted and unadjusted series will depend on the amplitude of the seasonal variation, the volatility of the seasonally adjusted series, and the pace of the change in the underlying trend cycle. The difference will be small, and often insignificant, for series with moderate to low seasonal amplitudes and for series with little volatility and trend-cycle change.

7.111 In the QNA, it is generally considered acceptable to force seasonally adjusted series to annual benchmarks of the national accounts. From a user's point of view, consistent quarterly and annual estimates are generally preferred. However, there are no reasons for forcing seasonally adjusted series when there are significant calendar effects or evolving seasonal patterns.[67] In fact, consistency with the annual series would be achieved at the expense of the quality of the seasonal adjustment.[68]

7.112 When a series is adjusted for calendar effects and these effects lead to significant changes in the annual rates, the seasonally adjusted data should be benchmarked to the annual data adjusted for calendar effects (see also paragraph 7.44). The annual data adjusted for calendar effects should be derived as the sum of quarterly data adjusted for calendar effects. For practical considerations, however, countries may choose to benchmark seasonally adjusted data to the original annual aggregates of national accounts. Maintaining two systems of annual data (unadjusted and adjusted for calendar effects) can be a challenging task for national accounts compilers. Users may also be puzzled when the results are different and the differences are not sufficiently explained by metadata.

7.113 X-13A-S provides an option for benchmarking the seasonally adjusted data to the annual original (or calendar adjusted) totals.[69] When this option is not chosen (i.e., when seasonally adjusted data are not benchmarked to the annual unadjusted data), the differences between the annual unadjusted data and the annual aggregation of seasonally (and calendar) adjusted data should be checked for plausibility. For example, different rates of change between unadjusted data and adjusted data for working days should be coherent with movements in the number of working days. When the number of working days in a year is larger (smaller) than the number of working days in the previous one, the rate of change in the annual adjusted series should be lower (higher) than the rate of change in the unadjusted series.

Length of the Series for Seasonal Adjustment

7.114 Seasonal adjustment requires sufficiently long time series for delivering results with acceptable

[67] The X-13A-S manual does not recommend the forcing option when trading-day (or working-day) adjustment is performed and if the seasonal pattern is undergoing changes.

[68] The effects of forcing the seasonally adjusted data to the annual totals (table D11.A) on the quarterly growth rates can be checked from table E4 in the X-13A-S output file.

[69] In X-13A-S, the spec name for benchmarking seasonally adjusted data to annual totals is FORCE. The default benchmarking method is the Cholette–Dagum method with autoregressive (AR) error (see Chapter 6), with the AR parameter sets to 0.9 for monthly series and 0.9^3 for quarterly series.

quality. When a series is too short, it may be difficult to identify a stable seasonal pattern and significant calendar effects from a small number of observations. Moreover, the estimated coefficients of the regARIMA model would be characterized by large uncertainty. This may have consequences in the reliability of the seasonally adjusted series, with the potential risk of large revisions when new data points are added to the series. Such risks are higher with model-based methods than with MA methods, as model-based methods (like SEATS) rely heavily on the results of the estimation process.

7.115 For QNA variables, it is recommended that at least five years of data (20 quarters) be used for seasonal adjustment. Time series with less than five years of data[70] may be seasonally adjusted for internal use, but not published until five complete years are available and the stability of results seems acceptable. Better results are to be expected when the data span more than five years. When starting a new QNA system, unadjusted data should be reconstructed as far back as possible before applying seasonal adjustment procedures.

7.116 Seasonal adjustment may also return questionable results for very long series. A long series may be affected by discontinuities and structural breaks in the seasonal pattern due to the existence of different economic conditions over a long period of time. Some breaks can be accounted for in the regARIMA model by means of outliers or specific intervention variables in the preadjustment stage, but it may be more difficult to model an evolving seasonal pattern. Furthermore, the assumption of fixed calendar effects may not be tenable for long time spans. For example, the average impact of one working day on production activities today is likely to be different from the impact of one working day 20–30 years ago due to productivity changes, different working regulations, or other structural factors.

7.117 When seasonal adjustment results are unsatisfactory for long series, it may be worth dividing the series in two (or more) contiguous periods characterized by relative stability and applying seasonal adjustment to each subperiod separately. The resulting seasonally adjusted series should be linked together to create a consistent, long time series. For calendar effects, stability of parameter estimates should be evaluated over time. When the impact of calendar effects significantly changes over time, it is advisable to estimate these effects from the most recent span in order to increase the precision of the latest seasonally adjusted data.

Seasonally Adjusting Indicators or QNA Series?

7.118 Seasonal adjustment can be applied either to monthly or quarterly indicators, or to unadjusted QNA series (i.e., to quarterly series benchmarked to ANA levels and consistent with other QNA variables). When seasonal adjustment is applied to indicators, the seasonally adjusted indicator is used to derive QNA data in seasonally adjusted form. When seasonal adjustment is applied to unadjusted QNA series, the seasonally adjusted QNA series is obtained as a result from the chosen seasonal adjustment method. Both approaches are equally acceptable. An advantage of applying seasonal adjustment directly to indicators is that seasonal effects originate from actual data sources; instead, unadjusted QNA series may contain artificial seasonality introduced by QNA techniques (e.g., benchmarking or chain-linking methods). On the other hand, unadjusted QNA series have the advantage of being consistent with other variables in the QNA. When seasonal adjustment is applied to consistent QNA series, one may expect to see a high degree of consistency in the seasonality of production, expenditure, and income components of the GDP.

7.119 This choice should consider the effects of temporal aggregation on seasonal adjustment, in particular whether the seasonal and calendar adjustment should be done at the monthly or quarterly frequency. As explained in "Preadjustment" section, calendar effects are better identified and estimated on monthly series than on quarterly series. Calendar adjustment on quarterly data should only be considered when indicators are not available on a monthly basis. Because QNA series are not available at the monthly frequency, the best approach is to identify and estimate calendar effects on monthly indicators. For seasonal adjustment, the choice between monthly or quarterly adjustment is less obvious. Studies have been con-

[70] At a minimum, X-13A-S requires three years of data (12 quarters) to produce seasonally adjusted data.

ducted on this issue but conclusions are still unclear.[71] In general, it is preferred to apply seasonal adjustment on quarterly series when temporal aggregation reduces the variance of the irregular component in the monthly series.

Organizing Seasonal Adjustment in the QNA

7.120 Many series are well behaved and easy to seasonally adjust, requiring little intervention from the user. Seasonal adjustment programs (such as X-13A-S or TRAMO-SEATS) offer automatic selection procedures that give satisfactory results for the majority of time series. Thus, lack of experience in seasonal adjustment or lack of staff with particular expertise in seasonal adjustment should not preclude one from starting to compile and publish seasonally adjusted estimates. Before compiling seasonally adjusted estimates, however, the main focus of compilation and presentation should be on the unadjusted QNA data.

7.121 For problematic series, substantial experience and expertise may be required to determine whether the seasonal adjustment is done properly or to fine-tune the seasonal adjustment options. In particularly unstable series with a strong irregular component (e.g., outliers and other special events, seasonal breaks, or level shifts), it may be difficult to derive satisfactory results without sufficient experience. In the medium term, the team responsible for seasonal adjustment should build skills and knowledge (both theoretical and practical) to be able to handle the adjustment of problematic series.

7.122 It is generally recommended that the statisticians who compile the statistics should also be responsible—either solely or together with seasonal adjustment specialists—for seasonally adjusting the statistics. This arrangement should give them greater insight into the data, make their job more interesting, help them understand the nature of the data better, and lead to improved quality of both the original unadjusted data and the seasonally adjusted data. However, it is advisable in addition to set up a small central group of seasonal adjustment experts, because the in-depth seasonal adjustment expertise required to handle ill-behaved series can only be acquired by hands-on experience with seasonal adjustment of many different types of series.

[71] For example, see Di Palma and Savio (2001), Burgess (2007), Zhang and Apted (2008), and Ciammola, Cicconi, and Di Palma (2013).

Status and Presentation of Seasonally Adjusted and Trend-Cycle QNA Estimates

7.123 The status and presentation of seasonally adjusted and trend-cycle QNA estimates vary. Some countries publish seasonally adjusted estimates for only a few main aggregates and present them as additional (sometimes unofficial) analytical elaborations of the official data. Other countries focus on the seasonally adjusted and trend-cycle estimates and publish an almost complete set of seasonally adjusted and trend-cycle QNA estimates in a reconciled accounting format. Data adjusted for calendar effects may also be published separately. This presentation makes the impact of calendar effects on the QNA aggregates visible for users.

7.124 The mode of presentation also varies substantially. Seasonally adjusted and trend-cycle data can be presented as charts; as tables with the actual data, either in money values or as index series; and as tables with derived measures of quarter-to-quarter rates of change. Calendar adjusted data should be presented in the same manner as the original unadjusted data (generally in levels and year-on-year changes). Quarter-to-quarter rates of change are not appropriate for calendar adjusted data, because these data still contain seasonal effects which may dominate quarterly movements.

7.125 Quarter-to-quarter rates of change should be presented as actual rates of change between one quarter and the previous one. Growth rates are sometimes annualized to make it easier for the user to interpret the data. Most users have a feel for the size of annual rates of change but not for monthly or quarterly ones. Annualizing growth rates, however, also means that the irregular effects are compounded. Irrespective of whether the actual or annualized quarterly rates of change are presented, it is important to clearly indicate what the data represent.

7.126 Growth rates representing different measures of change can easily be confused unless it is clearly indicated what the data represent. For instance, terms like “annual percentage change” or “annual rate of growth” can mean (a) the rate of change from one quarter to the next annualized (at annual rate); (b) the change from the same period of the previous year; (c) the change from one year to the next in annual data or, equivalently, the change from the average of one year to the average of the next year; or (d) the change from the end of one year to the end of the next year.

7.127 Some countries also present the level of quarterly data at annualized levels by multiplying the actual data by four. This presentation seems artificial, does not make the data easier to interpret, and may be confusing because annual flow data in monetary terms no longer can be derived as the sum of the quarters. Users not familiar with the practice of annualizing levels of current price data and volume data by multiplying the actual data by four may confuse annualized levels with forecast annual data. For these reasons, this practice is not recommended.

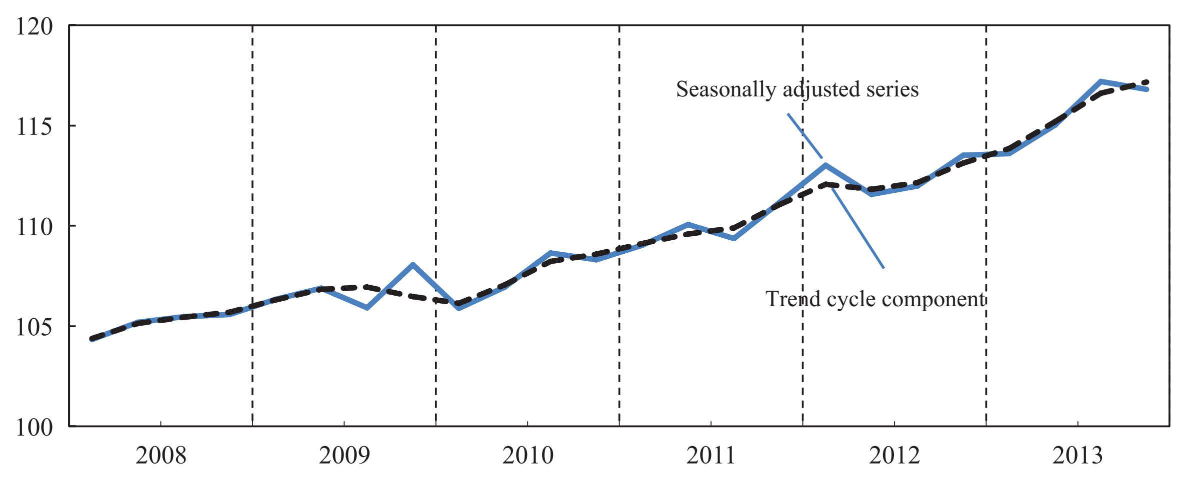
7.128 Finally, whether to present seasonally adjusted data or estimates of the trend-cycle component is still the subject of debate between experts in this area. In this manual, it is recommended to present both, preferably in the form of graphs incorporated into the same chart, as illustrated in Figure 7.4.

7.129 An integrated graphical presentation highlights the overall development in the two series over time, including the uncertainties represented by the irregular component. In contrast, measures of quarter-to-quarter rates of change (in particular, annualized rates) may result in an overemphasis on the short-term movements in the latest and most uncertain observations at the expense of the general trend in the series. The underlying data and derived measures of quarter-to-quarter rates of change, however, should be provided as supplementary information.

7.130 The presentation should highlight the lower reliability, particularly for the trend-cycle component, of the estimates for the latest observations as discussed in this section. Means of highlighting the lower quality of the endpoint estimates include noting past revisions to these estimates or showing the confidence interval of trend-cycle estimates in graphical and tabular presentations. When the irregular is particularly strong, trend-cycle estimates for the latest observations (up to two quarters) could be removed from graphical presentations.

Figure 7.4 Presentation of the Seasonally Adjusted Series and Trend-Cycle Component

(Based on data from Example 7.1)



Presenting the seasonally adjusted series and the trend-cycle component in the same chart highlights the overall development in the two series over time, including the uncertainty of the irregular component. Users should be informed that trend-cycle estimates of the latest observations are subject to high uncertainty and should be taken with caution.

Summary of Key Recommendations

- *Seasonally adjusted data in the QNA should be calculated to facilitate the analysis of current economic developments without the influence of seasonal and calendar effects. However, seasonally adjusted data should not replace the unadjusted QNA data.*
- *A series should be seasonally adjusted only when there is evidence of identifiable seasonality. Series with no seasonality or too unstable seasonality should not be seasonally adjusted.*
- *QNA series should also be adjusted for calendar effects. However, the adjustment should be done only for those series for which there is statistical evidence and economical interpretation of calendar effects.*
- *In the preadjustment stage, deterministic effects should be identified and removed from the series using regression models and diagnostics.*
- *Decomposition of the (preadjusted) series should be conducted using either the moving average X-11 method or the model-based SEATS method. The X-13A-S program, which implements both X-11 and SEATS, is the recommended procedure for seasonal adjustment in the QNA.*
- *Seasonal adjustment results should be evaluated using basic and advanced diagnostics. Seasonally adjusted series with residual seasonality should not be accepted.*
- *Seasonally adjusted data should be updated using a partial concurrent strategy. In a partial concurrent strategy, models and options for seasonal adjustment are selected at established review periods (usually once a year). In non-review periods, seasonal adjustment models and options are kept fixed but parameters are reestimated each time a new observation is added.*
- *The full seasonally adjusted series should be revised anytime the seasonal adjustment model is changed or updated. In non-review periods, seasonally adjusted data should at least cover the revision period of the unadjusted data.*
- *Revisions studies of seasonally adjusted QNA data should be conducted on a regular basis to identify where revisions are large and systematic.*
- *Due to moving seasonality and calendar effects, seasonally adjusted data may not be consistent with corresponding annual data. However, seasonally adjusted data could be benchmarked to annual benchmarks of national accounts for consistency reasons. When the series is adjusted for calendar effects, the seasonally adjusted data should be benchmarked to annual benchmarks adjusted for calendar effects.*
- *A minimum of five years is required to seasonally adjust QNA series. Shorter series may be adjusted for internal use but not disseminated.*
- *Seasonally adjusted data of the main QNA aggregates should be released to the public. Trend-cycle component and calendar adjusted data could also be disseminated. Metadata on seasonal adjustment models and revision policy should be made available for transparency.*

Bibliography

Bobbitt, L.G., and Otto, M.C. (1990), "Effects of Forecasts on the Revisions of Concurrent Seasonally Adjusted Data Using the X-11 Seasonal Adjustment Procedure," *Proceedings of the Business and Economic Statistics Section of the American Statistical Association*, American Statistical Association: Minneapolis, MN, pp. 449–453.

Burgess, S. (2007), "Change in Policy for Seasonal Adjustment of Quarterly Series," *Monetary and Financial Statistics*, April: 17–19.

Burman, J.P. (1980), "Seasonal Adjustment by Signal Extraction," *Journal of the Royal Statistical Society: Series A*, 143(3): 321–337.

Ciammola, A., C. Cicconi, and M. Marini (2010), "Seasonal Adjustment and the Statistics Treatment of the Economic Crisis: An Application to Some Italian Time Series," presented at the *6th Colloquium on Modern Tools for Business Cycle Analysis*, Eurostat, Luxembourg, September.

Ciammola, A., C. Cicconi, and F. Di Palma (2013), "Time Aggregation and Seasonal Adjustment of Airline Models," ISTAT Research Paper, Italy.

Dagum, E.B. (1980), "The X-11-ARIMA Seasonal Adjustment Method," Ottawa: Statistics Canada.

Dagum, E.B. (1982), "Revisions of Time Varying Seasonal Filters," *Journal of Forecasting*, 1(April–June): 173–187.

Dagum, E.B. (1987), "Monthly Versus Annual Revisions of Concurrent Seasonally Adjusted Series," in eds. I.B. MacNeill and G.J. Umphrey, *Time Series and Economic Modeling*, Dordrecht: D. Reidel, pp. 131–146.

Dagum, E.B., and M. Morry (1984), "Basic Issues on the Seasonal Adjustment of the Canadian Consumer Price Index," *Journal of Business & Economic Statistics*, 2(July): 250–259.

Deutsche Bundesbank (2012), *Calendar Effects on Economic Activity*, Monthly Report, December, pp. 51–60.

Di Palma, F., and G. Savio (2001), "Temporal Aggregation, Seasonal Adjustment and Data Revisions," *Proceedings of 2000 Joint Statistical Meetings*, American Statistical Association, Minneapolis, United States, pp. 130–143.

Di Palma, F., and M. Marini (2004), "The Calendar Adjustment of Italian Quarterly National Accounts: Methodology and Presentation of Main Results," *Rivista di Statistica Ufficiale*, ISTAT, 2: 5–51.

Eurostat (2009), *ESS Guidelines on Seasonal Adjustment*, Luxembourg.

Eurostat and European Central Bank (2008), *Final Report of Task Force on Seasonal Adjustment of Quarterly National Accounts*, January, Luxembourg.

Findley, D.F., B.C. Monsell, W.R. Bell, M.C. Otto, and B.-C. Chen (1998), "New Capabilities and Methods of the X-12-ARIMA Seasonal-Adjustment Program," *Journal of Business and Economic Statistics*, 16(2): 127–152.

Ghysels, E., and D.R. Osborn (2001), *The Econometric Analysis of Seasonal Time Series*, Cambridge: Cambridge University Press.

Gomez, V. and A. Maravall (1996), "Programs TRAMO and SEATS, Instruction for User," *Banco de Espana*, Working Paper 96/28.

Hillmer, S.C., and G.C. Tiao (1982), "An ARIMA-Model-Based Approach to Seasonal Adjustment," *Journal of the American Statistical Association*, 77(377): 63–70.

Hood, C.H, and D.F. Findley (1999), "X-12-ARIMA and Its Application to Some Italian Indicator Series," U.S. Bureau of Census, Washington, DC.

Huyot, G.J., K. Chiu, J. Higginson, and N. Gait (1986), "Analysis of Revisions in the Seasonal Adjustment of Data Using X-11-ARIMA Model-Based Filters," *International Journal of Forecasting*, 2(2): 217–229.

Hylleberg, S. (1992), *Modelling Seasonality: Advanced Texts in Econometrics*, Oxford: Oxford University Press.

Kaiser, R., and A. Maravall (2000), "Notes on Time Series Analysis, ARIMA Models and Signal Extraction," *Bank of Spain*, Working Paper 00/12.

Kenny, P.B., and J. Durbin (1982), "Local Trend Estimation and Seasonal Adjustment of Economic and Social Time Series," *Journal of the Royal Statistical Society: Series A*, 145(1): 1–41.

Ladiray, D., and B. Quenneville (2001), "Seasonal Adjustment with the X-11 Method," in *Lecture Notes in Statistics*, Vol. 158, New York: Springer.

Lytras, D., and W. Bell (2013), "Modeling Recession Effects and the Consequences on Seasonal Adjustment," U.S. Bureau of the Census, Washington, DC, available at https://www.census.gov/ts/papers/jsm2013lytrasfinal.pdf.

McKenzie, S. (1984), "Concurrent Seasonal Adjustment with Census X-11," *Journal of Business & Economic Statistics*, 2(3): 235–249.

ONS (2007), "Guide to Seasonal Adjustment with X-12-ARIMA," Office for National Statistics, Methodology and Statistical Development (Draft), Newport, UK.

Quenneville, B., and D.F. Findley (2012), "The Timing and Magnitude Relationships between Month-to-Month Changes and Year-to-Year Changes that Make Comparing Them Difficult," *Taiwan Economic Forecast and Policy*, 43(1): 119–138.

Scott, S., R. Tiller, and D. Chow (2007), "Empirical Evaluation of X-11 and Model-Based Seasonal Adjustment Methods," U.S. Bureau of Labor Statistics, Office of Survey Methods Research, Washington, DC.

Shiskin, J., A.H. Young, and J.C. Musgrave (1967), "The X-11 Variant of the Census Method II Seasonal Adjustment Program," Technical Report 15, U.S. Bureau of the Census, Washington, DC.

U.S. Census Bureau (2013), *X-13ARIMA-SEATS Reference Manual*, Statistical Research Division, U.S. Bureau of the Census, Washington, DC.

Wallis, K. F. (1982), "Seasonal Adjustment and Revision of Current Data: Linear Filters for the X-11 Method," *Journal of the Royal Statistical Society: Series A*, 145(1): 74–85.

Zhang, X.M., and L. Apted (2008), "Temporal Aggregation and Seasonal Adjustment," Research paper, Australian Bureau of Statistics, Canberra.

8 Price and Volume Measures

Price and volume measures in the quarterly national accounts (QNA) should be derived from observed price and volume data and be consistent with corresponding annual measures. This chapter examines specific aspects of price and volume measures derived at the quarterly frequency. In particular, it shows how to aggregate quarterly price and volume measures at the elementary level using Laspeyres and Fisher index formulas, how to derive quarterly chain volume series using alternative linking techniques, and how to handle the lack of additivity of quarterly chain volume series.

Introduction

8.1 A primary objective in compiling QNA is to obtain an accurate price and volume decomposition of quarterly transactions in goods and services. This decomposition provides the basis for measuring growth and inflation in macroeconomic aggregates, such as gross domestic product (GDP) in volume terms or household consumption deflator. To meet this objective, quarterly changes of transactions in goods and services at current prices need to be factored into two components: quarterly price changes and quarterly volume changes. As general principles, QNA price and volume measures should reflect the movements in quarterly price and volume indicators[1] and be temporally consistent with the corresponding price and volume measures derived from the annual national accounts (ANA).

8.2 The *2008 SNA* (chapter 15) defines basic principles for deriving price and volume measures within the system of national accounts in accord with index number theory and international standards of price statistics.[2] A key recommendation in the *2008 SNA*, also present in the *1993 SNA*, is to move away from the traditional national accounts measures "at constant prices"[3] toward chain-linked measures. Annual chain indices are superior to fixed-base indices, because weights are updated every year to reflect the current economic conditions. Chaining also avoids the need for re-weighting price and volume series when the base year is updated every five or ten years, which usually generates large revisions in the history of price and volume developments.[4] The *2008 SNA* recommends superlative index number formulas such as the Fisher and Tornquist formulas; however, a national accounts system based on Laspeyres volume indices (and the associated implicit Paasche price indices) is considered an acceptable alternative for practical reasons. A summary of the main recommendations of the *2008 SNA* is given in Box 8.1.

8.3 The *2008 SNA* also contains specific guidance on the compilation of quarterly price and volume measures. Although the same principles apply to both QNA and ANA, some complications derive from the different frequency of observation and the overarching requirement that quarterly and annual figures (when derived from independent compilation systems) should be made consistent with each other. The *2008 SNA* suggests that a sound approach to derive quarterly volume estimates is to calculate annually chained Laspeyres-type quarterly volume measures from quarterly data that are consistent with annual supply and use tables (SUT) expressed in current prices and in the prices of the previous year. Using

[1] See Chapter 3 for an overview of price and volume indicators for GDP by economic activities and by expenditure components.

[2] Main references of international standards of price statistics are the *Consumer Price Index Manual: Theory and Practice* (ILO and others, 2004a), *Producer Price Index Manual: Theory and Practice* (ILO and others, 2004b), and *Export and Import Price Index Manual: Theory and Practice* (ILO and others, 2009).

[3] Constant price measures are based on fixed-base Laspeyres volume indices (i.e., weights taken from a fixed-base year) and corresponding current period-weighted Paasche price indices.

[4] Chain-linked series are still subject to benchmark revisions (based on comprehensive data sources available every five or ten years) and methodological revisions (due to changes in national accounting principles) to current price data, which may generate difference in the aggregate price and volume indices.

Box 8.1 Main Recommendations on Price and Volume Measures in the *2008 SNA*

This box quotes the main recommendations of the *2008 SNA* on expressing national accounts in volume terms (*2008 SNA*, paragraph 15.180):

(a) Volume estimates of transactions in goods and services are best compiled in a supply and use framework, preferably in conjunction with, and at the same time as, the current value estimates. This implies working at as detailed a level of products as resources permit.

(b) In general, but not always, it is best to derive volume estimates by deflating the current value with an appropriate price index, rather than constructing the volume estimates directly. It is therefore very important to have a comprehensive suite of price indices available.

(c) The price indices used as deflators should match the values being deflated as closely as possible in terms of scope, valuation, and timing.

(d) If it is not practical to derive estimates of value added in real terms from a supply and use framework and either the volume estimates of output and intermediate consumption are not robust or the latter are not available, then satisfactory estimates can often be obtained using an indicator of output, at least in the short term. For quarterly data, this is the preferred approach, albeit with the estimates benchmarked to annual data. An output indicator derived by deflation is generally preferred to one derived by quantity extrapolation.

(e) Estimates of output and value added in volume and real terms should only be derived using inputs as a last resort, since they do not reflect any productivity change.

(f) The preferred measure of year-to-year movements of GDP volume is a Fisher volume index; price changes over longer periods being obtained by chaining: that is, by cumulating the year-to-year movements.

(g) The preferred measure of year-to-year inflation for GDP and other aggregates is, therefore, a Fisher price index; price changes over long periods being obtained by chaining the year-to-year price movements, or implicitly by dividing the Fisher chain volume index into an index of the current value series.

(h) Chain indices that use Laspeyres volume indices to measure year-to-year movements in the volume of GDP and the associated implicit Paasche price indices to measure year-to-year inflation provide acceptable alternatives to Fisher indices.

(i) Chain indices for aggregates cannot be additively consistent with their components whichever formula is used, but this need not prevent time series of values being compiled by extrapolating base year values by the appropriate chain indices.

(j) A sound approach to deriving quarterly current value and volume estimates is to benchmark them to annual estimates compiled in a supply and use framework. This approach lends itself to the construction of annually chained quarterly volume measures using either the Fisher or Laspeyres formula.

annual weights increases consistency with the annual estimates and makes the quarterly indices less subject to volatility due to seasonal effects and short-term irregularities present in quarterly data.

8.4 The ideal way of producing volume estimates of QNA aggregates is to work at a very detailed level. The next section discusses some basic principles to derive volume estimates in the national accounts at the elementary aggregation level, adapted to the quarterly context. For each individual transaction, the same estimation method should be used to derive volume estimates in both ANA and QNA. As discussed in Chapter 3, for most market transactions, the best results are generally obtained by deflating current price values using appropriate price indices. Volume extrapolation should be employed where appropriate price data are not available or are not observable (e.g., nonmarket output), while the application of quantity revaluation in the QNA can be considered for those transactions where detailed quantities are available on a quarterly basis.

8.5 When detailed quarterly data on output and intermediate consumption are available, volume estimates of value added should be derived using a double indicator method. Volume estimates of output and intermediate consumption should be derived independently using appropriate price or volume indices. However, quarterly data on detailed intermediate inputs may not be available or may be so with a long time lag. In these cases, the calculation of quarterly value added in volume should be based on single indicator methods. Typically, a fixed relationship between output and value added in volume terms is assumed. The next section elaborates further on using alternative single indicator methods to best approximate the double indicator approach.

8.6 Strict consistency between QNA and direct ANA price and volume measures is only guaranteed when annual and quarterly changes are aggregated using the same system of weights. Coherently, with the *2008 SNA*, the preferred solution to achieve fully consistent QNA and ANA price and volume measures is to calculate Laspeyres-type volume indices with annual weights from the previous year. When the annual overlap (AO) technique is used for chain-linking quarterly indices,[5] annually chained Laspeyres-type quarterly volume measures are also consistent with the corresponding annual Laspeyres volume measures. Quarterly indices based on other index formulas, including Paasche and Fisher, or linked with other techniques (e.g., the one-quarter overlap [QO] technique) do not aggregate exactly to their corresponding direct annual indices. In such cases, consistency between QNA and ANA price and volume measures requires either that the ANA measures are derived as the annual sum of QNA measures or that consistency is forced on the QNA data using benchmarking techniques.

8.7 Notwithstanding the practical advantages of Laspeyres-type volume indices, a price and volume decomposition based on superlative indices (like Fisher) remains a theoretically superior solution for both ANA and QNA. The Fisher formula is a symmetric one, one in which price and quantity relatives are aggregated using weights from both the base period and the current period, and provides a better aggregation of elementary price and quantity relatives between the two periods than the Laspeyres formula (which uses the base period) and the Paasche formula (which uses the current period). This chapter illustrates a solution to develop a Fisher-based price and volume estimation system in the QNA based on (true) quarterly and annual Fisher indices.

[5] As mentioned in this chapter, the annual overlap technique may introduce a break in the chain volume series between one year and the next. However, this happens only if there are strong changes in quantity weights within the year (see Annex 8.1).

8.8 Price and volume series should guarantee time-series characteristics: that is, data from different periods should be comparable in a consistent manner. Sequence of price and volume indices having different weight periods (e.g., volume series at previous year's prices) are not comparable over time and should not be presented in the form of time series. Chain-linking is a necessary operation to transform annual and quarterly links from the previous year (or from the previous quarter, in the case of quarterly Fisher indices) into consistent time series. This chapter provides guidance on how to calculate quarterly chain volume series using alternative linking techniques. Furthermore, it discusses how to resolve some practical issues arising from the lack of additivity of chain-linked measures, including the calculation of additive contributions to percent changes from nonadditive chain volume series based on the Laspeyres and Fisher formulas.

8.9 Strictly adhering to the *2008 SNA* principles, this chapter emphasizes the advantages of compiling chain-linked measures. Many countries, however, are still compiling traditional constant price estimates in both the ANA and QNA and are far from implementing chain-linked measures. These countries will find useful to examine the specific QNA methodological issues presented in the first three sections (basic principles, temporal consistency of price and volume measures, and choice of index formula for QNA volume measures), because these issues apply equally to constant price estimates. On the other hand, the discussion on chain-linking presented in the remainder of the chapter is more relevant for those countries that have already implemented chain-linking in the QNA or that plan to implement it soon.

Basic Principles for Deriving Volume Measures at the Elementary Aggregation Level

8.10 Volume measurement relates to decomposition of transaction values at current prices into their price and volume components. The aim of this decomposition is to analyze how much of the change is due to price movements and how much to volume changes.[6] This decomposition is admissible for transactions in goods and services for which it is possible to assume that the current value is composed of a price and a quantity component. In addition to pure transactions in goods and services, volume measures can be compiled for transactions such as taxes and subsidies on products, trade margins, consumption of fixed capital, and stocks of inventories and produced fixed assets. The accounting framework makes it possible to define and construct volume measures for value added, although value added does not represent any observable flow of goods and services that can be factored into a price and volume component directly. This section discusses some basic principles for deriving volume measures at the elementary aggregation level in the national accounts and how they should be implemented in the QNA context.

8.11 Volume estimates of national accounts should start from a very detailed level.[7] The most disaggregated level in the national accounts defines the level at which transactions in current values are deflated or extrapolated using available price or volume indices. To obtain accurate results, it is desirable for the price and volume indices to be as homogeneous as possible. The more detailed are the indices, the more homogeneous are the product groups measured by the indices. In the national accounts, these indices are considered elementary price indices, even though they are already aggregations of more detailed price indices. When the type of products of the index is homogeneous, the different underlying weighting methodologies can be assumed to be irrelevant and the price and volume changes from the indices can be used as price deflator or volume extrapolator for an elementary transaction of QNA.

8.12 In the QNA, the elementary level of aggregation should be decided on the basis of the ANA detail and the scope of price and volume indicators available on a quarterly basis. The ANA classification (by product, by industry, by expenditure function, etc.) generally defines the finest level of disaggregation possible for the QNA. Ideally, QNA price and volume measures should be derived at the same detail level used in the ANA. More often, the QNA detail is more aggregated than the ANA detail due to the reduced set of information available at the quarterly level. It is unnecessary and inefficient to keep the same ANA disaggregation in the QNA when the quarterly information set does not permit to distinguish nominal price and volume measures at that detail.

8.13 Prices and volumes are intrinsic components of nominal values. Denote with $c^{(s,y)}$ the value at current prices of an elementary QNA transaction for quarter s of year y, with $s = 1,2,3,4$ and $y = 1,2,\ldots$.[8] At the micro level, this transaction can be thought of as the sum of a (finite) number of individual "price × volume" transactions:

$$c^{(s,y)} = \sum_j c_j^{(s,y)} = \sum_j p_j^{(s,y)} q_j^{(s,y)}, \qquad (1)$$

where

j is an index for transactions included in the aggregate $c^{(s,y)}$,

$p_j^{(s,y)}$ is the price of transaction j in quarter s of year y, and

$q_j^{(s,y)}$ is the volume (quantity plus quality effects) of transaction j in quarter s of year y.

The entire set of individual transactions $c_j^{(s,y)}$, including their price and quantity details, are rarely directly observable. In the QNA, the quarterly value $c^{(s,y)}$ is derived using some quarterly value indicator (directly in nominal terms or derived as the combination of price–quantity indices). For any given year, the quarterly figures (equation (1)) are made consistent with the corresponding (generally more comprehensive) annual observation C_j^y through benchmarking.

8.14 As noted in this chapter, the most frequent solution adopted by countries for calculating consistent

[6] The expression "volume change" in the national accounts includes both quantity changes and quality changes. Changes in quality over time should be recorded as changes in volume and not as changes in price. Compositional changes should also be recorded as changes in volume, such as those resulting from a shift from or to higher quality products.

[7] Working at a detailed level means that, for example, volume estimates of GDP by industry should be derived from volume estimates of detailed economic activities, or that volume estimates of GDP by expenditure be derived from volume estimates of detailed categories of demand aggregates.

[8] Differently from previous chapters, notation in this chapter shows the time dimension in superscript and the item dimension in subscript. This notation is used in many price index theory textbooks and adopted by the *2008 SNA* (chapter 15). Lower-case letters denote quarterly observations, with quarter and year indicated in brackets. Upper-case letters denote annual observations.

price and volume measures in both ANA and QNA is to use annual weights.[9] This approach should be followed for both annual and quarterly data. For chain-linked measures, the weights should be updated every year. The volume measure associated with equation (1), denoted with $k^{y-1\to(s,y)}$, is expressed as the quantities of quarter s of year y valued at the prices of the previous year $y-1$:

$$k^{y-1\to(s,y)} = \sum_j k_j^{y-1\to(s,y)} = \sum_j P_j^{y-1} q_j^{(s,y)}, \quad (2)$$

where

P_j^{y-1} is a weighted average price of transaction j in year $y-1$ (for a discussion on how best to calculate weighted averages of quarterly price indices, see "Main Principles of Seasonal Adjustment" of this chapter). Equation (2) provides the quarterly volume measure at the (weighted average) prices of the previous year (or at previous year's prices) of the elementary transaction j for quarter s of year y.

8.15 By contrast, a constant price measure is expressed as follows:

$$k^{b\to(s,y)} = \sum_j k_j^{b\to(s,y)} = \sum_j P_j^b q_j^{(s,y)}, \quad (3)$$

where the quarterly quantities of quarter s of year y are valued at the average prices of a base year b. The advantage of using the volume estimate at previous year's prices in equation (2) instead of the constant price measure in equation (3) is that the weights are updated every year and are not taken from a fixed (and often distant) base year.

8.16 When detailed quantities in the current quarter and prices of the previous year are available, the volume measure $k^{y-1\to(s,y)}$ can be obtained by quantity revaluation. This method may provide accurate price and volume decomposition, as long as quality changes are incorporated in the quantities observed. This approach lends itself very well for homogeneous products, where quality changes are less likely to occur. Quantity revaluation finds some applications for agricultural products, whose quarterly quantities may be derived from work-in-progress models based on detailed crop forecasts, or for highly concentrated industries, such as oil-producing industries which often provide detailed data on their quarterly production through oil-related business associations.

8.17 More commonly, volume measures $k^{y-1\to(s,y)}$ are calculated using one of two alternative methods: price deflation and volume extrapolation.[10]

Price Deflation

8.18 The volume estimate $k^{y-1\to(s,y)}$ is derived by dividing the current price value $c^{(s,y)}$ by an appropriate price index. Ideally, the volume estimate $k^{y-1\to(s,y)}$ should be derived using a quarterly Paasche-type price index[11]:

$$PP^{y-1\to(s,y)} = \frac{\sum_j p_j^{(s,y)} q_j^{(s,y)}}{\sum_j P_j^{y-1} q_j^{(s,y)}}. \quad (4)$$

In effect, it is easily shown that

$$\frac{c^{(s,y)}}{PP^{y-1\to(s,y)}} = \frac{\sum_j p_j^{(s,y)} q_j^{(s,y)}}{\dfrac{\sum_j p_j^{(s,y)} q_j^{(s,y)}}{\sum_j P_j^{y-1} q_j^{(s,y)}}} = \sum_j P_j^{y-1} q_j^{(s,y)} = k^{y-1\to(s,y)}. \quad (5)$$

Paasche-type price indices are rarely available for national accounts purposes.[12] They require weights from every period and are difficult to calculate in practice. Price indices are usually calculated using the Laspeyres formula with a fixed-base year, with weights taken from a survey conducted in that year.[13] Denoting with $LP^{b\to(s,y)}$ a Laspeyres-type price index with a fixed-base year b, it is possible to calculate a price relative of quarter s of year y from the previous year $y-1$ as follows:

$$LP^{y-1\to(s,y)} = \frac{LP^{b\to(s,y)}}{LP^{b\to y-1}}, \quad (6)$$

[9]The following discussion can easily be adapted to calculating indices from the previous quarter, as required to derive quarterly Fisher indices.

[10]Chapter 3 identifies whether price deflation or volume extrapolation are most suitable for GDP components by economic activity and by expenditure categories.

[11] A quarterly Paasche-type price index is a weighted harmonic average of price relatives with weights from the current quarter.

[12] A notable exception of Paasche-type aggregation is unit value indices in merchandise trade statistics.

[13] In practice, statistical offices do not calculate Laspeyres-type indices but Lowe indices, where the weight period precedes the base period. On the relationship between Lowe, Laspeyres, and Paasche price indices, see the *Consumer Price Index Manual: Theory and Practice* (ILO and others, 2004a).

that is, the ratio between the fixed-base index for quarter s of year y and the fixed-base index for year $y-1$. Replacing $PP^{y-1\rightarrow(s,y)}$ with the (fixed-base) Laspeyres-type price index $LP^{y-1\rightarrow(s,y)}$ in equation (6) will provide an approximate volume measure $k^{y-1\rightarrow(s,y)}$.[14] Working at a detailed elementary level is crucial for assuming that a fixed-base Laspeyres price index is close to the ideal current period-weighted Paasche price index.

Volume Extrapolation

8.19 This method requires an annually weighted Laspeyres-type quarterly volume index, which is defined as follows:

$$LQ^{y-1\rightarrow(s,y)} = \frac{\sum_j P_j^{y-1} q_j^{(s,y)}}{\frac{1}{4}\sum_j P_j^{y-1} Q_j^{y-1}}, \tag{7}$$

where Q_j^{y-1} is the annual quantity of transaction j in year $y-1$.

The volume measure $k^{y-1\rightarrow(s,y)}$ can be derived ideally by extrapolating the (rescaled) current price value of the previous year using the index $LQ^{y-1\rightarrow(s,y)}$: that is,

$$\frac{1}{4}C^{y-1} \cdot LQ^{y-1\rightarrow(s,y)} = \sum_j P_j^{y-1} Q_j^{y-1} \cdot$$

$$\sum_j \frac{P_j^{y-1} q_j^{(s,y)}}{P_j^{y-1} Q_j^{y-1}} = \sum_j P_j^{y-1} q_j^{(s,y)} = k^{y-1\rightarrow(s,y)}. \tag{8}$$

Likewise prices, the available volume indices are normally fixed-base Laspeyres-type indices. Similar to the price relative calculated in equation (6), a (fixed-base) quantity relative from the previous year can be calculated as follows:

$$LQ^{y-1\rightarrow(s,y)} = \frac{LQ^{b\rightarrow(s,y)}}{LQ^{b\rightarrow y-1}} \tag{9}$$

and used in equation (8) to extrapolate the volume change from the previous year. At constant prices, the volume index $LQ^{b\rightarrow(s,y)}$ can be used directly to extrapolate the current price data in the base year.

8.20 In most countries, quarterly GDP is derived from the production approach. This fact results from a greater availability of quarterly data by economic activity compared with expenditure and income transactions. Therefore, it assumes particular relevance how volume estimates of quarterly value added are calculated. As discussed in Chapter 3, the best method to derive volume measures of value added is to use double indicator methods—a volume measure of value added as the difference between a direct estimate of output in volume and a direct estimate of intermediate consumption in volume (each of which can be derived either by direct revaluation, deflation, or volume extrapolation). However, in practice, the information needed for obtaining independent and reliable volume estimates of output and intermediate consumption may not be available or may not be of sufficient quality. In particular, to derive a proper deflator for intermediate consumption for each activity, detailed data on intermediate consumption by product in the current quarter is needed.

8.21 In the QNA, simplified approximation methods sometimes need to be used.[15] One such simplified method is to use volume indicators to extrapolate value added. This is called the *single extrapolation technique*. The single extrapolation technique, using a volume estimate of output[16] to extrapolate value added, is based on an underlying assumption of a constant relationship between output, intermediate consumption, and value added in volume terms. This assumption usually holds true in the short run for many industries in periods of economic stability, while it is a highly questionable assumption in the long run and for countries with rapid structural changes. The fixed-ratio assumption in volume terms should be checked continuously looking at the annual benchmarks of national accounts, making sure that there are no sudden changes in the output-to-intermediate consumption ratio between one year and the next.

[14] Constant price data can be derived directly by dividing the current price data $c^{(s,y)}$ with a fixed-base Laspeyres price index $LP^{b\rightarrow(s,y)}$ or by extrapolating the current price data in the base year $\frac{1}{4}C^b$ with a fixed-based Laspeyres volume index $LQ^{b\rightarrow(s,y)}$.

[15] For an empirical assessment of the differences between double deflation and single indicator methods, see Alexander and others (2017).

[16] As noted in Chapter 3, input-related volume indicators (such as deflated wages or employment data) may be considered to extrapolate value added when information on output is absent or less reliable (one example is nonmarket output).

8.22 An alternative, less satisfactory, approximation is to use a price indicator (e.g., the price deflator for output, intermediate consumption, or a wage index) to deflate value added directly. This is known as the *single deflation technique*. The single deflation technique, using the price deflator for output as the deflator for value added, is based on an underlying assumption of a constant relationship between the price deflators for output, intermediate consumption, and value added. While there is reason to expect the relationship between output, intermediate consumption, and value added in volume terms to change only gradually, there is no reason to expect a stable relationship between the price deflators for output, intermediate consumption, and value added. This is a highly questionable assumption to rely on because price relatives may change abruptly, even in the short term. For this reason, the single deflation technique should be avoided.

8.23 When simplified methods such as the single extrapolation technique are used, it is strongly recommended to estimate all the components of the production account in volume terms, and not only value added. Furthermore, it is recommended to derive estimates based on more than one estimation technique and to assess the estimates and the validity of the underlying assumptions by inspecting and comparing the implicit deflators for output, intermediate consumption, and value added, or by assessing the intermediate consumption shares at the quarterly frequency.

Aggregating Price and Volume Measures Over Time

8.24 Aggregation over time means deriving less frequent data (e.g., annual) from more frequent data (e.g., quarterly). Incorrect aggregation of prices, or price indices, over time to derive annual deflators can introduce errors in independently compiled annual estimates and thus can cause inconsistency between QNA and ANA estimates, even when they are derived from the same underlying data. When deriving annual volume estimates by deflating annual current price data, a common practice is to compute the annual price deflators as a simple unweighted average of monthly or quarterly price indices. This practice may introduce substantial errors in the derived annual volume estimates, even when inflation is low. This may happen when

a. there are seasonal or other within-year variations in prices or quantities and

b. the within-year pattern of variation in either prices or quantities is unstable.

8.25 Volume measures for aggregated periods of time should conceptually be constructed from period-total quantities for each individual homogenous product. The corresponding implicit price measures would be quantity-weighted period-average price measures. For example, annual volume measures for single homogenous products[17] should be constructed as sums of the quantities in each subperiod. The corresponding implicit annual average price, derived as the annual current price value divided by the annual quantity, would therefore be a quantity-weighted average of the prices in each quarter. As shown in Example 8.1, the quantity-weighted average price will generally differ, sometimes significantly, from the unweighted average price. Similarly, for groups of products, conceptually, annual volume measures can be constructed as a weighted aggregate of the annual quantities for each individual product. The corresponding implicit annual price deflator for the group would be a weighted aggregate of the quantity-weighted annual average prices for the individual products. This annual price deflator for the group based on the quantity-weighted annual average prices would generally differ, sometimes significantly, from the annual price deflators derived as a simple unweighted average of monthly or quarterly price indices often used in ANA systems—deflation by the latter may introduce substantial errors in the derived annual volume estimates.

8.26 Consequently, to obtain correct volume measures for aggregated periods of time, deflators should take into account variations in quantities as well as prices within the period. For example, annual deflators could be derived implicitly from annual volume measures derived from the sum of quarterly volume

[17] Homogenous products are identical in physical and economic terms to other items in that product group and over time. In contrast, when there are significant variations among items or over time in the physical or economic characteristic of the product group, each version should be treated as a separate product (e.g., out-of-season fruit and vegetables such as old potatoes may be regarded as different products than in-season fruit and vegetables such as new potatoes).

Example 8.1 Weighted and Unweighted Annual Averages of Prices (or Price Indices) When Sales and Price Patterns Through the Year Are Uneven

						Volume estimates	
	Quantity	Price	Current Price Value	Unweighted Average Price	Unit Value Weighted Average Price	At Unweighted Average 2010 Prices	At Weighted Average 2010 Prices
Quarter	(1)	(2)	(3)	(4)	(5) = (3)/(1)	(6) = (4)*(1)	(7) = (5)*(1)
q1	0	80	0			0	0
q2	150	50	7,500			7,500	6,750
q3	50	30	1,500			2,500	2,250
q4	0	40	0			0	0
2010	**200**		**9,000**	**50**	**45**	**10,000**	**9,000**
q1	0	40	0			0	0
q2	180	50	9,000			9,000	8,100
q3	20	30	600			1,000	900
q4	0	40	0			0	0
2011	**200**		**9,600**	**40**	**48**	**10,000**	**9,000**
Change from 2010 to 2011 (%)	0.00		6.67	–20.00	6.67	0.00	0.00
Direct Deflation of Annual Current Price Data							
2011 at 2010 prices	9,600/(40/50) = 9,600/0.8 = 12,000						
Change from 2010	(12,000/9,000 – 1) × 100 = 33.3%						

This example highlights the case of an unweighted annual average of prices (or price indices) being misleading when sales and price patterns through the year are uneven for a single homogenous product. The products sold in the different quarters are assumed to be identical in all economic aspects.

In the example, the annual quantities and the quarterly prices in quarters with nonzero sales are the same in both years, but the pattern of sales shifts toward the second quarter of 2011. As a result, the total annual current price value increases by 6.67 percent.

If the annual deflator is based on a simple average of quarterly prices, then the deflator appears to have dropped by 20 percent. As a result, the annual constant price estimates will wrongly show an increase in volume of 33.3 percent.

Consistent with the quantity data, the annual sum of the quarterly volume estimates for 2010 and 2011, derived by valuing the quantities using their quantity-weighted average 2010 price, shows no increase in volumes (column 7). The change in annual current price value shows up as an increase in the implicit annual deflator, which would be implicitly weighted by each quarter's proportion of annual sales in volume terms.

Price indices typically use unweighted averages as the price base, which corresponds to valuing the quantities using their unweighted average price. As shown in column 6, this results in an annual sum of the quarterly volume estimates in the base year (2010) that differs from the current price data, which it should not. As explained above and in this chapter, quarterly weighted prices should be used to derive annual prices. The difference between unweighted and weighted annual prices in the base year, however, can easily be removed by a multiplicative adjustment of the complete constant price time series, leaving the period-to-period rate of change unchanged. The adjustment factor is the ratio between the annual current price data and sum of the quarterly volume data in the base year (9,000/10,000).

estimates obtained using the following three-step procedure:

a. benchmark the quarterly current price data/indicator(s) to the corresponding annual current price data,
b. construct quarterly volume data by dividing the benchmarked quarterly current price data by the quarterly price index, and
c. derive the annual volume data as sum of the quarterly volume data.

Equivalently, the annual volume measure could be obtained by deflating, using an annual deflator that weights the quarterly price indices by the volume values of that transaction for each quarter. Either way of calculation achieves annual deflators that are quantity-weighted average annual price measures.

8.27 The procedure described above guarantees the best results of deflation if it is possible to obtain a reliable measurement of the quarterly pattern at current prices. If the current price indicator used to decompose the annual value is deemed to provide an inaccurate quarterly decomposition of the year (e.g., seasonal effects which are not fully representative of the transaction), the annual volume data could be affected by a distorted allocation of weights to quarterly prices. When it is not possible to derive accurate quarterly decomposition of current price data, unweighted averages of sub-annual indices represent a feasible choice for the ANA.

8.28 A more difficult case occurs when the annual estimates are based on more detailed price and value information than is available quarterly. In those cases, if seasonal volatility is significant, it would be possible to approximate the correct procedure using weights derived from more aggregated, but closely related, quarterly data.

8.29 The issue of price and quantity variations also applies within quarters. Accordingly, when monthly data are available, quarterly data will better take into account variations within the period if they are built up from the monthly data.

8.30 In many cases, variation in prices and quantities within years and quarters will be so insignificant that it will not substantially affect the estimates. Comparing weighted and unweighted averages can help identify the products for which the distinction is most relevant. Primary products and high-inflation countries are cases where the variation can be particularly significant. Of course, there are many cases in which there are no data to measure variations within the period.

8.31 A related problem that can be observed in quarterly data at constant prices of a fixed-base year is the annual sum of the quarterly volume estimates in the base year differing from the annual sum of the current price data, which should not be the case. This difference can be caused by the use of unweighted annual average prices as the price base when constructing monthly and quarterly price indices. Deflating quarterly data with deflators constructed with unweighted average prices as the price base corresponds to valuing the quantities using their unweighted annual average price rather than their weighted annual average price. This difference in the base year between the annual sum of the quarterly volume estimates and the annual sum of the current price data can easily be removed by a multiplicative adjustment of the complete volume series, leaving the period-to-period rate of change unchanged. The adjustment factor is the ratio between the annual current price data and the sum of the initial quarterly volume data based on the unweighted annual average prices in the base year, which, for a single product, is identical to the ratio of the weighted and unweighted average price.

Index Formula for QNA Volume Measures

8.32 Using the same notation introduced earlier, the application of revaluation, deflation, or volume extrapolation methods at the most detailed level in the QNA generates a set of elementary volume indices:

$$q_j^{y-1\to(s,y)} = \frac{k_j^{y-1\to(s,y)}}{C_j^{y-1}/4}, \qquad (10)$$

where

j denotes a generic QNA transaction,

$q_j^{y-1\to(s,y)}$ is a volume index from year $y-1$ to quarter s of year y for the j-th transaction,

$k_j^{y-1\to(s,y)}$ is the volume estimate of quarter s of year y at previous year's prices, and

$C_j^{y-1}/4$ is the (rescaled) annual value at current prices in the previous year.

Because numerator and denominator are valued using the same set of prices, the ratio measures a volume movement from year $y-1$ to quarter s of year y. The formula is additive within the year and coincides with the annual volume index. It is also additive across QNA transactions: the same formula can be used to extrapolate higher-level aggregates. Equation (1) provides the links to form chain-linked volume series, which is discussed in section "Chain-Linking in the QNA."

8.33 In a constant price system, equation (1) is modified as follows:

$$q_j^{b\to(s,y)} = \frac{k_j^{b\to(s,y)}}{K_j^{b\to y-1}/4}, \qquad (11)$$

where

$q_j^{b\to(s,y)}$ is a fixed-base volume index of quarter s of year y for transaction j,

$k_j^{b \to (s,y)}$ is the estimate of quarter s of year y at constant prices of a (fixed) base year b, and

$K_j^{b \to y-1} / 4$ is the (rescaled) constant price data in the previous year.

Because equation (11) derives fixed-base indices (i.e., indices expressed with a common base year), there is no need for using linking techniques between different years. Linking, however, is still necessary when the base year changes and the rebased series need to be linked to the series in the old base year. The techniques introduced in section "Chain-Linking in the QNA" are also relevant for linking constant prices series with different base years.

8.34 Elementary volume indices (equation (1) or (11)) need to be aggregated to derive QNA volume estimates. This section discusses how to aggregate elementary indices using the Laspeyres and Fisher formulas.

Laspeyres-Type Formula

8.35 A Laspeyres-type index aggregates elementary indices using weights from the base period. The base period for the QNA elementary volume indices shown in equation (1) is the previous year $y-1$.[18] An annually weighted Laspeyres-type quarterly volume index $LQ^{y-1 \to (s,y)}$ can be calculated as the weighted average of elementary volume indices of quarter s of year y with weights from year $y-1$:

$$\begin{aligned} LQ^{y-1 \to (s,y)} &= \sum_{j=1}^{n} q_j^{y-1 \to (s,y)} \cdot W_j^{y-1} \\ &= \sum_{j=1}^{n} q_j^{y-1 \to (s,y)} \cdot \frac{C_j^{y-1}}{\sum_{j=1}^{n} C_j^{y-1}} \end{aligned} \tag{12}$$

where

j is the index for transactions in the aggregate,

n is the number of transactions in the aggregate,

$q_j^{y-1 \to (s,y)}$ is the elementary volume index of transaction j from year $y-1$ to quarter s of year y as shown in equation (1),

C_j^{y-1} is the annual value at current prices of transaction j for year $y-1$,

$\sum_j C_j^{y-1}$ is the sum of all the annual values in the aggregate at current prices for year $y-1$, and

W_j^{y-1} is the share of C_j^{y-1} in the aggregate for year $y-1$.

Calculation of annually weighted Laspeyres-type volume measures from elementary volume indices is shown in Example 8.2.

8.36 Combining equation (1) and equations (2)–(9), equation (12) can be rewritten as follows:

$$LQ^{y-1 \to (s,y)} = \frac{\sum_{j=1}^{n} P_j^{y-1} q_j^{(s,y)}}{\frac{1}{4} \sum_{j=1}^{n} P_j^{y-1} Q^{y-1}}, \tag{13}$$

where

$q_j^{(s,y)}$ is the quantity of transaction j in quarter s of year y,

P_j^{y-1} is the price of transaction j in year $y-1$, and

Q_j^{y-1} is the quantity of transaction j in year $y-1$.

Equation (13) shows that a Laspeyres-type index is the ratio between the quantities of the current quarter valued at the (average) prices of the previous year and the rescaled annual value of the previous year at current prices. This notation is commonly found in the presentation of index numbers; however, it is difficult to apply in practice because, as noted before, price and quantities of QNA transactions are not available in most situations. For this reason, equation (12) is used in practice and is applied in the examples throughout this chapter.

8.37 As discussed earlier, annual weights for Laspeyres-type volume indices are generally preferable over quarterly weights. Use of the prices of one particular quarter, the prices of the corresponding quarter of the previous year, the prices of the corresponding quarter of a "fixed-base year," or the prices of the previous quarter are not appropriate for time series of Laspeyres-type volume measures in the national accounts for the following reasons:

- Consistency between directly derived ANA and QNA Laspeyres-type volume measures requires that the same price weights are used in the ANA

[18] For the sake of clarity, the following notation is based on volume indices at previous year's prices. However, any index aggregation formulas presented in this section apply equally to fixed-base indices.

Example 8.2 Deriving Annual and Quarterly Volume Measures Using Laspeyres-Type Formula

	Current Prices			Elementary Price Indices (Previous Year = 100)		Elementary Volume Measures (in Monetary Terms)			Elementary Volume Indices (Previous Year = 100)		Laspeyres Volume Index (Previous Year = 100)	Laspeyres Volume Measure (in Monetary Terms)
	(1)			(2)		(3) = (1)/(2) × 100			(4)		(5)	(6)
	A	B	Total	A	B	A	B	Sum	A	B	Total	Total
2010	600.0	900.0	1,500.0			600.0	900.0	*1,500.0*	100.00	100.00	100.00	*1,500.0*
2011	660.0	854.9	1,514.9	102.63	98.50	643.1	867.9	*1,511.0*	107.18	96.43	100.73	*1,511.0*
2012	759.0	769.5	1,528.5	101.72	98.34	746.2	782.5	*1,528.7*	113.05	91.53	100.91	*1,528.7*
2013	948.8	615.6	1,564.4	99.34	101.08	955.1	609.0	*1,564.1*	125.83	79.14	102.33	*1,564.1*
q1 2011	159.7	218.9	378.6	102.00	99.00	156.6	221.1	*377.7*	104.38	98.27	100.71	*377.7*
q2 2011	163.2	213.7	376.9	102.50	98.00	159.2	218.1	*377.3*	106.15	96.92	100.61	*377.3*
q3 2011	167.4	210.6	378.0	103.00	98.00	162.5	214.9	*377.4*	108.35	95.51	100.65	*377.4*
q4 2011	169.7	211.7	381.4	103.00	99.00	164.8	213.8	*378.6*	109.84	95.04	100.96	*378.6*
Sum 2011	**660.0**	**854.9**	**1,514.9**			**643.1**	**867.9**	***1,511.0***	**107.18**	**96.43**	**100.73**	***1,511.0***
q1 2012	174.2	204.1	378.3	102.50	97.00	170.0	210.4	*380.4*	103.00	98.45	100.43	*380.4*
q2 2012	180.4	201.4	381.8	102.00	99.00	176.9	203.4	*380.3*	107.19	95.19	100.42	*380.3*
q3 2012	188.9	192.3	381.2	101.00	98.50	187.0	195.2	*382.3*	113.35	91.35	100.93	*382.3*
q4 2012	215.5	171.7	387.2	101.50	99.00	212.3	173.4	*385.7*	128.68	81.15	101.85	*385.7*
Sum 2012	**759.0**	**769.5**	**1,528.5**			**746.2**	**782.5**	***1,528.7***	**113.05**	**91.53**	**100.91**	***1,528.7***
q1 2013	224.7	166.0	390.7	100.50	100.00	223.6	166.0	*389.6*	117.83	86.29	101.95	*389.6*
q2 2013	235.8	156.3	392.1	99.50	101.00	237.0	154.8	*391.7*	124.89	80.44	102.52	*391.7*
q3 2013	242.9	148.5	391.4	99.00	101.50	245.4	146.3	*391.7*	129.30	76.05	102.49	*391.7*
q4 2013	245.4	144.8	390.2	98.50	102.00	249.1	142.0	*391.1*	131.30	73.79	102.35	*391.1*
Sum 2013	**948.8**	**615.6**	**1,564.4**			**955.1**	**609.0**	***1,564.1***	**125.83**	**79.14**	**102.33**	***1,564.1***

(Rounding errors in the table may occur.)

Deflation at the Elementary Level

This example explains how to derive volume estimates of two transactions at the most detailed level (A and B) and how to derive a volume index using an annually weighted Laspeyres-type formula. Annual and quarterly data at current prices of the two transactions from 2010 to 2013 are presented in column 1, with the quarterly split available from q1 2011. On average, transaction A shows a 16.5 percent increase a year, while transaction B declines at a 11.9 percent annual rate: total increase is 1.4 percent a year. The relative size of transactions A and B is reverted after three years. Column 2 contains the elementary price indices for A and B of each quarter compared with the previous year, as explained in equations (1)–(9). Volume estimates for A and B are obtained by price deflation in column 3. For instance, volume estimates of A for the quarters of 2011 are calculated as follows:

q1 2011: (159.7/102.0) × 100 = 156.6
q2 2011: (163.2/102.5) × 100 = 159.2
q3 2011: (167.4/103.0) × 100 = 162.5
q4 2011: (169.7/103.0) × 100 = 164.8.

The same operations are done using the annual data. As explained in this chapter, annual price changes are derived as weighted average of the quarterly indices with weights given by the quarterly volume estimates in column 3. Note that because annual indices are weighted average of quarterly indices, the sum of the quarterly volume estimates corresponds to the independently calculated annual volume figure. This condition is also met for the total aggregate.

Elementary Volume Indices Elementary volume indices are shown in column 4. For the annual data, they are derived implicitly by dividing the annual volume measures in column 3 by the current price value in the previous year. For instance, the annual index for 2011 for transaction A is 643.1/600 = 107.18. For the quarterly data, the elementary volume indices are derived by dividing the quarterly volume measures in column 3 by the rescaled current price value in the previous year (see equation (9)). The quarterly index for q1 2011 for transaction A is 156.6/(600/4) = 104.38.

Laspeyres-Type Volume Indices and Laspeyres-Type Volume Measures in Monetary Terms

The annually weighted Laspeyres-type volume indices in column 5 are calculated as a weighted average of the elementary volume indices in columns 4. The weights are the share at current prices from the previous year. The annual indices are calculated as follows:

2011: 107.18 × (600/1,500) + 96.43 × (900/1,500) = 100.73
2012: 113.05 × (660/1,514.9) + 91.53 × (854.9/1,514.9) = 100.91
2013: 125.83 × (759/1,528.6) + 79.14 × (769.5/1,528.6) = 102.33.

Similar to the annual indices, the quarterly indices are calculated using weights from the previous year. For the quarters of 2011,

q1 2011: 104.38 × (600/1,500) + 98.27 × (900/1,500) = 100.71
q2 2011: 106.15 × (600/1,500) + 96.92 × (900/1,500) = 100.61
q3 2011: 108.35 × (600/1,500) + 95.51 × (900/1,500) = 100.65
q4 2011: 109.84 × (600/1,500) + 95.04 × (900/1,500) = 100.96.

For the quarters of 2012,

q1 2012: 103.00 × (660/1,514.9) + 98.45 × (854.9/1,514.9) = 100.43
q2 2012: 107.19 × (660/1,514.9) + 95.19 × (854.9/1,514.9) = 100.42
q3 2012: 113.35 × (660/1,514.9) + 91.35 × (854.9/1,514.9) = 100.93
q4 2012: 128.68 × (660/1,514.9) + 81.15 × (854.9/1,514.9) = 101.85.

Volume estimates in monetary terms are derived by multiplying the Laspeyres volume indices by the total current price value in the previous year. For 2011 and 2012,

2011:	100.73 × 1,500 = 1,511.0	2012:	100.91 × 1,514.9 = 1,528.7
q1 2011:	100.71 × (1,500/4) = 377.7	q1 2012:	100.43 × (1,514.9/4) = 380.4
q2 2011:	100.61 × (1,500/4) = 377.3	q2 2012:	100.42 × (1,514.9/4) = 380.3
q3 2011:	100.65 × (1,500/4) = 377.4	q3 2012:	100.93 × (1,514.9/4) = 382.3
q4 2011:	100.96 × (1,500/4) = 378.6	q4 2012:	101.85 × (1,514.9/4) = 385.7.

It is easily shown that the sum of the quarterly volume measures in monetary terms corresponds to the corresponding annual volume measure. This condition is verified within each link using the Laspeyres-type formula. In addition, note that the quarterly volume measures in monetary terms are equal to the sum of the deflated elementary transactions shown in column 3 at both annual and quarterly levels.

and the QNA, and that the same price weights are used for all quarters of the year.

- The prices of one particular quarter are not suitable as price weights for volume measures in the ANA, and thus in the QNA, because of seasonal fluctuations and other short-term volatilities in relative prices. Use of weighted annual average prices reduces these effects. Therefore, weighted annual average prices are more representative for the other quarters of the year as well as for the year as a whole.
- The prices of the corresponding quarter of the previous year or the corresponding quarter of a "fixed-base year" are not suitable as price weights for volume measures in the QNA because the derived volume measures only allow the current quarter to be compared with the same quarter of the previous year or years. Series of year-to-year changes do not constitute time series that allow different periods to be compared and cannot be linked together to form such time series. In particular, because they involve using different prices for each quarter of the year, they do not allow different quarters within the same year to be compared. For the same reason, they do not allow the quarters within the same year to be aggregated and compared with their corresponding direct annual estimates. Furthermore, as shown in Chapter 1, changes from the same period in the previous year can introduce significant lags in identifying the current trend in economic activity.
- The prices of the previous quarter are not suitable as price weights for Laspeyres-type volume measures for two reasons:
  a. The use of different price weights for each quarter of the year does not allow the quarters within the same year to be aggregated and compared with their corresponding direct annual estimates.
  b. If the quarter-to-quarter changes are linked together to form a time series, short-term volatility in relative prices may cause the quarterly chain-linked measures to show substantial drift compared to corresponding direct measures.

8.38 In sum, the Laspeyres formula offers a very convenient solution to achieve consistency between ANA and QNA volume measures. As shown in Example 8.2, the sum of annually weighted Laspeyres-type quarterly volume measures (i.e., the quarterly volume estimates at previous year's prices) matches the independently derived Laspeyres-type annual volume measures (i.e., the annual volume estimate at previous year's prices). Moreover, the quarterly volume estimates at previous year's prices are additive within each link (quarter or year). Laspeyres-type indices have these properties because annual and quarterly indices use the same set of weights. Fisher indices, as explained in paragraph 8.76, do not have these properties and need to be reconciled when they are calculated at different frequencies.

8.39 Because Laspeyres-type volume estimates in monetary terms are additive in each period, volume estimates of aggregates can simply be derived as the sum of the elementary volume components (see Example 8.2). As noted at the beginning of this subsection, equation (12) can be used to calculate Laspeyres-type volume indices from both elementary items and aggregates. They can be derived by dividing the sum of elementary volume components for a particular quarter by the (rescaled) aggregate estimate at current prices of the previous year (i.e., by applying equation (1) on the aggregate estimates).

Fisher-Type Formula

8.40 A Fisher index is the geometric mean of the Laspeyres and Paasche indices. A Fisher index is a symmetric index, one that makes equal use of the prices and quantities in both the periods compared and treat them symmetrically. Symmetric indices satisfy a set of desirable properties in index number theory (like the time reversal test) and are to be preferred for economic reasons because they assign equal weight to the two situations being compared.[19]

8.41 Calculation of annually weighted quarterly Fisher-type indices is complicated. They should be derived as symmetric annually weighted Laspeyres-type and Paasche-type quarterly volume indices. However, the (implicit) Paasche-type quarterly index corresponding to the annually weighted Laspeyres-type quarterly index shown in equation (12) has weights from the current quarter (i.e., the current period). This would make the geometric average of Laspeyres and Paasche indices (i.e., the Fisher index) temporally asymmetric, because the weight structure would be taken from the previous year and the current quarter.

8.42 The *2008 SNA* illustrates a solution to calculate symmetric annually weighted quarterly Fisher-type indices (paragraphs 15.53–55). For each pair of consecutive years, Laspeyres-type and Paasche-type quarterly indices are constructed for the last two quarters of the first year and the first two quarters of the second year. The annual value shares are taken from the two years to construct Laspeyres-type and Paasche-type quarterly indices. The annually chained Fisher-type indices are derived as the geometric mean of these two indices. The resulting quarterly Fisher indices need to be benchmarked to annual chain Fisher indices. At the end of the series (when Paasche indices using annual weights from the current year are impossible to calculate), true quarterly Fisher indices can be used to extrapolate the annually chained Fisher-type indices.

8.43 True quarterly Fisher indices provide results that are not exactly consistent with corresponding annual Fisher indices; nevertheless, they are usually close enough when quantity and price weights are relatively stable within the year. When the Fisher formula is chosen in the ANA, the preferred solution for the QNA is to calculate true quarterly Fisher indices (with quarterly weights) and benchmark them to the corresponding annual Fisher indices.[20] The benchmarking process forces the quarterly volume measures to be consistent with the annual ones. Before benchmarking, the difference between the annual and quarterly indices should be investigated carefully to detect possible drifts in the chain quarterly series (see the drift problem in the section "Frequency of Chain-Linking").

8.44 To calculate quarterly Fisher volume indices, quarterly Laspeyres volume indices and quarterly Paasche volume indices[21] are necessary. They can be calculated as follows:

$$LQ^{t-1\to t} = \sum_{j=1}^{n} q_j^{t-1\to t} \cdot \frac{c_j^{t-1}}{\sum_{j=1}^{n} c_j^{t-1}} \tag{14}$$

$$PQ^{t-1\to t} = \left(\sum_{j=1}^{n} \left(q_j^{t-1\to t} \right)^{-1} \cdot \frac{c_j^{t}}{\sum_{j=1}^{n} c_j^{t}} \right)^{-1}, \tag{15}$$

[19]Other symmetric (and superlative) indices are the Walsh and Törnqvist indices. Details on the theory of symmetric and superlative indices can be found in the *Consumer Price Index Manual: Theory and Practice* (ILO and others, 2004a).

[20]The United States adopts this solution to calculate consistent annual and quarterly Fisher price and volume indices in the national accounts (see Parker and Seskin, 1997).

[21] Quarterly Paasche volume indices adopt as weights the current price data for the most recent quarter. Because data for the last quarter may be subject to large revisions, Paasche indices could be more volatile over time than the corresponding Laspeyres indices.

where

t is a generic index for quarters,

$q_j^{t-1\to t}$ is an elementary volume index for transaction j from quarter $t-1$ to t (e.g., the usual quarterly percent change), and

c_j^t is the current price data of transaction j in quarter t.

Defining $q_j^{t-1\to t} = q_j^t / q_j^{t-1}$ and $c_j^t = p_j^t q_j^t$, equations (14) and (15) can be rewritten in the usual notation:

$$LQ^{t-1\to t} = \frac{\sum_j p_j^{t-1} q_j^t}{\sum_j p_j^{t-1} q_j^{t-1}}$$

$$PQ^{t-1\to t} = \frac{\sum_j p_j^t q_j^t}{\sum_j p_j^t q_j^{t-1}},$$

which shows clearly that a Laspeyres volume index weights the quantities from the two periods compared with prices from the previous quarter $t-1$ and a Paasche volume index uses prices from the current quarter t.

8.45 The quarterly Fisher volume index is the geometric mean of the Laspeyres index (equation (14)) and the Paasche index (equation (15)):

$$FQ^{t-1\to t} = \sqrt{LQ^{t-1\to t} \cdot PQ^{t-1\to t}}\ . \tag{16}$$

Differently from the Laspeyres and Paasche indices (but not their combination), a Fisher index satisfies the value decomposition test. The product of a Fisher price index and a Fisher volume index reproduces the change in the value aggregate for any given period (year or quarter). The Fisher price index can therefore be derived implicitly by dividing the current price data with the Fisher volume index (equation (16)).

8.46 The procedure described above applies to annual data as well, replacing quarters with annual observations in equations (14) and (15). However, as mentioned before, the quarterly Fisher indices will not be consistent with the annual ones. The best solution is to benchmark the quarterly chain Fisher indices to the annual chain Fisher indices using a benchmarking technique that preserves the original movements in the quarterly indices, such as the Denton proportional benchmarking method (see Chapter 6 for details). For the most recent quarters, the quarterly Fisher indices can be used to extrapolate the benchmarked quarterly indices.

Calculation of annual and quarterly Fisher indices is given in Examples 8.3 and 8.4.

Chain-Linking in the QNA

General

8.47 The *2008 SNA* recommends moving away from the traditional fixed-base year constant price estimates to chain-linked volume measures. Constant price estimates use the average prices of a particular year (the base period) to weight together the corresponding quantities. Constant price data have the advantage for the users of the component series being additive, unlike alternative volume measures. The pattern of relative prices in the base year, however, is less representative of economic conditions for periods farther away from the base year. Therefore, from time to time, it is necessary to update the base period to adopt weights that better reflect the current conditions (i.e., with respect to production technology and user preferences). Different base periods, and thus different sets of price weights, give different perspectives. When the base period is changed, data for the distant past should not be recalculated (rebased). Instead, to form a consistent time series, data on the old base should be linked to data on the new base.[22] Change of base period and chain-linking can be done with different frequencies: every ten years, every five years, every year, or every quarter/month. The *2008 SNA* recommends changing the base period, and thus conducting the chain-linking, annually.

8.48 The concepts of base, weight, and reference period should be distinguished clearly. In particular, the term "base period" is sometimes used for different concepts. Similarly, the terms "base period," "weight period," and "reference period" are sometimes used interchangeably. In this manual, following the *2008*

[22] This should be done for each series, aggregates as well as subcomponents of the aggregates, independently of any aggregation or accounting relationship between the series. As a consequence, the chain-linked components will not aggregate to the corresponding aggregates. No attempts should be made to remove this "chain discrepancy," because any such attempt implies distorting the movements in one or several of the series.

Example 8.3 Deriving Annual Volume Measures Using Fisher Formula

	Current Prices			Elementary Price Indices (Previous Year = 100)		Elementary Level Deflation		Elementary Volume Indices (Previous Year = 100)		Laspeyres Volume Index (Previous Year = 100)	Paasche Volume Index (Previous Year = 100)	Fisher Volume Index (Previous Year = 100)
	(1)			(2)		(3) = (1)/(2) × 100		(4)		(5)	(6)	(7)
Year	A	B	Total	A	B	A	B	A	B	Total	Total	Total
2010	600.0	900.0	1,500.0							100.00	100.00	100.00
2011	660.0	854.9	1,514.9	102.63	98.50	643.1	867.9	107.18	96.43	100.73	100.84	100.79
2012	759.0	769.5	1,528.5	101.72	98.34	746.2	782.5	113.05	91.53	100.91	101.09	101.00
2013	948.8	615.6	1,564.4	99.34	101.08	955.1	609.0	125.83	79.14	102.33	102.13	102.23

(Rounding errors in the table may occur.)

This example shows the calculation of Fisher indices with annual data. The elementary volume indices in column 4 are aggregated using the Laspeyres and Paasche formulas in columns 5 and 6. The annual Laspeyres indices are the same calculated in Example 8.2. The Paasche indices are calculated as follows:

2011: 1/[(1/107.18) × (660/1,514.9) + (1/96.43) × (854.9/1,514.9)] = 100.84
2012: 1/[(1/113.05) × (759/1,528.6) + (1/91.53) × (769.6/1,528.6)] = 101.09
2013: 1/[(1/125.83) × (948.8/1,564.4) + (1/79.14) × (615.6/1,564.4)] = 102.13,

which is a harmonic average of quantity indices with weights from the current year. The Fisher indices are derived as geometric average of the Laspeyres and Paasche indices in each year:

2011: $\sqrt{100.73 \cdot 100.84} = 100.79$

2012: $\sqrt{100.91 \cdot 101.09} = 101.00$

2013: $\sqrt{102.33 \cdot 102.13} = 102.23 \cdot$

SNA and the current dominant national accounts practice, the following terminology is used:

- *Base period* for (i) the base of the price or quantity ratios being weighted together (e.g., period 0 is the base for the quantity ratio q_j^t / q_j^0) and (ii) the pricing year (the base year) for the constant price data.
- *Weight period* for the period(s) from which the weights are taken. The weight period is equal to the base period for a Laspeyres index and to the current period for a Paasche index. Symmetric index formulas like Fisher and Tornquist have two weight periods—the base period and the current period.
- *Reference period* for the period for which the index series is expressed as equal to 100. The reference period can be changed by simply dividing the index series with its level in any period chosen as the new reference period.

8.49 Chain-linking means constructing long-run price or volume measures by cumulating movements in short-term indices with different base periods. For example, a period-to-period chain-linked index measuring the changes from period 0 to t (i.e., $CI^{0\to t}$) can be constructed by multiplying a series of short-term indices measuring the change from one period to the next as follows:

$$CI^{0\to n} = I^{0\to 1} \cdot I^{1\to 2} \cdot \ldots \cdot I^{t-1\to t} \cdot \ldots \cdot I^{n-1\to n} = \prod_{t=1}^{n} I^{t-1\to t}, \tag{17}$$

where $I^{t-1\to t}$ represents a price or volume index measuring the change from period $t-1$ to t, with period $t-1$ as base and reference period.

8.50 The corresponding run, or time series, of chain-linked index numbers where the links are

Example 8.4 Deriving Quarterly Volume Measures Using Fisher Formula

Quarter	Current Prices			Elementary Price Indices (Previous Quarter = 100)		Elementary Level Deflation		Elementary Volume Indices (Previous Quarter = 100)		Laspeyres Volume Index (Previous Quarter = 100)	Paasche Volume Index (Previous Quarter = 100)	Fisher Volume Index (Previous Quarter = 100)
	(1)			(2)		(3) = (1)/(2) × 100		(4)		(5)	(6)	(7)
	A	B	Total	A	B	A	B	A	B	Total	Total	Total
2010	150.0	225.0	375.0							100.00	100.00	100.00
q1 2011	159.7	218.9	378.6	102.00	99.00	156.6	221.1	104.38	98.27	100.71	100.76	100.74
q2 2011	163.2	213.7	376.9	100.49	98.99	162.4	215.9	101.69	98.62	99.92	99.93	99.92
q3 2011	167.4	210.6	378.0	100.49	100.00	166.6	210.6	102.08	98.55	100.08	100.08	100.08
q4 2011	169.7	211.7	381.4	100.00	101.02	169.7	209.6	101.37	99.51	100.33	100.33	100.33
q1 2012	174.2	204.1	378.3	102.13	96.51	170.6	211.5	100.51	99.90	100.17	100.18	100.18
q2 2012	180.4	201.4	381.8	99.51	102.06	181.3	197.3	104.07	96.68	100.08	100.04	100.06
q3 2012	188.9	192.3	381.2	99.02	99.49	190.8	193.3	105.75	95.97	100.59	100.58	100.58
q4 2012	215.5	171.7	387.2	100.50	100.51	214.4	170.8	113.52	88.84	101.07	101.07	101.07
q1 2013	224.7	166.0	390.7	100.75	99.37	223.0	167.1	103.50	97.29	100.75	100.77	100.76
q2 2013	235.8	156.3	392.1	99.00	101.00	238.2	154.8	105.99	93.22	100.57	100.51	100.54
q3 2013	242.9	148.5	391.4	99.50	100.50	244.1	147.8	103.53	94.54	99.95	99.93	99.94
q4 2013	245.4	144.8	390.2	99.49	100.49	246.6	144.1	101.54	97.03	99.83	99.82	99.83

(Rounding errors in the table may occur.)

Quarterly Fisher indices are calculated in this example. They are derived as aggregation of quarter-to-quarter elementary volume indices using quarterly weights from the previous quarter and the current quarter. Quarter-to-quarter elementary price indices are shown in column 2. These indices are consistent with the elementary price indices from the previous year used for the annually weighted Laspeyres-type indices calculated in Example 8.2 (the q1 2011 link is compared with the average level of 2010). The elementary volume indices from the previous quarter are derived in column 4.

As for the annual Fisher indices derived in Example 8.3, the first step is to derive quarterly Laspeyres volume indices and quarterly Paasche volume indices. Taking 2011 as an example, the Laspeyres volume indices are calculated as follows:

q1 2011: [104.38 × (150/375) + 98.27 × (225.0/375)] = 100.71
q2 2011: [101.69 × (159.7/378.6) + 98.62 × (218.9/378.6)] = 99.92
q3 2011: [102.08 × (163.2/376.9) + 98.55 × (213.7/376.9)] = 100.08
q4 2011: [101.37 × (167.4/378.0) + 99.51 × (210.6/378.0)] = 100.33.

Note that these indices are different from the annually weighted Laspeyres-type indices derived in Example 8.2, which use weights from the previous year. The Paasche volume indices for 2011 are derived using equation (15):

q1 2011: 1/[(1/104.37) × (159.7/378.6) + (1/98.27) × (218.9/378.6)] = 100.76
q2 2011: 1/[(1/101.69) × (163.2/376.9) + (1/98.62) × (213.7/376.9)] = 99.93
q3 2011: 1/[(1/102.08) × (167.4/378.0) + (1/98.55) × (210.6/378.0)] = 100.08
q4 2011: 1/[(1/101.37) × (169.7/381.4) + (1/99.51) × (211.7/381.4)] = 100.33.

As evident, the spread between the Laspeyres and Paasche aggregations is very small because relative shares moves slowly between one quarter and the next. The quarterly Fisher indices for 2011 are derived as follows:

q1 2011: $\sqrt{100.71 \cdot 100.76} = 100.74$

q2 2011: $\sqrt{99.92 \cdot 99.93} = 99.92$

q3 2011: $\sqrt{100.08 \cdot 100.08} = 100.08$

q4 2011: $\sqrt{100.33 \cdot 100.33} = 100.33$.

Annual and quarterly Fisher indices derived in Examples 8.3 and 8.4 are not directly comparable until they are chain-linked. See Example 8.8 for their comparison.

chained together so as to express the full time series on a fixed reference period is given by

$$\begin{cases} CI^{0\to 0} = 1 \\ CI^{0\to 1} = I^{0\to 1} \\ CI^{0\to 2} = I^{0\to 1} \cdot I^{1\to 2} \\ CI^{0\to 3} = I^{0\to 1} \cdot I^{1\to 2} \cdot I^{2\to 3} \\ \\ CI^{0\to n} = \prod_{t=1}^{n} I^{t-1\to t}. \end{cases} \tag{18}$$

8.51 Chain-linked indices do not have a particular base or weight period. Each link $I^{t-1\to t}$ of the chain-linked index in equation (18) has a base period and one or two weight periods, and the base and weight periods are changing from link to link. By the same token, the full run of index numbers in equation (18) derived by chaining each link together does not have a particular base period—it has a fixed reference period.

8.52 The reference period can be chosen freely without altering the rates of change in the series. For the chain-linked index time series in equation (18), period 0 is referred to as the index's reference period and is conventionally expressed as equal to 100. The reference period can be changed simply by dividing the index series with its level in any period chosen as a new reference period. For instance, the reference period for the run of index numbers in equation (18) can be changed from period 0 to period 2 by dividing all elements of the run by $CI^{0\to 2}$ as follows:

$$\begin{cases} CI^{2\to 0} = CI^{0\to 1} / CI^{0\to 2} = 1 / I^{0\to 1} I^{1\to 2} \\ CI^{2\to 1} = CI^{0\to 1} / CI^{0\to 2} = 1 / I^{1\to 2} \\ CI^{2\to 2} = CI^{0\to 2} / CI^{0\to 2} = 1 \\ CI^{2\to 3} = CI^{0\to 3} / CI^{0\to 2} = I^{2\to 3} \\ \\ CI^{2\to n} = CI^{0\to t} / CI^{0\to 2} = \prod_{t=3}^{n} I^{t-1\to t}. \end{cases} \tag{19}$$

8.53 The chain-linked index series in equation (17) and equations (18) and (19) will constitute a period-to-period chain-linked Laspeyres volume index series if, for each link, the short-term indices $I^{t-1\to t}$ are constructed as Laspeyres volume indices with the previous period as base and reference period: that is, if

$$LQ^{t-1\to t} = \sum_i \frac{q_i^t}{q_i^{t-1}} \cdot w_i^{t-1} = \frac{\sum_i p_i^{t-1} \cdot q_i^t}{\sum_i p_i^{t-1} \cdot q_i^{t-1}} = \frac{\sum_i p_i^{t-1} \cdot q_i^t}{C^{t-1}}, \tag{20}$$

where

$LQ^{t-1\to t}$ represents a Laspeyres volume index measuring the volume change from period t –1 to t, with period t – 1 as base and reference period;

p_i^{t-1} is the price of transaction i in period t–1 (the "price weights");

q_i^t is the quantity of transaction i in period t;

w_i^{t-1} is the base period "share weight": that is, the transaction's share in the total value of period t – 1; and

C^{t-1} is the total value at current prices in period t – 1.

8.54 Similarly, the chain-linked index series in equation (17) will constitute a period-to-period chain-linked Fisher volume index series if, for each link, the short-term indices $I^{t-1\to t}$ are constructed as Fisher volume indices with the previous period as base and reference period as in equation (16).

8.55 Any two index series with different base and reference periods can be linked to measure the change from the first year to the last year as follows:

$$CI^{0\to t} = I^{0\to t-h} \cdot I^{t-h\to t}. \tag{21}$$

That is, each link may cover any number of periods. For instance, if in equation (21) t = 10 and h = 5, the resulting linked index ($CI^{0\to 10}$) constitutes a five-year chain-linked annual index measuring the change from year 0 to year 10.

8.56 Growth rates and index numbers computed for series that can take positive, negative, and zero values—such as changes in inventories and crop harvest data—generally are misleading and meaningless. For instance, consider a series for changes in inventories that is –10 in period one and +20 in period two at the average prices of period one. The corresponding volume growth rate between these two periods is –300 percent (= [(20/–10) – 1] • 100), which obviously is both misleading and meaningless. As a consequence, chain volume measures cannot be calculated for these series. The preferred solution to analyze price and volume effects for such series is to calculate their contribution to percent change, as explained later in this section.

8.57 As an alternative, the *2008 SNA* provides a solution to calculate pseudo chain volume series from variables that change sign[23]:

a. identify two associated time series that take only positive values and are such that the difference yield the target series,

b. apply chain-linking to the two series separately, and

c. derive the chain volume series as a difference.

8.58 The chain volume series is called pseudo chain because it is derived as the difference of two chained components, which are not additive by construction. Possible examples are a chain volume series of changes in inventories as a chain volume series of closing inventories less a chain volume series of opening inventories, or a chain volume series of external trade balance as a difference between chain volume series of exports and imports.

Frequency of Chain-Linking

8.59 The *2008 SNA* recommends that chain-linking should not be done more frequently than annually. This is mainly because short-term volatility in relative prices (e.g., caused by sampling errors and seasonal effects) can cause volume measures that are chain-linked more frequently than annually to show substantial drift—particularly so for nonsuperlative index formulas like Laspeyres and Paasche. Similarly, short-term volatility in relative quantities can cause price measures that are chain-linked more frequently than annually to show substantial drift. The purpose of chain-linking is to take into account long-term trends in changes in relative prices, not temporary short-term variations.

8.60 Superlative index formulas, such as the Fisher index formula, are more robust against the drift problem than the other index formulas—as illustrated in Example 8.5. For this reason, a quarterly chain-linked Fisher index may be a feasible alternative to annually chain-linked Laspeyres indices for quarterly data that show little or no short-term volatility. The quarterly chain-linked Fisher index does not aggregate exactly to the corresponding direct annual Fisher index.[24] For chain-linked Fisher indices, consistency between QNA and ANA price and volume measures can only be achieved by deriving the ANA measures from the quarterly measures or by forcing consistency on the data with the help of benchmarking techniques. There is no reason to believe that for nonvolatile series the average of an annually chain-linked Fisher will be closer to a direct annual Fisher index than the average of a quarterly chain-linked Fisher.

8.61 When quarterly weights are preferred, chain-linking should only be applied to Fisher-type indices. Because seasonally adjusted data are less subject to volatility in relative prices and volumes than unadjusted data, quarterly chain Fisher indices of seasonally adjusted data can be expected to produce satisfactory results in most circumstances. On the other hand, quarterly Fisher indices of unadjusted data should always be benchmarked to corresponding annual Fisher indices to avoid possible drifts.

8.62 For Laspeyres-type volume measures, consistency between QNA and ANA provides an additional reason for not chain-linking more frequently than annually. Consistency between quarterly data and corresponding direct annual indices requires that the same price weights are used in the ANA and the QNA, and consequently that the QNA should follow the same change of base year/chain-linking practice as in the ANA. Under those circumstances, the AO linking technique presented in the next section ensures that the quarterly data aggregate exactly to the corresponding direct index. Moreover, under the same circumstances, any difference between the average of the quarterly data and the direct annual index caused by the QO technique can be resolved through benchmarking.

8.63 Thus, when the Laspeyres formula is used in the ANA, chain-linked Laspeyres-type quarterly volume measures can be derived consistently by compiling quarterly estimates at the average prices of the

[23] See *2008 SNA* (paragraph 15.62).

[24] Neither does the annually linked, nor the fixed-based, Fisher index.

Example 8.5 Frequency of Chain-Linking and the Problem of "Drift" in the Case of Price and Quantity Oscillation

Observation/Quarter	Quarter 1	Quarter 2	Quarter 3	Quarter 4
Price item A	2	3	4	2
Price item B	5	4	2	5
Quantities item A	50	40	60	50
Quantities item B	60	70	30	60
Total value	400	400	300	400
Volume Indices	**q1**	**q2**	**q3**	**q4**
Fixed-based Laspeyres (q1-based)	100.0	107.5	67.5	100.0
Fixed-based Paasche (q1-based)	100.0	102.6	93.8	100.0
Fixed-based Fisher (q1-based)	100.0	105.0	79.5	100.0
Quarterly chain-linked Laspeyres	100.0	107.5	80.6	86.0
Quarterly chain-linked Paasche	100.0	102.6	102.6	151.9
Quarterly chain-linked Fisher	100.0	105.0	90.9	114.3

(Rounding errors in the table may occur.)

Fixed-Based Laspeyres Index:

$$I_L^{q1\to t} = \frac{\sum_j p_j^{q1} q_j^t}{\sum_j p_j^{q1} q_j^{q1}} \equiv \frac{\sum_j p_j^{q1} q_j^t}{c^{q1}}$$

$$\begin{aligned} I_L^{q1\to q2} &= [(2\times 40+5\times 70)/400]\times 100 = 107.5 \\ I_L^{q1\to q3} &= [(2\times 60+5\times 30)/400]\times 100 = 67.5 \\ I_L^{q1\to q4} &= [(2\times 50+5\times 60)/400]\times 100 = 100.0 \end{aligned}$$

Fixed-Based Paasche Index:

$$I_P^{q1\to t} = \frac{\sum_j p_j^t q_j^t}{\sum_j p_j^t q_j^{q1}} \equiv \frac{c^t}{\sum_j p_j^t q_j^{q1}}$$

$$\begin{aligned} I_P^{q1\to q2} &= [400/(3\times 50+4\times 60)]\times 100 = 102.6 \\ I_P^{q1\to q3} &= [300/(4\times 50+2\times 60)]\times 100 = 93.8 \\ I_P^{q1\to q4} &= [400/(2\times 50+5\times 60)]\times 100 = 100.0 \end{aligned}$$

Quarterly Chain-Linked Laspeyres Index:

$$CL_L^{q1\to t} = \prod_{\tau=1}^{t} I_L^{(\tau-1)\to\tau} = \prod_{\tau=1}^{t} \frac{\sum_j p_j^{\tau-1} q_j^{\tau}}{\sum_j p_j^{\tau-1} q_j^{\tau-1}}$$

$$\begin{aligned} CL_L^{q1\to q2} &= I_L^{q1\to q2} = 107.5 \\ CL_L^{q1\to q3} &= CL_L^{q1\to q2}\cdot[(3\times 60+4\times 30)/400] = 80.6 \\ CL_L^{q1\to q4} &= CL_L^{q1\to q3}\cdot[(4\times 50+2\times 60)/300] = 86.0 \end{aligned}$$

Quarterly Chain-Linked Paasche Index:

$$CL_P^{q1\to t} = \prod_{\tau=1}^{t} I_P^{(\tau-1)\to\tau} = \prod_{\tau=1}^{t} \frac{\sum_j p_j^{\tau} q_j^{\tau}}{\sum_j p_j^{\tau} q_j^{\tau-1}}$$

$$\begin{aligned} CL_P^{q1\to q2} &= I_P^{q1\to q2} = 102.6 \\ CL_P^{q1\to q3} &= CL_P^{q1\to q2}\cdot[300/(4\times 40+2\times 70)] = 102.6 \\ CL_P^{q1\to q4} &= CL_P^{q1\to q3}\cdot[400/(2\times 60+5\times 30)] = 151.9 \end{aligned}$$

In this example, the prices and quantities in quarter 4 are the same as those in quarter 1: that is, the prices and quantities oscillate rather than move as a trend. The fixed-base indices correspondingly show identical values for q1 and q4, but the chain-linked indices show completely different values. This problem can also occur in annual data if prices and quantities oscillate and may make annual chaining inappropriate in some cases. It is more likely to occur in data for shorter periods, however, because seasonal and irregular effects cause those data to be more volatile.

Furthermore, observe that the differences between the q1 and q4 data for the quarterly chain-linked Laspeyres and the quarterly chain-linked Paasche indices are in opposite directions; and, correspondingly, that the quarterly chain-linked Fisher index drifts less. This is a universal result. This example is based on Szultc (1983).

previous year. These quarterly volume measures for each year should then be linked to form long, consistent time series—the result constitutes an annually chained quarterly Laspeyres index. Alternative linking techniques for such series are discussed section "Chain-Linking Techniques for Quarterly Data."

8.64 When relative prices are subject to large swings, the quality of chain-linking deteriorates. This may happen due to the effects of oil shocks or in high-inflation situations. In such cases, updating the weight period every year may also produce drift effects like the one described in Example 8.5, and produce inaccurate volume estimates. In such cases, constant price data based on a regular update of the base year (e.g., every five years) are preferable over chain-linking.

Choice of Index Number Formulas for Chain-Linking

8.65 The *2008 SNA* recommends compiling annually chain-linked price and volume measures, preferably using superlative index number formulas such as the Fisher and Tornquist formulas. The rationale for this recommendation is that index number theory shows that annually chain-linked Fisher and Tornquist indices will most closely approximate the theoretically ideal index. Fisher and Tornquist indices will, in practice, yield almost the same results, and Fisher—being the geometric average of a Laspeyres index and a Paasche index—will be within the upper and lower bounds provided by those two index formulas. Most countries that have implemented chain-linking in their national accounts, however, have adopted the annually chain-linked Laspeyres formula for volume measures.[25]

8.66 Annual chain-linking of quarterly data implies that each link in the chain is constructed using the chosen index number formula with the average of the previous year ($y-1$) as base and reference period. The resulting short-term quarterly indices must subsequently be linked to form long, consistent time series expressed on a fixed reference period. Alternative annual linking techniques for such series are discussed in section "Chain-Linking Techniques for Quarterly Data." The annually weighted Laspeyres-type quarterly volume index formula for each short-term link is given in equation (12). While the discussion here focuses on Laspeyres indices, the techniques illustrated and the issues discussed are applicable to all annually chain-linked index formulas.

8.67 Countries have opted for an annually chained Laspeyres formula instead of an annually chained Fisher formula[26] for volume measures mainly for several practical reasons:

a. Experience and theoretical studies indicate that annual chain-linking tends to reduce index number spread to the degree that the exact choice of index number formula assumes less significance (see, e.g., *2008 SNA*, paragraph 15.41).

b. The Laspeyres formula is simpler to work with and to explain to users than the Fisher index. For instance, time series of annually chained Laspeyres indices can be converted easily into series of data valued at the average prices of the previous year that are additive if corresponding current price data are made available. This feature makes it easy for users to construct their own aggregates from published data.

c. The annually chained quarterly Fisher index does not aggregate to the corresponding direct annual index.[27] The annually chained Laspeyres index, linked using the AO technique discussed in the next subsection, does.[28]

d. The Fisher formula is not consistent in aggregation within each link; it is only approximately

[25] Currently, only the United States and Canada have opted for a chain-linked Fisher index. The United States adopted an annually chain-linked quarterly Fisher-type formula in 1996, using annual weights in both the Laspeyres and the Paasche part of the index. In 1999, the United States moved to a standard quarterly chain Fisher index that is benchmarked to the corresponding annual Fisher index. In 2001, Canada implemented a quarterly chain Fisher volume index as the official volume measure of the expenditure-based GDP (see Chevalier, 2003).

[26] For example, the European Union's statistical office (Eurostat) requires member states to provide annually chain-linked volume measures using the Laspeyres formula.

[27] Neither does the quarterly chain linked, nor the fixed-based, quarterly Fisher index.

[28] However, this may not be a decisive argument for two reasons. First, simulations indicate that, in practice, the difference between a direct annual Fisher and the average of a quarterly Fisher may often not be significant and may easily be removed using benchmarking techniques (see Example 8.8). Second, the one-quarter overlap technique for Laspeyres indices also introduces differences between direct annual indices and the average of quarterly indices.

consistent in aggregation (i.e., the sum of volume estimates of two components in monetary terms is not equal to the volume estimate of their sum).

e. The formulas for computing contribution to percent change are easier for data based on the annually chained Laspeyres formula than for data based on the Fisher index (see section "Contributions to Percent Change from Chain-Linked Measures").

f. The Laspeyres formula, in contrast, is additive within each link (prior to chain-linking). This makes it easier to combine chain-linking with compilation analytical tools like SUT and input–output (IO) tables that require additivity of components.

g. Chain volume measures in monetary terms[29] based on the annually chained Laspeyres formula will be additive in the reference year and the subsequent year,[30] while volume measures based on the Fisher index will not.

8.68 When the Fisher formula is chosen, true Fisher indices should be calculated in both ANA and QNA, and the quarterly indices should be benchmarked to the annual indices. By constraining the quarterly indices to the annual ones, the benchmarking process makes sure that the Fisher-based QNA volume measures are free from possible drifts generated by seasonality or short-term volatility in the quarterly data.

Chain-Linking Techniques for Quarterly Data

8.69 Two alternative techniques for chain-linking of annually weighted quarterly data are usually applied: the annual overlap (AO) technique and the one-quarter overlap (QO) technique. While standard price statistics compilation exclusively uses the QO technique, the AO technique may be more practical for Laspeyres-type volume measures in the national accounts because it results in data that aggregate exactly to the corresponding direct annual index. In contrast, the QO technique does not result in data that aggregate exactly to the corresponding direct annual index. The QO technique, however, provides the smoothest transition between each link, while the AO technique may introduce a step between each link. The two linking techniques are presented below.[31]

8.70 In addition to these two conventional chain-linking techniques, a third technique sometimes is used based on changes from the same period in the previous year (the "over-the-year" technique). The over-the-year technique corresponds to the QO technique applied to each individual quarter of the year. In situations with strong changes in relative quantities and relative prices, the over-the-year technique can result in distorted seasonal patterns in the linked series. For this reason, the over-the-year technique should be avoided in the QNA.

The Annual Overlap Technique

8.71 The AO technique implies compiling estimates for each quarter at the weighted annual average prices of the previous year. The annual data at previous year's prices provide the linking factors to scale the quarterly data upward or downward. The AO technique requires quarterly volume measures at previous year's prices and annual current price data. It consists of the following three steps:

Step 1: Calculate quarterly volume indices from the previous year

Quarterly volume indices for a given quarter are derived as relative change between the volume estimate at previous year's prices for the quarter and the (rescaled) current price data in the previous year. In mathematical terms,

$$q^{y-1\to(s,y)} = \frac{k^{y-1\to(s,y)}}{C^{y-1}/4} \quad \text{for } y = 2,3,\ldots \quad \text{and } s = 1,\ldots,4, \tag{22}$$

where

$k^{y-1\to(s,y)}$ is the volume measure in quarter s of year y at the prices of the previous year and C^{y-1} is the current price data for year $y-1$.

[29] See discussion in section "Presentation of Chain-Linked Measures" on presenting chain volume measures in monetary terms.

[30] See Example 8.4 for an illustration of the nonadditivity property of most index number formulas besides the fixed-based Laspeyres formula.

[31] Annex 6.1 compares the annual overlap (AO) and one-quarter overlap techniques formally and provides an interpretation of the possible step in the AO technique.

Step 2: Link the quarterly volume indices using annual overlaps

The quarterly chain indices $q^{1\to(s,y)}$ are derived using the recursion

$$q^{1\to(s,y)} = Q^{1\to 2} \cdot Q^{2\to 3} \cdot \ldots \cdot Q^{t-1\to t} \cdot \ldots \cdot Q^{y-2\to y-1} \cdot q^{y-1\to(s,y)} \cdot 100\,, \qquad (23)$$

where

$$Q^{t-1\to t} = \frac{K^{t-1\to t}}{C^{t-1}} \qquad (24)$$

are the annual links (i.e., the annual growth rates), with

$K^{t-1\to t}$ being the volume measure of year t at the prices of year $t-1$ and

C^{y-1} is the current price data for year $y-1$.

Step 3: Re-reference the quarterly chain series to a chosen year

By construction, the reference year of the quarterly chain indices $q^{1\to(s,y)}$ is year 1. It is possible to re-reference the chain series to any other year, denoted by r, by dividing the chain series with the corresponding annual chain index: that is,

$$q^{r\to(s,y)} = \frac{q^{1\to(s,y)}}{Q^{1\to r}} \cdot 100 \text{ for } y = 2,3,\ldots,\; s = 1,\ldots,4, \text{ and } 1 \le r \le y\,, \qquad (25)$$

where

$Q^{1\to r} = Q^{1\to 2} \cdot Q^{2\to 3} \cdot \ldots \cdot Q^{r-1\to r}$ is the annual chain index for year r.

The chain indices $q^{r\to(s,y)}$ can be expressed in monetary terms by multiplying the entire series by the (rescaled) annual current price data of the reference year.

Example 8.6 provides an illustration of the AO technique.

The One-Quarter Overlap Technique

8.72 The QO technique requires compiling estimates for the fourth quarter of each year (e.g., the overlap quarter) at the weighted annual average prices of the current year in addition to estimates at the average prices of the previous year. The ratio between the estimates for the fourth quarter at the average prices of the previous year and at the average prices of the current year provides the linking factor to scale the quarterly data up or down. Similar to the AO technique, the QO technique is calculated in three steps:

Step 1: Calculate quarterly volume indices from the fourth quarter of the previous year

Quarterly volume indices for a given quarter are derived as relative change between the volume estimate at previous year's prices of that quarter and the estimate of the fourth quarter in the previous year at the average prices of the same year. In mathematical terms,

$$q^{(4,y-1)\to(s,y)} = \frac{k^{y-1\to(s,y)}}{cy^{(4,y-1)}} \text{ for } y = 3,4,\ldots,\; s = 1,\ldots,4, \qquad (26)$$

with

$$cy^{(4,y-1)} = \sum_j P_j^{y-1} q_j^{(4,y-1)}$$

aggregating the quantities of the fourth quarter of year $y-1$ using the average prices of the whole year $y-1$, which differs from the current price data $c^{(4,y-1)}$ where the quarterly quantities are valued at the prices of the fourth quarter.[32]

Step 2: Link the quarterly volume indices using quarterly overlaps

The quarterly chain indices $q^{1\to(s,y)}$ using the QO technique are derived using the recursion

$$q^{1\to(s,y)} = q^{1\to(4,2)} \cdot q^{(4,2)\to(4,3)} \cdot \ldots \cdot q^{(4,t-1)\to(4,t)} \cdot \ldots \cdot q^{(4,y-1)\to(s,y)} \cdot 100\,, \qquad (27)$$

[32] Usually, there is no information on the price and volume development for the first year of the series (i.e., volume estimates for year 1 at the prices of year 0 are unavailable). As a consequence, it is not possible to derive a quarterly link from the fourth quarter of year 1. By convention, the one-quarter overlap technique uses the same links used in the annual overlap approach for year 2 (see formula (22)).

Example 8.6 Chain-Linking Annually Weighted Laspeyres-Type Indices: Annual Overlap Technique

Year/ Quarter	Current Prices			Previous Year's Prices			Volume Measures (Previous Year = 100)			Chain-Indices with Annual Overlap (2010 =100)			Chain Volume Measures with Annual Overlap in Monetary Terms			
	(1)			(2)			Step 1			Step 2			Step 3			
	A	B	Sum	A	B	Sum	A	B	Sum	A	B	Sum	A	B	Sum	Discrepancies
2010	600.0	900.0	1,500.0							100.00	100.00	100.00	600.0	900.0	1,500.0	*0.0*
2011	660.0	854.9	1,514.9	643.1	867.9	1,511.0	107.18	96.43	100.73	107.18	96.43	100.73	643.1	867.9	1,511.0	*0.0*
2012	759.0	769.5	1,528.5	746.2	782.5	1,528.7	113.05	91.53	100.91	121.17	88.27	101.65	727.0	794.4	1,524.7	*–3.3*
2013	948.8	615.6	1,564.4	955.1	609.0	1,564.1	125.83	79.14	102.33	152.47	69.86	104.01	914.8	628.7	1,560.2	*–16.6*
q1 2011	159.7	218.9	378.6	156.6	221.1	377.7	104.38	98.27	100.71	104.38	98.27	100.71	156.6	221.1	377.7	*0.0*
q2 2011	163.2	213.7	376.9	159.2	218.1	377.3	106.15	96.92	100.61	106.15	96.92	100.61	159.2	218.1	377.3	*0.0*
q3 2011	167.4	210.6	378.0	162.5	214.9	377.4	108.35	95.51	100.65	108.35	95.51	100.65	162.5	214.9	377.4	*0.0*
q4 2011	169.7	211.7	381.4	164.8	213.8	378.6	109.84	95.04	100.96	109.84	95.04	100.96	164.8	213.8	378.6	*0.0*
q1 2012	174.2	204.1	378.3	170.0	210.4	380.4	103.00	98.45	100.43	110.39	94.94	101.17	165.6	213.6	379.4	*–0.2*
q2 2012	180.4	201.4	381.8	176.9	203.4	380.3	107.19	95.19	100.42	114.88	91.79	101.15	172.3	206.5	379.3	*–0.5*
q3 2012	188.9	192.3	381.2	187.0	195.2	382.3	113.35	91.35	100.93	121.49	88.09	101.67	182.2	198.2	381.3	*–0.8*
q4 2012	215.5	171.7	387.2	212.3	173.4	385.7	128.68	81.15	101.85	137.91	78.25	102.60	206.9	176.1	384.8	*–1.8*
q1 2013	224.7	166.0	390.7	223.6	166.0	389.6	117.83	86.29	101.95	142.77	76.17	103.63	214.2	171.4	388.6	*–3.1*
q2 2013	235.8	156.3	392.1	237.0	154.8	391.7	124.89	80.44	102.52	151.33	71.01	104.20	227.0	159.8	390.8	*–4.0*
q3 2013	242.9	148.5	391.4	245.4	146.3	391.7	129.30	76.05	102.49	156.68	67.13	104.18	235.0	151.0	390.7	*–4.6*
q4 2013	245.4	144.8	390.2	249.1	142.0	391.1	131.30	73.79	102.35	159.09	65.14	104.03	238.6	146.6	390.1	*–4.9*
Sum of Quarterly Values																
2011	660.0	854.9	1,514.9	643.1	867.9	1,511.0	107.18	96.43	100.73	107.18	96.43	100.73	643.1	867.9	1,511.0	*0.0*
2012	759.0	769.5	1,528.5	746.2	782.5	1,528.7	113.05	91.53	100.91	121.17	88.27	101.65	727.0	794.4	1,524.7	*–3.3*
2013	948.8	615.6	1,564.4	955.1	609.0	1,564.1	125.83	79.14	102.33	152.47	69.86	104.01	914.8	628.7	1,560.2	*–16.6*

(Rounding errors in the table may occur.)

This example shows how to calculate chain Laspeyres-type volume indices and chain Laspeyres-type volume measures expressed in monetary terms using the annual overlap technique. Calculations are done for annual and quarterly data separately. Columns 1 and 2 display the data at current prices and at the average prices of the previous year derived in Example 8.2. The annual overlap technique consists of three steps.

Step 1. Derive volume indices from the previous year

For each year and quarter, compile volume indices with the previous year as base period. These are the links of the chain volume series. They are obtained by dividing the estimate at previous year's prices (column 2) by the estimate at current prices in the previous year (column 1). For quarterly data, the current price data from the previous year is divided by 4 to rescale the value to be comparable on a quarterly basis. For the total,

2011:	(1,511.0/1,500.0) × 100 = 100.73	2012:	(1,528.7/1,514.9) × 100 = 100.91
…		…	
q1 2011:	[377.7/(1,500.0/4)] × 100 = 100.71	q1 2012:	[80.36/(1,514.9/4)] × 100 = 100.43
q2 2011:	[377.3/(1,500.0/4)] × 100 = 100.61	q2 2012:	[380.30/(1,514.9/4)] × 100 = 100.42
…		…	

Step 2. Chain-link volume indices with the annual overlap technique

The volume indices obtained at Step 1 are chain-linked using the annual overlap technique. Each volume index is multiplied by the average of the chain-linked index in the previous year. Note that quarterly data are linked through annual data, which is the distinctive feature of the annual overlap approach. For 2011, the chain volume indices remain the same (the previous year's index is 100). Calculations for 2012 and 2013 are as follows:

2012:	(100.91 × 100.73)/100 = 101.65	2013:	(102.33 × 101.65)/100 = 104.01
q1 2012:	(100.43 × 100.73)/100 = 101.17	q1 2013:	(101.95 × 101.65)/100 = 103.63
q2 2012:	(100.42 × 100.73)/100 = 101.15	q2 2013:	(102.52 × 101.65)/100 = 104.20
…			…

Step 3. Calculate the chain volume series in monetary terms

For annual data, the chain-linked indices are rescaled using the annual value at current prices in the reference year. For quarterly data, the annual value of the reference year is divided by 4. In this example, the reference year is 2010.

2011:	(100.73 × 1,500.0)/100 = 1,511.0
2012:	(101.65 × 1,500.0)/100 = 1,524.7
2013:	(104.01 × 1,500.0)/100 = 1,560.2
q1 2011:	[100.71 × (1,500.0/4)]/100 = 377.7
q2 2011:	[100.61 × (1,500.0/4)]/100 = 377.3
…	
q1 2012:	[101.17 × (1,500.0/4)]/100 = 379.4
q2 2012:	[101.15 × (1,500.0/4)]/100 = 379.3
…	
q1 2013:	[103.63 × (1,500.0/4)]/100 = 388.6
q2 2013:	[104.20 × (1,500.0/4)]/100 = 390.8
…	

Note that the sum of the quarterly chain volume data for each year is equal to the annual chain volume data. This property is only guaranteed by using annually weighted Laspeyres-type quarterly volume indices that are chained with the annual overlap technique. However, the sum of chain-linked data of transactions A and B does not match the chain-linked total data (except in the year following the reference period). Discrepancies are shown in the last column of the table. Chain-linked components never add up to chain-linked aggregates, as discussed in the section on lack of additivity.

where

$$q^{(4,t-1)\rightarrow(4,t)} = \frac{k^{(4,t)}}{cy^{(4,t-1)}} \quad (28)$$

are the quarterly links from the fourth quarter of consecutive years and

$q^{1\rightarrow(4,2)}$ is the quarterly link from the first year, as derived in equation (23).

Step 3: Re-reference the quarterly chain series to a chosen year

This step is equal to Step 3 presented above for the AO technique. For comparison with the annual data, the same reference year is usually chosen. Example 8.7 provides a numerical illustration of the QO technique.

8.73 The QO technique preserves better the time-series properties of the chain volume series. In using quarterly overlaps, it provides the smoothest transition between the fourth quarter of one year and the first quarter of the next year. However, when Laspeyres-type volume measures are implemented, compilers and users of QNA may prefer the use of the AO technique for several practical reasons:

a. The QO technique requires the calculation of quarterly data at the prices of the current year and at the prices of the previous year, while the AO technique requires only estimates at the prices of the previous year.

b. Estimates at the prices of the current year are usually not published, and therefore users are unable to replicate the calculation of chain volume measures using the QO technique or, more importantly, calculate chain-linked estimates of different aggregations.

c. To preserve consistency with the annual data, the QO technique requires an additional step of benchmarking. Benchmarking may also be necessary to remove a possible drift introduced by linking to the fourth quarter of each year. Furthermore, by using benchmarking, the original changes of q1–q3 derived from the QO technique are all adjusted to fit the given annual totals. The benchmarking step may affect the statistical properties of the chained series, with possible impact on the measurement of business-cycle peaks and troughs.

d. The AO technique may give similar results to the QO technique in many circumstances. It can be shown that the two techniques differ for an annual factor that depends on the difference between the quantity shares in the fourth quarter and the quantity shares of the whole year (see Annex 8.1). Relative quantity weights of macroeconomic aggregates tend to be stable within a year, especially when they are expressed in seasonally adjusted form.

e. Following a general principle of consistency of the system of national accounts, it is preferable to use the same methodology to derive annual and quarterly volume estimates. When Laspeyres-type indices are used in the national accounts, the AO technique for quarterly data is the only method for chain-linking annual data.

8.74 Quarterly Fisher indices should always be chain-linked using the QO technique. Differently from annually weighted Laspeyres indices, quarterly and annual Fisher indices are never consistent and there is no reason to adopt the AO approach for the sake of consistency. The quarterly chain Fisher indices should be benchmarked to annual chain Fisher indices to avoid possible drifts in the quarterly data, especially when the data include seasonal effects or short-term volatility. Example 8.8 provides a numerical illustration of benchmarking quarterly chain Fisher indices to annual ones.

8.75 To conclude, the QO technique with benchmarking to remove any discrepancies with the annual data provides the best results for chain-linking. However, when Laspeyres-type volume measures are implemented in both ANA and QNA (i.e., when a system of annual and quarterly volume estimates at previous year's prices is implemented), the AO technique can be used to obtain quarterly chain-linked data that are automatically consistent with their annual counterparts. Experimental tests (on a continuous basis) should be performed to verify that the AO technique does not introduce artificial steps between years in the chain-linked series.

8.76 On the other hand, quarterly Fisher indices are never automatically consistent with their annual counterparts and should always be linked with the QO technique to preserve the best quality time-series characteristics of such series. When consistency is required with the annual data, benchmarking should be used to remove any resulting discrepancies between quarterly and annual Fisher indices. Quarterly Fisher indices may contain nonnegligible drifts when the formula is applied to quarterly data containing seasonal effects and short-term volatility.

Example 8.7 Chain-Linking Annually Weighted Laspeyres-Type Indices: The One-Quarter Overlap Technique

Year/ Quarter	Current Year's Prices			Previous Year's Prices			Volume Measures (q4 Previous Year = 100)			Chain-Indices with One-Quarter Overlap (2010 = 100)			Chain Volume Measures with One-Quarter Overlap in Monetary Terms			
	(1)			(2)			Step 1			Step 2			Step 3			
	A	B	Sum	A	B	Sum	A	B	Sum	A	B	Sum	A	B	Sum	*Discrepancies*
2010	600.0	900.0	1,500.0													
2011	660.0	854.9	1,514.9	643.1	867.9	1,511.0										
2012	759.0	769.5	1,528.5	746.2	782.5	1,528.7										
2013	948.8	615.6	1,564.4	955.1	609.0	1,564.1										
q1 2011	160.7	217.8	378.5	156.6	221.1	377.7	104.38	98.27	100.71	104.38	98.27	100.71	156.6	221.1	377.7	*0.0*
q2 2011	163.4	214.8	378.2	159.2	218.1	377.3	106.15	96.92	100.61	106.15	96.92	100.61	159.2	218.1	377.3	*0.0*
q3 2011	166.8	211.7	378.5	162.5	214.9	377.4	108.35	95.51	100.65	108.35	95.51	100.65	162.5	214.9	377.4	*0.0*
q4 2011	169.1	210.6	379.7	164.8	213.8	378.6	109.84	95.04	100.96	109.84	95.04	100.96	164.8	213.8	378.6	*0.0*
q1 2012	172.9	206.9	379.8	170.0	210.4	380.4	100.51	99.90	100.17	110.39	94.94	101.13	165.6	213.6	379.2	*0.0*
q2 2012	179.9	200.1	380.0	176.9	203.4	380.3	104.59	96.58	100.15	114.88	91.79	101.11	172.3	206.5	379.2	*–0.3*
q3 2012	190.2	192.0	382.2	187.0	195.2	382.3	110.61	92.69	100.67	121.49	88.09	101.63	182.2	198.2	381.1	*–0.7*
q4 2012	216.0	170.6	386.5	212.3	173.4	385.7	125.56	82.34	101.59	137.91	78.25	102.56	206.9	176.1	384.6	*–1.7*
q1 2013	222.1	167.8	389.9	223.6	166.0	389.6	103.53	97.33	100.79	142.77	76.17	103.37	214.2	171.4	387.6	*–2.1*
q2 2013	235.4	156.4	391.9	237.0	154.8	391.7	109.73	90.74	101.35	151.33	71.01	103.94	227.0	159.8	389.8	*–3.0*
q3 2013	243.7	147.9	391.6	245.4	146.3	391.7	113.61	85.78	101.33	156.68	67.13	103.92	235.0	151.0	389.7	*–3.7*
q4 2013	247.5	143.5	391.0	249.1	142.0	391.1	115.36	83.24	101.18	159.09	65.14	103.77	238.6	146.6	389.2	*–4.0*
Sum of Quarterly Values																
2011	660.0	854.9	1,514.9	643.1	867.9	1,511.0	107.18	96.43	100.73	107.18	96.43	100.73	643.1	867.9	1,511.0	*0.0*
2012	759.0	769.5	1,528.5	746.2	782.5	1,528.7	110.32	92.88	100.64	121.17	88.27	101.61	727.0	794.4	1,524.1	*–2.7*
2013	948.8	615.6	1,564.4	955.1	609.0	1,564.1	110.55	89.27	101.16	152.47	69.86	103.75	914.8	628.7	1,556.3	*–12.7*

(Rounding errors in the table may occur.)

This example shows how to calculate chain Laspeyres-type volume indices and chain Laspeyres-type volume measures expressed in monetary terms using the one-quarter overlap technique. Because the method uses quarterly links, this method applies only to quarterly data. Column 1 displays the data at the average prices of the same year. At the annual level, they are equal to the current price data. Quarterly data are different because quantities are valued at the average prices of the whole year and not at the prices of each quarter. Column 2 shows the estimates at previous year's prices shown in Example 8.6.

Step 1. Derive volume indices from the fourth quarter in the previous year

For each quarter, compile volume indices with the fourth quarter in the previous year as base period. These are the links of the chain volume series. They are obtained dividing the estimate at previous year's prices (column 2) by the estimate of the fourth quarter in the previous year valued at the average prices of the previous year (column 1). Because there is no quarterly data for 2010, the 2011 link is derived using the annual overlap technique as in the previous example. Instead, for 2012 and 2013, the volume indices for the total are calculated as follows:

q1 2012:	$(380.4/379.7) \times 100 = 100.17$	q1 2013:	$(389.6/386.5) \times 100 = 100.79$
q2 2012:	$(380.3/379.7) \times 100 = 100.15$	q2 2013:	$(391.7/386.5) \times 100 = 101.35$
…		…	

Step 2. Chain-link volume indices with the one-quarter overlap technique

The volume indices obtained at Step 1 are chain-linked using the one-quarter overlap technique. Each volume index is multiplied by the chain-linked index of the fourth quarter in the previous year. Differently from the annual overlap approach, the link is given by the fourth quarter of each year (and not the whole year). Calculations for 2012 and 2013 are as follows:

q1 2012:	(100.17 × 100.96)/100 = 101.13	q1 2013:	(100.79 × 102.56)/100 = 103.37
q2 2012:	(100.15 × 100.96)/100 = 101.11	q1 2013:	(101.35 × 102.56)/100 = 103.94
…			

Step 3. Calculate the chain volume series in monetary terms

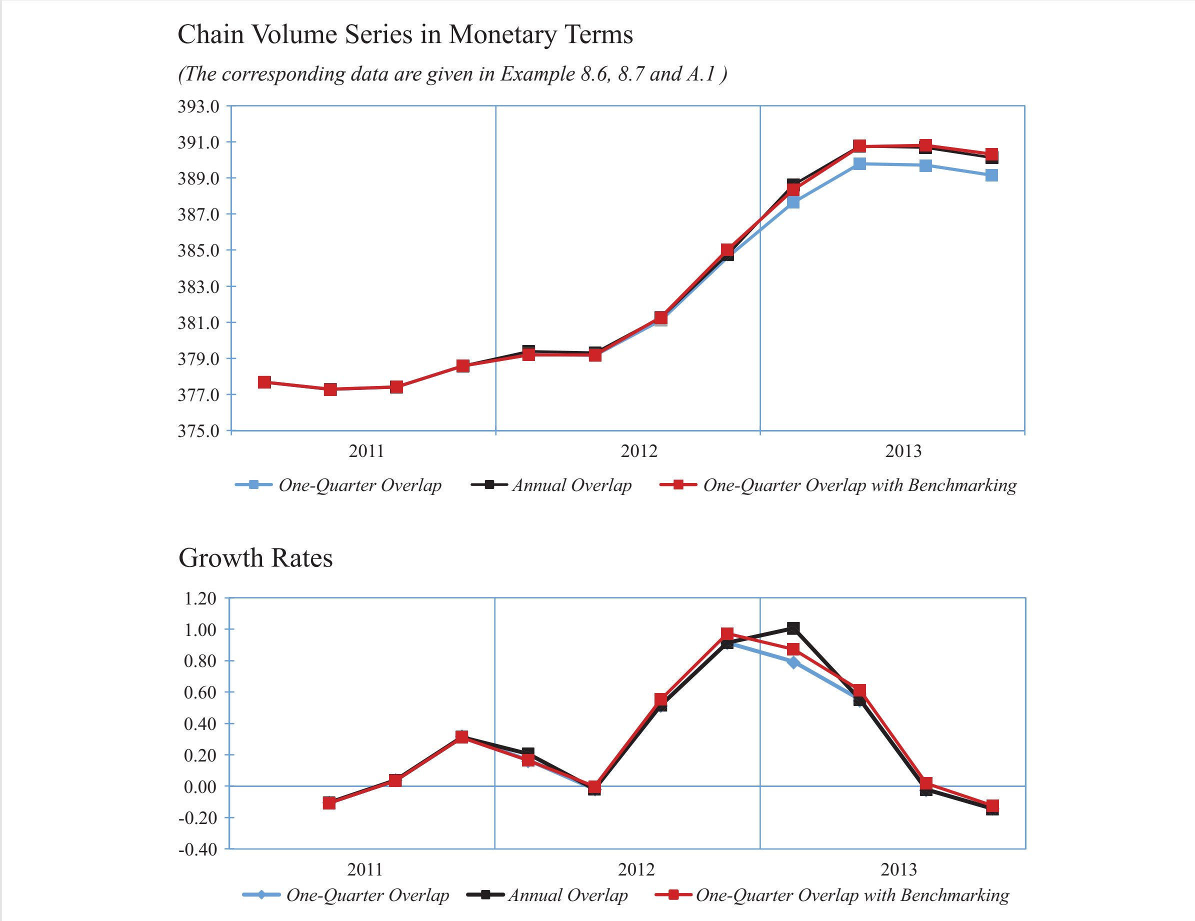
For consistency with the annual overlap approach, the quarterly chain indices are rescaled using the annual value at current prices in 2010 (i.e., the reference year is 2010).

q1 2011:	[100.71 × (1,500.0/4)]/100 = 377.7
q2 2011:	[100.61 × (1,500.0/4)]/100 = 377.3
…	
q1 2012:	[101.13 × (1,500.0/4)]/100 = 379.2
q2 2012:	[101.11 × (1,500.0/4)]/100 = 379.2
…	
q1 2013:	[103.37 × (1,500.0/4)]/100 = 387.6
q2 2013:	[103.94 × (1,500.0/4)]/100 = 389.8
…	

Using the quarterly overlap technique, the sum of the quarterly chain volume data for each year does not match the annual chain volume data. In fact, the quarterly sum for 2012 and 2013 (1,524.1 and 1,556.3, respectively) are different from the annual chain volume data in monetary terms (1,524.7 and 1,560.2 from Example 8.6). However, quarterly chain indices derived with the one-quarter overlap technique can be made consistent with annual chain indices using benchmarking (see Example A8.1). It should be noted that this example has been designed to emphasize the difference between the annual and quarterly overlap techniques. Differences between the approaches are generally smaller in real-life series.

The chain volume series derived with the annual overlap technique, the one-quarter overlap technique, and the one-quarter overlap technique with benchmarking are plotted in Figure 8.1.

Figure 8.1 Annually Weighted Laspeyres Indices: Annual Overlap and One-Quarter Overlap Techniques



Lack of Additivity of Chain-Linked Measures

8.77 In contrast to constant price data, chain-linked volume measures are not additive. To preserve the correct volume changes, related series should be linked independently of any aggregation or accounting relationships that exist between them; as a result, additivity is lost. Additivity is a specific version of the consistency in aggregation property for index numbers. Consistency in aggregation means that an aggregate can be constructed both directly by aggregating the detailed components and indirectly by aggregating sub-aggregates using the same aggregation formula. Lack of additivity is an intrinsic characteristic of a chain-linking system and should be communicated clearly to users.

8.78 Before the application of any chain-linking techniques, however, annually weighted Laspeyres-type indices are consistent in aggregation within each link—both across variables and between different frequencies. The corresponding volume estimates at previous year's prices (expressed in monetary terms) are additive. This formula makes it possible to calculate volume estimates at previous year's prices of an aggregate as the sum of volume estimates at previous year's prices of its components, as well as deriving annual volume estimates as the sum of the corresponding quarterly volume estimates. Additivity is maintained because the weight period (the previous year) coincides with the base period and the system of weights (the current price data from the previous year) is additive. Additivity of these estimates is crucial to compile SUT in volume terms and to calculate additive contributions to percent change. All other indices in common use are not additive within each link.[33]

[33]The reason for non-additivity is that different weights are used for different annual periods, and therefore, will not yield the same results unless there have been no shifts in the weights.

Example 8.8 Chain-Linking and Benchmarking Quarterly Fisher Indices

	Quarterly		Annual		Difference	Quarterly Benchmarked
	Fisher Volume Index (Previous Quarter = 100)	Chain Fisher Volume Index (2010 = 100)	Fisher Volume Index (Previous Year = 100)	Chain Fisher Volume Index (2010 = 100)	Quarterly Chain Fisher – Annual Chain Fisher	Benchmarked Chain Fisher Volume Index (2010 =100)
	(1)	(2)	(3)	(4)	(5) = (4) – (2)	(6)
2010		100.00	100.00	100.00	0.00	100.00
2011		100.80	100.79	100.79	0.01	100.79
2012		101.86	101.00	101.79	0.07	101.79
2013		104.11	102.23	104.06	0.05	104.06
q1 2011	100.74	100.74				100.73
q2 2011	99.92	100.66				100.65
q3 2011	100.08	100.74				100.72
q4 2011	100.33	101.07				101.04
q1 2012	100.18	101.25				101.19
q2 2012	100.06	101.31				101.24
q3 2012	100.58	101.90				101.82
q4 2012	101.07	102.99				102.91
q1 2013	100.76	103.77				103.71
q2 2013	100.54	104.32				104.27
q3 2013	99.94	104.26				104.21
q4 2013	99.83	104.08				104.04

(Rounding errors in the table may occur.)

This example calculates the annual chain Fisher indices and the quarterly chain Fisher indices from the data obtained in Examples 8.3 and 8.4, and uses the Denton proportional method to benchmark the quarterly chain indices to the annual ones.

The quarterly Fisher links are reported in column 1. They are chain-linked using the one-quarter overlap technique, that is, by chaining recursively the indices from the previous quarter shown in column 1:

q2 2011: (99.92 × 100.74)/100.0 = 100.66
q3 2011: (100.08 × 100.66)/100.0 = 100.74
q4 2011: (100.33 × 100.74)/100.0 = 101.07
q1 2012: (100.18 × 101.07)/100.0 = 101.25
…
q4 2013: (99.83 × 104.26)/100.0 = 104.08.

The annual average of the quarterly chain indices are shown at the top of column 2:

2011: (100.74+100.66+100.74+101.07)/4 = 100.80
2012: (101.25+101.31+101.90+102.99)/4 = 101.86
2013: (103.77+104.32+104.26+104.08)/4 = 104.11.

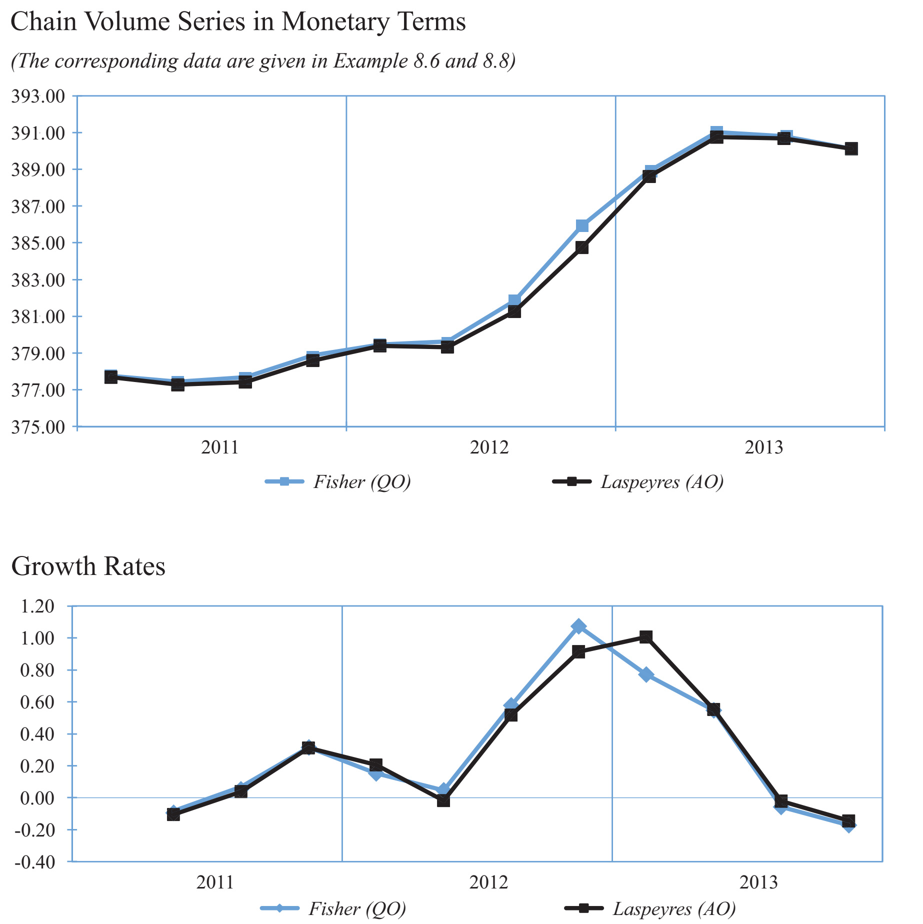
The chaining procedure is applied to the annual data shown in column 3, with the results shown in column 4:

2012: (101.00 × 100.79)/100 = 101.79
2013: (102.23 × 101.79)/100 = 104.06.

Column 5 shows small differences between the annual averages of the quarterly chain Fisher indices and the annual chain Fisher indices. Column 6 shows the quarterly benchmarked chain Fisher indices using the Denton proportional method. It can be noted that the small discrepancies of 2012 and 2013 are distributed smoothly over the quarters.

Figure 8.2 compares the quarterly benchmarked chain Fisher volume series shown in column 6 and the quarterly chain Laspeyres volume series derived with the annual overlap technique (column 3 of Example 8.6). Both series are expressed in monetary terms with reference year 2010.

Figure 8.2 Chain Laspeyres Volume Series and Chain Fisher Volume Series



8.79 Chain volume series derived by chaining annually weighted Laspeyres-type indices using the AO technique are also additive in the reference year and the subsequent year, as shown in Example 8.6.

Chain-Linking, Benchmarking, and Seasonal Adjustment

8.80 Benchmarking and seasonal adjustment require consistent time series with a fixed reference period at a detailed level, while many standard national accounts compilation methods require additive data. Examples of national accounts compilation methods requiring additive data include estimating value added as the difference between output and intermediate consumption, commodity flow techniques, and use of SUT as an integrating framework. Both requirements may appear inconsistent with chain-linking. This section explains how to address the lack of additivity of chained series for benchmarking and seasonal adjustment purposes.

8.81 Benchmarking and seasonal adjustment should be applied to chain-linked volume data (expressed either in index form or monetary terms). On the contrary, sequences of Laspeyres-type volume indices at previous year's prices in equation (12) or Fisher volume indices at previous quarter's prices in equation (16) do not have time-series properties and should not be benchmarked or seasonally adjusted directly. These indices can be derived indirectly from benchmarked and seasonally adjusted data at current prices and in chain-linked form using the inverse process of chain-linking ("unchaining"). The Laspeyres formula is additive within each link, therefore it can be used to derive any required aggregations from benchmarked and seasonally adjusted components.

8.82 Annually chained Laspeyres-type quarterly volume measures with the annual overlap technique are automatically consistent with corresponding annual chain Laspeyres measures and do not require benchmarking. However, when the annual price indices used to deflate ANA variables are derived as simple average of quarterly price indices, benchmarking is still necessary to eliminate the (usually small) inconsistencies between annual and quarterly measures. In theory, annual Laspeyres-type volume measures could be derived as the sum of quarterly Laspeyres-type volume measures.

8.83 Seasonal adjustment can be applied either to price and volume indicators (i.e., the input data) or to chain QNA price and volume series (i.e., the output data). In the former case, seasonally adjusted price and volume indices are used to deflate and extrapolate seasonally adjusted QNA data at current prices. An advantage of this approach is that seasonal effects are detected (and removed) from series showing a seasonal pattern that is observed from actual data. The deflation/extrapolation methodology in the QNA can introduce spurious seasonality in the unadjusted QNA volume series (like, e.g., a possible step in the first quarter using the AO technique), and this may hamper the quality of the seasonal adjustment results. On the other hand, applying seasonal adjustment to the QNA volume series allows a better control process of the seasonal profile of QNA components and aggregates (especially when aggregates are derived using the direct approach).

8.84 The sequence of benchmarking, seasonal adjustment, and chain-linking in the QNA can be configured in different ways. The following procedure is an example of a well-designed combination of the three steps:

- Derive seasonally adjusted price and volume indices (fixed-weighted or chain-linked) at the most detailed level of aggregation.
- Calculate QNA volume series at the elementary level by deflating or extrapolating benchmarked QNA current price data using both unadjusted and seasonally adjusted price and volume indices, following the procedures discussed in paragraphs 8.10–23 to calculate elementary price and volume indices.
- Derive QNA volume indices at every detail level using the preferred index formula (Laspeyres or Fisher). When using the Laspeyres formula, aggregate volume data in monetary terms can be derived simply as the sum of elementary volume estimates.
- Chain-link the QNA volume series (with the preferred linking technique) in both unadjusted and seasonally adjusted forms.
- Verify that seasonally adjusted chain QNA volume series do not contain spurious seasonality (following the indications given in Chapter 7). Residual seasonality may remain from the seasonal adjustment process or introduced artificially by chain-linking with the AO technique. In the latter case, the QO technique with benchmarking should be used.
- Benchmark the chain QNA volume series to the corresponding chain ANA volume series (if they are inconsistent).
- As discussed above, a possible variant of this approach is to apply seasonal adjustment to the chain-linked unadjusted QNA volume series. If consistency with ANA is required for seasonally adjusted data, benchmarking will be necessary to force the seasonally adjusted data to comply with the relevant annual values.

Contributions to Percent Change from Chain-Linked Measures

8.85 The inconvenience for users of chain-linked measures being nonadditive can be reduced somewhat by presenting measures of the components' contribution to percent change in the aggregate. Contributions to percent change measures are additive and thus allow cross-sectional analysis, such as explaining the relative importance of GDP components to overall GDP volume growth. The exact formula for calculating contribution to percent change depends on the aggregation formula used in constructing the aggregate series considered and the time span the percent change covers. This section illustrates solutions to calculate additive contributions from annually chained Laspeyres-type indices and quarterly Fisher indices.

8.86 Additive contributions to percent change can be calculated from annually chained Laspeyres-type quarterly volume measures when the AO technique is used.[34] The data required are the quarterly chain (Laspeyres-type) volume series expressed in monetary terms and the corresponding annual chain (implicit) Paasche deflators. This solution uses

[34] For more details on the methodology to calculate additive contributions from annually chained Laspeyres-type volume series, refer to a technical note by INSEE (2007).

a different formula for the first quarter, where an adjustment factor is needed to make the contributions exactly additive.

8.87 Assuming that the AO technique is used for chain-linking,[35] exact quarterly contributions for q2–q4 can be derived using the following formula:

$$cL_{x,z}^{(s-1,y)\to(s,y)} = 100 \cdot \left(\frac{xch^{(s,y)} - xch^{(s-1,y)}}{zch^{(s-1,y)}} \right) \left(\frac{DX^{y-1}}{DZ^{y-1}} \right),$$

$$\text{for } s = 2,3,4, \tag{29}$$

where

$xch^{(s,y)}$ is the annually chained Laspeyres-type quarterly volume measure of component x in quarter s of year y,

$zch^{(s-1,y)}$ is the annually chained Laspeyres-type quarterly volume measure of aggregate z in quarter $s-1$ of year y,

DX^{y-1} is the annual chain deflator[36] for component X in year $y-1$, and

DZ^{y-1} is the annual chain deflator for aggregate Z in year $y-1$.

For the first quarter ($s=1$), the formula for additive contributions requires an additional term:

$$cL_{x,z}^{(4,y-1)\to(1,y)} = 100 \cdot \left[\left(\frac{xch^{(1,y)} - xch^{(4,y-1)}}{zch^{(4,y-1)}} \right) \left(\frac{DX^{y-1}}{DZ^{y-1}} \right) + \left(\frac{xch^{(4,y-1)}}{zch^{(4,y-1)}} - \frac{XCH^{y-1}}{ZCH^{y-1}} \right) \left(\frac{DX^{y-1}}{DZ^{y-1}} - \frac{DX^{y-2}}{DZ^{y-2}} \right) \right], \tag{30}$$

where

XCH^{y-1} is the annual chain Laspeyres-type volume measure for component X in year $y-1$ and

ZCH^{y-1} is the annual chain Laspeyres-type volume measure for aggregate Z in year $y-1$.[37]

An example of contributions to percent change from annually chained Laspeyres-type quarterly volume measures is given in Example 8.9. The example shows that equation (29) also applies to annual data.

8.88 Equation (30) can be modified to derive additive contributions for year-on-year percent changes:

$$cL_{x,z}^{(s,y-1)\to(s,y)} = 100 \cdot \left[\left(\frac{xch^{(s,y)} - xch^{(s,y-1)}}{zch^{(s,y-1)}} \right) \left(\frac{DX^{y-1}}{DZ^{y-1}} \right) + \left(\frac{xch^{(s,y-1)}}{zch^{(s,y-1)}} - \frac{XCH^{y-1}}{ZCH^{y-1}} \right) \left(\frac{DX^{y-1}}{DZ^{y-1}} - \frac{DX^{y-2}}{DZ^{y-2}} \right) \right]. \tag{31}$$

These contributions are very helpful to analyze the development of chain-linked volume series unadjusted for seasonal effects.

8.89 When quarterly Fisher indices are used, contributions to percent change from quarter t–1 to quarter t can be calculated using the following formula[38]:

$$cF_{x,z}^{t-1\to t} = 100 \cdot \left[\frac{\frac{z^{t-1}}{z^t}\left(x^t \frac{p_x^{t-1}}{p_x^t} - x^{t-1} \right) + FQ_z^t \left(x^t - x^{t-1} \frac{p_x^{t-1}}{p_x^t} \right)}{z^t + FQ_z^t \sum_j c_j^{t-1} \frac{p_j^t}{p_j^{t-1}}} \right], \tag{32}$$

where

FQ_z^t is the Fisher volume index for the aggregate z in quarter t with quarter t – 1 as base and reference period,

z^t is the current price data of aggregate z in quarter t,

x^t is the current price data of component x in quarter t,

c_j^t is the current price data of a generic component j of aggregate z in quarter t, and

p_j^t is the price for component j (including x) in quarter t.

Contributions $cF_{x,z}^{t-1\to t}$ provide an exact decomposition of the aggregate percent change of a quarterly Fisher volume index.[39]

[35] Formula can be used to calculate contributions from chain-linked Laspeyres-type measures derived with the one-quarter overlap technique, but the contributions are not exactly additive.

[36] Annual chain deflators can be calculated implicitly as the annual current price series divided by the annual chain volume series.

[37] The adjustment factor (i.e., the second addend of equation) is usually very small. Formula can be used to provide an approximate decomposition of the quarter-to-quarter change in the first quarter.

[38] Formula is drawn from Chevalier (2003, Appendix II). This formula is currently used by the United States and Canada to derive contributions from chain Fisher indices of national accounts (from both annual and quarterly data). However, quarterly contributions are adjusted to offset (i) the effects of benchmarking quarterly Fisher indices to the annual ones and (ii) the use of percent change expressed at annual rates.

[39] More details on the property of this formula are given in Ehemann, Katz, and Moulton (2002) and Marshall (2002).

Example 8.9 Contributions to Percent Change from Annually Chained Laspeyres-Type Volume Measures

Quarter/Year	Current Prices			Chain Volume Measures (Laspeyres formula, Annual Overlap, and Monetary Terms)			Implicit Chain Deflator			Contribution to Percent Change			Percent Change
	(1)			(2)			(3) = (1)/(2) × 100			(4)			(5)
	A	B	Total	A	B	Total	A	B	Total	A	B	Sum	Total
2010	600.00	900.00	1,500.00	600.00	900.00	1,500.00	100.00	100.00	100.00				
2011	660.00	854.90	1,514.90	643.07	867.91	1,510.98	102.63	98.50	100.26	2.87	–2.14	*0.73*	0.73
2012	759.00	769.50	1,528.50	727.02	794.42	1,524.71	104.40	96.86	100.25	5.69	–4.78	*0.91*	0.91
2013	948.80	615.60	1,564.40	914.81	628.74	1,560.20	103.71	97.91	100.27	12.83	–10.50	*2.33*	2.33
q1 2011	159.70	218.90	378.60	156.57	221.11	377.68							
q2 2011	163.20	213.70	376.90	159.22	218.06	377.28				0.70	–0.81	*–0.11*	–0.11
q3 2011	167.40	210.60	378.00	162.52	214.90	377.42				0.88	–0.84	*0.04*	0.04
q4 2011	169.70	211.70	381.40	164.76	213.84	378.60				0.59	–0.28	*0.31*	0.31
q1 2012	174.20	204.10	378.30	165.59	213.61	379.38				0.25	–0.04	*0.21*	0.21
q2 2012	180.40	201.40	381.80	172.33	206.53	379.31				1.82	–1.84	*–0.02*	–0.02
q3 2012	188.90	192.30	381.20	182.23	198.20	381.27				2.67	–2.15	*0.52*	0.52
q4 2012	215.50	171.70	387.20	206.87	176.07	384.75				6.61	–5.70	*0.91*	0.91
q1 2013	224.70	166.00	390.70	214.16	171.38	388.62				2.08	–1.08	*1.00*	1.00
q2 2013	235.80	156.30	392.10	227.00	159.76	390.77				3.44	–2.89	*0.55*	0.55
q3 2013	242.90	148.50	391.40	235.02	151.04	390.69				2.14	–2.16	*–0.02*	–0.02
q4 2013	245.40	144.80	390.20	238.64	146.56	390.13				0.97	–1.11	*–0.14*	–0.14

(Rounding errors in the table may occur.)

This example shows how to derive additive contributions to percent change from annually chained Lasperyres-type volume measures expressed in monetary terms. Current price data in column 1 and chain volume series in column 2 are taken from Example 8.6. In this table, figures are shown with two decimal places to reduce rounding errors in the contributions. As shown by equations (29) and (30), the annual chain (implicit) deflator is needed in the calculations. The chain deflator is derived as the current price data divided by the chain volume data. For the total, the annual chain deflators are calculated as follows:

2011: 1,514.90/1,510.98 = 100.26
2012: 1,528.50/1,524.71 = 100.25
2013: 1,564.40/1,560.20 = 100.27.

To calculate contributions using equations (29) and (30), the data required are the quarterly chain volume series in column 2 and the annual chain deflator in column 3. Annual contributions for transaction A are calculated as follows:

2011: [(643.07 – 600)/1,500.0] × (100.0/100.0) × 100 = 2.87
2012: [(727.02 – 643.07)/1,510.98] × (102.63/100.26) × 100 = 5.69
2013: [(914.81 – 727.02)/1,524.71] × (104.40/100.25) × 100 = 12.83.

For transaction B,

2011: [(867.91 – 900)/1,500.0] × (100.0/100.0) × 100 = –2.14
2012: [(794.42 – 867.91)/1,510.98] × (98.50/100.26) × 100 = –4.78
2013: [(628.74 – 794.42)/1,524.71] × (96.86/100.25) × 100 = –10.50.

The sum of contributions for transactions A and B returns the annual percent changes in the chain volume aggregate, shown in column 5:

2011: 2.87 + (–2.14) = 0.73
2012: 5.69 + (–4.78) = 0.91
2013: 12.83 + (–10.50) = 2.33.

For quarterly data, equation (29) applies for q2–q4. For example, contribution of transaction A in q2 2012 is given as follows:

q2 2012: [(172.33 – 165.59)/379.38] × (102.63/100.26) × 100 = 1.82.

For q1, equation (30) should be used to derive contributions that are exactly additive. The formula incorporates an adjustment factor that modifies the contribution calculated with equation (29). As an example, contribution for transaction A in q1 2012 is calculated as follows:

q1 2012: [(165.59 – 164.76)/378.60] × (102.63/100.26) × 100 + [(164.76/378.60) – (643.07/1,510.98)] × [(102.63/100.26) – (100.0/100.0)] × 100 = 0.25,

where the adjustment factor is shown in the second row.

8.90 Contributions of changes in inventories (and any other variables that can take negative, zero, or positive values) should be calculated residually using formula (29) or (32). For example, contribution of changes in inventories can be derived as the difference between the contributions of gross capital formation and gross fixed capital formation to GDP growth.

Presentation of Chain-Linked Measures

8.91 There are some important aspects to consider in presenting chain-linked measures in publications:

- whether to present measures of percent change or time series with a fixed reference period,
- whether to present time series as index numbers or in monetary terms,
- terminology to avoid confusing chain-linked measures in monetary terms for constant price data (fixed-based measures),
- choice of reference year and frequency of reference year change—among others, as a means to reduce the inconvenience of nonadditivity associated with chain-linked measures, and
- whether to present supplementary measures of contribution of components to percent change in aggregates.

8.92 Chain-linked price and volume measures must, at the minimum, be made available as time series with a fixed reference period. The main reason is that data presented with a fixed reference period allow different periods and periods of different duration to be compared and provide measures of long-run changes. Thus, presentation of price and volume measures should not be restricted to presenting only tables with period-to-period or year-on-year percent change nor tables with each quarter presented as a percentage of a previous quarter. For users, tables with percent changes derived from the time series may represent a useful supplement to the time series with a fixed reference period and may be best suited for presentation of headline measures. Tables with such data cannot replace the time-series data with a fixed reference period, however, because such tables do not provide the same user flexibility. Tables with each quarter presented as a percentage of a previous quarter (e.g., the previous quarter or the same quarter in the previous year) should be avoided, because they are less useful and can result in users confusing the original index with the derived changes. Restricting the presentation of price and volume measures to presenting changes only runs counter to the core idea behind chain-linking, which is to construct long-run measures of change by cumulating a chain of short-term measures.

8.93 Chain-linked volume measures can be presented either as index numbers or in monetary terms. The difference between the two presentations is in how the reference period is expressed. As explained in paragraph 8.44, the reference period and level can be chosen freely without altering the rates of change in the series. The index number presentation shows the series with a fixed reference period that is set to 100, as shown in Examples 8.6–8.8. The presentation is in line with usual index practice. It emphasizes that volume measures fundamentally are measures of relative change and that the choice and form of the reference point, and thus the level of the series, is arbitrary. It also highlights the differences of chain-linked measures from constant price estimates and prevents users from treating components as additive. Alternatively, the time series of chain-linked volume measures can be presented in monetary terms by multiplying the series by a constant to equal the constant price value in a particular reference period, usually a recent year. While this presentation has the advantage of showing the relative importance of the series, the indication of relative importance can be highly sensitive to the choice of reference year and may thus be misleading.[40] Because relative prices are changing over time, different reference years may give very different measures of relative importance. In addition, volume data expressed in monetary terms may wrongly suggest additivity to users who are not aware of the nature of chain-linked measures. On the other hand, they make it easier for users to gauge the extent of nonadditivity. Both presentations show the same underlying growth rates and both are used in practice.

8.94 Annually chain-linked Laspeyres volume measures in monetary terms are additive in the reference period. The nonadditivity inconvenience of chain

[40] For the same reason, measuring relative importance from chain-linked data can be grossly misleading. For most purposes, it is better to make comparisons of relative importance based on data at current prices—these are the prices that are most relevant for the period for which the comparisons are done, and restating the aggregates relative to prices for a different period detracts from the comparison.

volume measures in monetary terms may further be reduced by simultaneously doing the following:

- using the average of a year and not the level of a particular quarter as reference period,
- choosing the last complete year as reference year, and
- moving the reference year forward annually.

This procedure may give chain volume measures presented in monetary terms that are approximately additive for the last two years of the series. As illustrated in Example 8.6, the chain discrepancy increases (unless the weight changes are cyclical or noise) the more distant the reference year is. Thus, moving the reference year forward can reduce the chain discrepancies significantly for the most recent section of the time series (at the expense of increased nonadditivity at the beginning of the series). For most users, additivity at the end of the series is more important than additivity at the beginning of the series.

8.95 To avoid chain discrepancies completely for the last two years of the series, some countries have adopted a practice of compiling and presenting data for the quarters of the last two years as the weighted annual average prices of the first of these two years. That second-to-last year of the series is also used as reference year for the complete time series. Again the reference year is moved forward annually. This approach has the advantage of providing absolute additivity for the last two years (provided a Laspeyres formula with annual weights is used).

8.96 Chain-linked volume measures presented in monetary terms are not constant price measures and should not be labeled as measures at "Constant xxxx Prices." Constant prices mean estimates based on fixed-price weights, and thus the term should not be used for anything other than true constant price data based on fixed-price weights. Instead, chain-volume measures presented in monetary terms can be referred to as "chain-volume measures referenced to their nominal level in xxxx."

8.97 The nonadditivity inconvenience of chain-linking often can be circumvented by simply noting that chain Laspeyres volume measures are additive within each link. For that reason, chain-linked Laspeyres volume measures, for instance, can be combined with analytical tools like volume SUT and IO tables/models that require additivity.

Summary of Key Recommendations

- *For consistency reasons, ANA and QNA volume data should be derived using the same formula index. A superlative index, such as the Fisher index, is the preferred formula for aggregating elementary price and volume indices in the QNA. An acceptable alternative is to use a Laspeyres formula for volumes with the implicit Paasche formula for prices.*
- *Quarterly Fisher indices should be calculated using quarterly weights. The Fisher formula is more robust against the drift problem than other index formulas. Quarterly Fisher indices should be chain-linked using the one-quarter overlap technique. The quarterly chain Fisher series should be benchmarked to the corresponding annual chain Fisher series to preserve consistency and eliminate possible drifts from the quarterly indices (especially when quarterly data contain seasonal effects and short-term volatility).*
- *When the Laspeyres volume index is chosen, quarterly volume measures should be derived using annual weights from the previous year. Quarterly volume measures based on the Laspeyres formula can be chain-linked using either the one-quarter overlap (QO) technique or the annual overlap (AO) technique. The QO technique is the best choice to preserve the time-series properties of the volume series, but should always be used in conjunction with benchmarking to remove inconsistencies with the annual chain-linked data. Instead, the AO technique can be used to derive quarterly volume measures that are automatically consistent with the corresponding annual ones. When the AO technique is preferred, tests should be run to verify that there are no artificial steps between years in the chain-linked series.*
- *Because chain volume data in monetary terms are never additive, the discrepancy between chain-linked components and chain-linked aggregates should not be removed.*
- *To reduce the inconvenience of nonadditivity, chain-linked measures should be presented as contributions to percent change in the aggregates. Formulas that calculate additive contributions from annually chained Laspeyres indices and chain Fisher indices should be preferred. Additive volume data at previous year's prices should also be made available to users.*

Annex 8.1 Interpreting the Difference between the Annual Overlap and One-Quarter Overlap Techniques

A8.1 Annually weighted Laspeyres-type quarterly volume measures can be chain-linked using two alternative techniques: the annual overlap (AO) technique and the one-quarter overlap (QO) technique. As discussed in this chapter, the AO technique has the advantage of producing quarterly indices that are consistent with the corresponding annual chain indices; however, it may introduce a step between one year and the next. For this reason, the QO technique preserves better the time-series properties of the quarterly indices. When consistency with the annual data is strictly required, the chain series obtained with the QO technique can be benchmarked to the corresponding annual chain indices. This annex clarifies and interprets the factor explaining the difference between the chain series derived with the AO and QO techniques and highlights the effects of benchmarking on the QO chain-linked series.

A8.2 The following algebra shows that chain volume series derived with the AO and QO linking techniques differ for a constant factor in each linking year. This factor is defined as the ratio between a price index with quantity weights from the fourth quarter and a price index with quantity weights from the whole year.

A8.3 The AO linking technique is defined by equations (22)–(25) of this chapter. Assuming no quarterly price and volume decomposition in the first year, the quarterly links for the AO and QO techniques are equal for second year. The two techniques provide different results from third year onwards. The quarterly chain indices for the quarters of the third year with reference to the first year are calculated as follows:

$$q_{AO}^{1\rightarrow(s,3)} = Q^{1\rightarrow2} \cdot q^{2\rightarrow(s,3)} \cdot 100\,, \tag{A1}$$

where

$$s = 1,2,3,4\,,$$

$$q^{2\rightarrow(s,3)} = \frac{k^{2\rightarrow(s,3)}}{C^2/4}\,, \tag{A2}$$

$$Q^{1\rightarrow2} = \frac{K^{1\rightarrow2}}{C^1} \tag{A3}$$

with

$k^{2\rightarrow(s,3)}$ the volume estimate of quarter s of year 3 at the prices of year 2,

$K^{1\rightarrow2}$ the volume estimate of year 2 at the prices of year 1, and

C^1 and C^2 the annual current price data for years 1 and 2.

Replacing the above expressions in equation (A1), the annual links for year 3 become

$$q_{AO}^{1\rightarrow(s,3)} = \left(\frac{K^{1\rightarrow2}}{C^1}\right) \cdot \left(\frac{k^{2\rightarrow(s,3)}}{\frac{1}{4}C^2}\right) \cdot 100. \tag{A4}$$

A8.4 The recursion formula of the QO technique is defined by equations (26)–(28). The quarterly chain indices for the quarters of the third year with reference to the first year are calculated as follows:

$$q_{QO}^{1\rightarrow(s,3)} = q^{1\rightarrow(4,2)} \cdot q^{(4,2)\rightarrow(s,3)} \cdot 100\,. \tag{A5}$$

Differently from the AO technique, equation (A5) uses a quarterly linking factor from the fourth quarter of the second year ($q^{1\rightarrow(4,2)}$) and not the annual linking factor of the second year ($Q^{1\rightarrow2}$). In addition, the QO technique carries forward the movement of the current quarter from the fourth quarter of the previous year ($q^{(4,2)\rightarrow(s,3)}$) and not from the previous year ($q^{2\rightarrow(s,3)}$).

Using equation (A2) for $q^{1\rightarrow(4,2)}$ and equation (26) for $q^{(4,2)\rightarrow(s,3)}$, the linking formula in equation (A5) can be expressed as follows:

$$q_{QO}^{1\rightarrow(s,3)} = \left(\frac{k^{1\rightarrow(4,2)}}{\frac{1}{4}C^1}\right) \cdot \left(\frac{k^{2\rightarrow(s,3)}}{cy^{(4,2)}}\right) \cdot 100\,, \tag{A6}$$

where

$k^{1\rightarrow(4,2)}$ is the quarterly volume estimate at previous year's prices of quarter 4 of year 2 and

$cy^{(4,2)}$ is the quarterly estimate at the average prices of year 2 of quarter 4, year 2.

A8.5 The ratio between equations (A4) and (A6) explains the differences between the AO and QO techniques. For the third year, the ratio is equal to

$$d^{2\to3} = \frac{\left[\frac{K^{1\to2}}{C^1} \cdot \frac{k^{2\to(s,3)}}{\frac{1}{4}C^2}\right]}{\left[\frac{k^{1\to(4,2)}}{\frac{1}{4}C^1} \cdot \frac{k^{2\to(s,3)}}{cy^{(4,2)}}\right]}. \tag{A7}$$

Factor $d^{2\to3}$ explains the difference between the AO and QO approaches when the quarterly indices of the third year 3 are linked to the second year. This ratio also formalizes the step problem of the AO technique.

A8.6 After rearranging the terms and doing simple algebra operations on equation (A7), ratio $d^{2\to3}$ can be expressed as follows:

$$d^{2\to3} = \frac{\left[\frac{cy^{(4,2)}}{k^{1\to(4,2)}}\right]}{\left[\frac{C^2}{K^{1\to2}}\right]}. \tag{A8}$$

Each term of equation (A8) can be expressed as a "price × volume" expression as follows:

$$cy^{(4,2)} = \sum_j P_j^2 q_j^{(4,2)},$$

$$k^{1\to(4,2)} = \sum_j P_j^1 q_j^{(4,2)},$$

$$C^2 = \sum_j P_j^2 Q_j^2, \text{ and}$$

$$K^{1\to2} = \sum_j P_j^1 Q_j^2 .$$

Replacing the above expressions into equation (A8) provides the following ratio:

$$d^{2\to3} = \frac{\left[\frac{\sum_j P_j^2 q_j^{(4,2)}}{\sum_j P_j^1 q_j^{(4,2)}}\right]}{\left[\frac{\sum_j P_j^2 Q_j^2}{\sum_j P_j^1 Q_j^2}\right]}, \tag{A9}$$

which helps in interpreting the difference between the AO and QO techniques. The numerator of equation (A9) is a price index from the first year to the second year, with quantities from the fourth quarter of the second year. The denominator is also a price index from the first year to the second year, but the quantities are those of the second year (the denominator is a true annual Paasche price index). The larger are the differences between these two price indices, the larger are the differences between the chain-linked series calculated with the AO and QO techniques (and the bigger is the risk of introducing a step using the AO approach).

A8.7 Based on expression (A9), the AO and QO techniques provide similar results when the quantity shares in the fourth quarter of a linking year are similar to the quantity shares for the same year as a whole. Large differences between quarterly and annual shares of quantities may arise from data with different seasonal patterns or in periods characterized by strong relative changes. In these situations, the AO technique may introduce an artificial step in the chain volume series. On the contrary, the step problem for the AO technique should be negligible for data that are seasonally adjusted, present relatively stable seasonal patterns, and are characterized by relative stability within the year.

A8.8 Equation (A8) can be generalized for any linking year as follows:

$$d^{t-1\to t} = \frac{\left[\frac{cy^{(4,t-1)}}{k^{t-2\to(4,t-1)}}\right]}{\left[\frac{C^{t-1}}{K^{t-2\to t-1}}\right]} \text{ for } t = 3,4,5,\ldots .$$

The chain-linked ratio $d^{2\to y}$

$$d^{2\to y} = d^{2\to3} \cdot d^{3\to4} \cdot \ldots \cdot d^{y-1\to y} \tag{A10}$$

is equal to the ratio between the chain volume series derived from the AO and QO techniques.

Example A8.1 demonstrates this equivalence using the numerical example used in this chapter.

A8.9 The only disadvantage of the QO technique is that it provides quarterly chain indices that are inconsistent with the corresponding annual chain indices. In monetary terms, this means that the annual

Example A8.1 Annual Overlap, One-Quarter Overlap, and One-Quarter Overlap with Benchmarking

	Chain Volume Series with Annual Overlap (AO)		Chain Volume Series with One-Quarter Overlap (QO)		Ratio AO/QO	Chain Volume Series with One-Quarter Overlap with Benchmarking (QOB)		Ratio QOB/QO	Differences between AO and QOB
	(1)		(2)		(3) = (1)/(2)	(4)		(5) = (4)/(2)	(6) = (4) – (1)
	Level	Percent Change	Level	Percent Change	Level	Level	Percent Change	Level	Percent Change
2011	1,511.0		1,511.0			1,511.0			
2012	1,524.7	0.9	1,524.1	0.9	1.00039	1,524.7	0.9		
2013	1,560.2	2.3	1,556.3	2.1	1.00250	1,560.2	2.3		
q1 2011	377.7		377.7		1.00000	377.7		1.0000	
q2 2011	377.3	–0.1	377.3	–0.1	1.00000	377.3	–0.1	1.0000	0.0
q3 2011	377.4	0.0	377.4	0.0	1.00000	377.4	0.0	1.0000	0.0
q4 2011	378.6	0.3	378.6	0.3	1.00000	378.6	0.3	1.0000	0.0
q1 2012	379.4	0.2	379.2	0.2	1.00039	379.2	0.2	0.9999	0.0
q2 2012	379.3	0.0	379.2	0.0	1.00039	379.2	0.0	1.0001	0.0
q3 2012	381.3	0.5	381.1	0.5	1.00039	381.3	0.6	1.0005	0.0
q4 2012	384.8	0.9	384.6	0.9	1.00039	385.0	1.0	1.0010	0.1
q1 2013	388.6	1.0	387.6	0.8	1.00250	388.4	0.9	1.0018	–0.1
q2 2013	390.8	0.6	389.8	0.6	1.00250	390.7	0.6	1.0024	0.1
q3 2013	390.7	0.0	389.7	0.0	1.00250	390.8	0.0	1.0028	0.0
q4 2013	390.1	–0.1	389.2	–0.1	1.00250	390.3	–0.1	1.0030	0.0

Columns 1 and 2 show level and percent change of the chain Laspeyres-type volume series using the annual overlap (AO) and one-quarter overlap (QO) techniques derived in Examples 8.6 and 8.7, respectively. As shown in column 3, the two series are identical for the 2011 quarters and differ for two constant factors in 2012 and 2013.

The ratio between the AO and QO techniques is explained in formula. Using the figures for 2012 in Examples 8.6 and 8.7,

$$d^{2011\rightarrow 2012} = \left[\frac{cy^{(4,2011)}}{K^{2010\rightarrow(4,2011)}}\right] \Big/ \left[\frac{C^{2011}}{K^{2010\rightarrow 2011}}\right] = \left[\frac{379.73}{378.60}\right] \Big/ \left[\frac{1,514.90}{1,511.00}\right] = 1.00039,$$

which is the ratio between the AO series and the QO series as shown in column 3 in 2012. For 2013,

$$d^{2012\rightarrow 2013} = \left[\frac{cy^{(4,2012)}}{K^{2011\rightarrow(4,2012)}}\right] \Big/ \left[\frac{C^{2012}}{K^{2011\rightarrow 2012}}\right] = \left[\frac{386.52}{385.75}\right] \Big/ \left[\frac{1,528.50}{1,528.67}\right] = 1.00211.$$

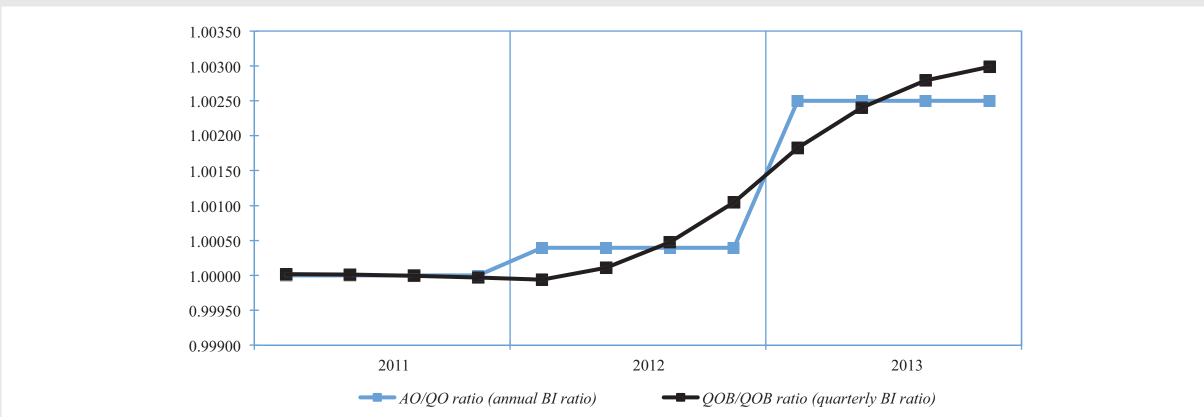
The chain ratio for 2013 is

$$d^{2011\rightarrow 2013} = 1.00039 \cdot 1.00211 = 1.00250,$$

which corresponds to the constant factor for 2013 as shown in column 3.

To eliminate discrepancies with the annual data, the QO series should be benchmarked to the annual chain volume series (the AO series does not present such inconsistencies). Column 4 shows the QO benchmarked (QOB) series using the Denton proportional benchmarking method. The differences with the AO series, shown in column 5, are distributed smoothly between 2012 and 2013. Figure A8.1 shows how the Denton method realigns the QO series with the annual benchmarks. Note that the AO/QO ratio can be interpreted as the annual benchmark-to-indicator ratio in the benchmarking process of the QO series. The QOB/QO ratio is the interpolation of the AO/QO ratio based on the proportional benchmarking method.

Figure A8.1 Annually Weighted Laspeyres Indices: Annual Overlap and One-Quarter Overlap Techniques



sum of the chain quarterly volume measures does not add up to the independently chained annual volume measures. To eliminate the inconsistencies, the quarterly chain indices using the QO technique should be benchmarked to the annual chain indices. The benchmarking process should be conducted with a method that preserves the movements in the original QO series and, at the same time, satisfies the annual benchmark indices. As recommended in Chapter 6, the Denton proportional benchmarking method can be used to this purpose. Benchmarking using the Denton method distributes smoothly the discrepancies between the QO series and the annual chain-linked series.

A8.10 Under the benchmarking framework, the chain-linked ratio (equation (A10)) corresponds to the annual benchmark-to-indicator (BI) ratio resulting from benchmarking the quarterly chain volume series derived with the QO technique to annual chain indices. A time-series analysis of the annual BI ratio can be helpful to appreciate the size and direction of the differences between the AO and QO linking techniques. When small variations of equation (10) are noted over time, the AO and QO techniques are expected to produce similar results.

Example A8.1 and Figure A8.1 shows the effects of benchmarking a quarterly chain volume series derived with the QO technique to the corresponding annual chain volume series.

Bibliography

Al, P.G., B. Balk, S. de Boer, and G.P. den Bakker (1985), "The Use of Chain Indices for Deflating the National Accounts," *Statistical Journal of the United Nations Economic Commission for Europe*, 4 (5): 47–68.

Alexander, T., C. Dziobek, M. Marini, E. Metreau, and M. Stanger (2017), *Measure Up: A Better Way to Calculate GDP*, Staff Discussion Notes No. 17/02, Washington, DC: IMF.

Baquite National De Belgique (2010), "Issues Encountered with Quarterly Volume Balances Measured in Chain-linked Euros: Levels and Contributions to Growth—A New Approach for the Quarterly National Accounts," Annex to *Comptes Nationaux—Comptes Trimestriels 2010-II*, pp. 10–21.

Chevalier, M. (2003), *Chain Fisher Volume Index Methodology*, Research Paper, Statistics Canada, Ottawa, November.

Ehemann, C., A.J. Katz, and B.R. Moulton (2002), "The Chain-Additivity Issue and the US National Economic Accounts," *Journal of Economic and Social Measurement*, 28(1/2): 37–49.

Eurostat (2001), *Handbook on Price and Volume Measures in National Accounts*, Luxembourg: Office for Official Publications of the European Commission.

ILO, IMF, OECD, Eurostat, UN, Economic Commission for Europe, and World Bank (2004a), *Consumer Price Index Manual: Theory and Practice*, Geneva: ILO.

ILO, IMF, OECD, UN, Economic Commission for Europe, and World Bank (2004b), *Producer Price Index Manual: Theory and Practice*, Washington, DC: IMF.

ILO, IMF, OECD, UN, Economic Commission for Europe, and World Bank (2009), *Export and Import Price Index Manual: Theory and Practice*, Washington, DC: IMF.

INSEE (2007), "Calcul des Contributions en Volumes Chainés," Technical note to users, available at http://www.insee.fr/fr/themes/theme.asp?theme=16&sous_theme=8&type=2&nivgeo=0&page=methodologie.html.

Kulshreshtha, A.C. (2000), *Basic Principles and Practices in Rebasing and Linking National Accounts Series*, Paper prepared for the ADB/ESCAP Workshop on Rebasing and Linking National Accounts Series in Selected Developing Member Countries, Bangkok, Thailand, March.

Landefeld, J.S., and R.P. Parker (1997), "BEA's Chain Indexes, Time Series, and Measures of Long-Term Economic Growth," *Survey of Current Business*, 77(5): 58–68.

Parker, R.P., and E.P. Seskin (1997), "Annual Revision of the National Income and Product Accounts," *Survey of Current Business*, August: 6–35.

Reinsdorf, B. M. (2002), "Additive Decompositions for Fisher, Törnqvist and Geometric Mean Indexes," *Journal of Economic and Social Measurement*, 28(1/2): 51–61.

Szultc, B., 1983, "Linking Price Index Numbers," in eds. W.E. Diewert and C. Montmarquette, *Price Level Measurement: Proceedings of a Conference Sponsored by Statistics Canada*, Ottawa: Statistics Canada, pp. 537–566.

United Nations (2010), *International Recommendations for the Index of Industrial Production*, New York: U.N. Statistics Divisions.

United Nations, European Commission, International Monetary Fund, and Organization for Economic Co-operation and Development (2008), *The System of National Accounts, 2008* (New York: United Nations).

9 Editing Procedures

Editing procedures should be an integral part of the quarterly national accounts (QNA). The objective of editing is to validate the consistency of the quarterly results within the national accounts and with other related economic information. A number of logical and plausibility checks are suggested for identifying common problems in the various stages of the quarterly gross domestic product (GDP) compilation process. This chapter also proposes the use of available annual supply and use tables as an editing tool to address and resolve the quarterly GDP discrepancies at a detailed level.

Introduction

9.1 Editing procedures are essential steps of statistical production and are among the tasks in national accounts compilation that require the greatest skill. While other chapters deal with the sources of data and techniques, this chapter emphasizes reviewing and understanding the data. The process of reviewing and understanding data can be called "editing," "checking," or "data validation." It should occur at all stages—before, during, and after—of the calculation of the estimates. "Reconciliation" or "confrontation" is a special kind of editing done after initial compilation, in which alternative data are checked in the context of national accounting relationships. Editing may involve fixing errors or adopting alternative sources and methods.

9.2 QNA results should be evaluated and understood before their publication. National accounts compilation is a complicated process, bringing together a wide range and large volume of data. The data come from varying sources, are of varying quality, cover different periods, and may have different units, concepts, and timing. Large volumes of data and tight deadlines mean that mistakes are easy to make and hard to find. In addition, when a method or program has worked well in the past, the production process has gone smoothly, or the calculations are complicated, there is a natural tendency for busy compilers to accept the data without close scrutiny, resulting in a risk of errors. Editing (or checking) procedures should be put in place to review all the different stages of the QNA calculation process and make sure that the final results satisfy all the national accounts relationships and provide a credible measurement of the economy.

9.3 Many of the editing and reconciliation issues in QNA are the same as in annual national accounts (ANA). However, these issues are particularly important in the compilation of QNA. Deadlines for QNA are usually much tighter than for ANA, work is more rushed, and a higher proportion of source data may be preliminary or unpublished. As a result, errors are more likely to occur. There is typically less detailed information in QNA. The tight deadlines applying to quarterly compilation impose a severe limit on the amount of investigation done for the latest quarter. In the time available, it may be necessary to limit checks to known problem areas, the most recent periods, and some major ratios. In the time between the end of one quarterly compilation cycle and the beginning of the next, however, there may be opportunities to undertake further investigation.

9.4 Editing procedures should aim at monitoring and reviewing the quality of the data and methods used, and also interpreting the key messages from the QNA results. A number of methods should be put in place to control and validate input data, intermediate steps, and final results. A basic principle in this validation process is that the QNA results should reflect the data sources. Any deviation from sources should clearly be investigated and explained. Second, QNA should be internally consistent and satisfy all the national accounts relationships at both the aggregate level and the detailed level. This includes consistency with published ANA. QNA series should also be comparable over time and show no artificial breaks between one quarter and the next. Finally, QNA data should be consistent with other qualitative and quantitative information measuring the current state of the economy.

9.5 Balancing alternative measures of GDP is a particular kind of editing designed to reduce or eliminate inconsistencies between measures derived from the production, expenditure, and income approaches. These inconsistencies arise from the use of numerous and varied source data when developing the measures. In theory, GDP calculated by the production approach is equal to the value of GDP calculated by the expenditure and income approaches. At a detailed level, the GDP equivalence transforms into the fundamental economic identity that the supply of products must equal their use. In practice, however, discrepancies generally occur because the supply and use of products are estimated using different data sources.

9.6 Editing procedures may result in changes to the estimates. They may involve fixing errors or adopting alternative sources and methods. It is important that such changes are justified and documented. For example, sometimes mistakes are identified and the correct figure can be used instead. In other instances, a method may have become unsuitable because the assumptions behind it have become obsolete, or the source data may have problems in reporting or coverage.

9.7 The editing work should never be an excuse for manipulating data without evidence, adjusting data to fit forecasts, or for political reasons. A distinction needs to be made between editing and unacceptable manipulation of data. An unexpected change in a series should lead to checking that there is no error or problem with the data source. Editing may suggest that an alternative source or method is justified; however, data should not be changed just because they are unexpected, as this may lead to charges of manipulation and may undermine the reputation of compilers if it becomes known. Further, in reality, many unexpected developments occur, and the purpose of QNA is to show actual developments in the economy, particularly when they are unexpected. In line with principles of integrity and transparency, QNA estimates should be explained by reference to source data, publicly available compilation methods, and adjustments documented with the supporting evidence.

Editing as Part of the Compilation Process

9.8 Editing is an iterative process for validating the quality of QNA data. Editing should involve all stages of the QNA compilation process. Editing procedures should be organized into a systematic framework that allows compilers to identify and address promptly any shortcomings in the input data, intermediate or final QNA results.

9.9 Editing can occur at all stages of data processing:

a. before receipt by the national accounts compilers,
b. during data input (i.e., the data as supplied to the national accounts compilers),
c. during data output (i.e., the data as planned to be published), and
d. during intermediate stages:
   i. before and after benchmarking,
   ii. before and after deflation,
   iii. before and after balancing,
   iv. before and after seasonal adjustment, and
   v. before and after other major adjustments (for timing, coverage, etc.).

9.10 Editing at each stage is desirable. Each stage of processing and adjustment can introduce new errors or hide earlier ones. Earlier identification of problems and errors is generally preferable.

9.11 Good editing practices should be applied by all compilers of statistical data. Data suppliers are an integral part of national accounts compilation, so editing should be supplemented by continuing contact with suppliers to gain knowledge from them about problems they have identified or suspect. Those who collect the data need to monitor the results and anticipate queries for their own purposes. In some countries, the national accounts compilers have contributed toward educating the data collection staff through the perspective that comes from seeing macroeconomic links, from undertaking deflation and seasonal adjustment, and from maintaining consistent time series. The national accounts compilation process itself may shed new light through volume measures, seasonally adjusted and trend-cycle data, analysis of revision patterns, and reconciliation with related data sources.

9.12 In addition, national accounts compilers may have meetings or standardized data supply forms to allow the data collectors to notify them of major movements in the data, known economic developments, response rates, standard errors, changes to questionnaires, and other changes in methods. Good procedures or structures for interaction between data collection staff and national accounts compilers are essential for data validation as well as for helping maintain effective cooperation and avoid conflicts. Thus, communication needs to be in both directions.

9.13 Original estimates, adjustments, and reasons should be documented along with supporting evidence. As a good practice, when national accounts data are changed during the editing process, the source data, original estimates, and adjusted estimates should be stored. Although only the adjusted data will be published, it is important to be able to document how the source data were amended and the cause of the problem. Documentation is necessary so that the reasons may be understood and verified later. While it is tempting to put off documentation work, memories are not a good substitute, because people move on to other jobs, forget, are on leave at a crucial time, or have conflicting recollections. Documentation is a defense against accusations of manipulation. As later data become available, patterns may be more apparent from a consistent series of original data, or alternative adjustments may be developed. Later information may lead to the conclusion that some adjustments were ill-advised and should be revised. Documentation could be on paper files or, better still, on the computer system if it allows different versions of a series to be saved and associated metadata to be linked to a series.

9.14 The ability of the national accounts compiler to make adjustments is limited if consistency with some or all published source data is a constraint. In some countries, particular data are regarded as binding for QNA compilation because of their relatively high quality or need for consistency (e.g., exports and imports of goods and services). On the other hand, data that are known to be particularly poor are identified as being subject to adjustments (e.g., consistency between the production and expenditure estimates being achieved by adjustments to changes in inventories because the source data used to compile that component are known to be of poor quality).

9.15 The highest priority in editing is usually to identify and remove errors before publication; however, there are other benefits. Editing helps national accountants understand the data and the economy better. It also helps national accountants anticipate queries from users, because unusual movements will already have been identified; explanations for the expected queries can thus be given immediately. Successful editing enhances both the quality of the data and the confidence of users in the compilation procedures.

9.16 Editing procedures usually rely on relationships within data to identify problems and questions. Only rarely will looking at a single number help point to anomalies. The foundation of editing is to compare observations of the same variable in different periods or to compare one variable with other variables that are expected to have some linkage.

9.17 The analysis of revisions is another important tool of the editing framework. Substantial differences with previous estimates of the same quarter should be understood and validated. Revisions that are caused by new or updated source data are generally justified, provided that they are plausible in economic terms and consistent through the accounts. When large revisions are generated by statistical procedures (such as seasonal adjustment), a thorough investigation must be conducted to verify that there are no glitches in the methodology and that these revisions measure in the most accurate way what is happening in the economy.[1]

9.18 Deciding how much editing work to do depends on staffing, deadlines, and knowledge of the kinds of problems that typically arise. In theory, more editing is always better. In practice, the extra work and time required to establish editing systems and then check the data mean that edits must be limited to the types that are most likely to be useful.

9.19 Computers have greatly increased the capacity for editing. Automated routines should be developed

[1] For more details on revisions of QNA data, see Chapter 12.

to monitor the QNA results quickly and continuously during the compilation process. Compilers should be able to evaluate the impact of any change in the data, both for the variables directly involved and for the system as a whole. At the same time, computerized systems may need more checking because the data processing itself involves less human observation. Computerized tools require maintenance from time to time, for example with the beginning of a new year or when a new classification is adopted.

9.20 The compilation schedule needs to allow time for editing and subsequent investigation and revision of data. If time is only allocated to carry out basic data entry and calculation tasks, it will not be possible to make any changes before the publication deadline.

9.21 More complicated estimation methods for particular components are at more risk of mistakes. Similarly, the need for editing is stronger when data or methods are weak because the risk of inappropriate results is greater. Because numbers in a computer are all treated as numbers regardless of their origin, it is important for the compiler to bear in mind the link between the quality of data input and the quality of data output: "garbage in, garbage out."

Causes of Data Problems

9.22 There is a range of causes for failure of data to fit expected relationships. When there is a data problem, it is first necessary to confirm that the input data are consistent with those supplied by the data collectors. Next, it is important to confirm that the computer program is doing what was intended. This check will show whether any anomalies were due to mistakes made in the national accounts compilation system itself. In the interest of good relationships with data suppliers, the possibility of an error in the compilation system should be excluded before pursuing other avenues of inquiry.

9.23 Typical errors leading to data failing to fit expected relationships include the following:

a. *Errors in data entry by national accounts compilers.* These include mistyping of numbers, putting numbers in the wrong place, and using old data that should have been updated.

b. *Errors in national accounts compilation systems.* At a basic level, these include wrong formulas, which are particularly likely when changes are made to programs, especially in spreadsheets. In addition, the assumptions and indicators may become inappropriate as conditions change; for example, use of a generalized deflator or direct deflation of value added may give acceptable results when there is little relative price change, but may become quite misleading under different economic circumstances. Adjustments are required when data sources do not fully meet national accounts requirements and are particularly prone to becoming outdated by economic changes. Examples are adjustments for timing, valuation, and geographic/size/product coverage.

c. *Errors in data recording by respondents.* Reporting quality is often a problem, but it can be improved by good questionnaire design, helpful completion instructions, and availability of assistance in completing forms. Timing problems can be particularly important in QNA. Timing problems occur when transactions are not recorded at the time required by the *2008 SNA*. The *2008 SNA* standard is based on accrual principles and change of economic ownership; however, many data sources do not meet these requirements. Government data are often recorded on a cash basis. International trade data are typically recorded at the time the goods cross the customs frontier or when the customs authorities process the form. Administrative by-product data (e.g., value added or payroll tax data) may cover periods that do not coincide with a quarter because the agency is more interested in tax collection than statistical objectives. Businesses may also use different accounting periods that do not exactly match the three-month period used in the QNA, such as weeks, four-week periods, or nonstandard quarters. These problems are also found in annual data but are more significant in QNA, because a timing error of the same size is relatively larger in quarterly data.

d. *Errors and problems in source collection systems.* Problems can occur in classification, data entry, estimation of missing items or returns, sample design, tabulation, treatment of late response, incomplete business registers, and omitted components. Estimation of non-reporting units is a particularly important issue for QNA because of the higher proportion of missing data owing to earlier deadlines. Early estimates are often based on incomplete response, complemented by estimation processes for the missing respondents. Treatments of outliers may also differ. A systematic difference between early and late estimates suggests that the estimation for the missing components is biased. Large but nonsystematic errors suggest that it would be desirable to put more effort into early follow-up. National accounts compilers need to be sympathetic to the constraints of resources and respondent cooperation faced by their data collection colleagues.

9.24 Errors should clearly be distinguished from real changes in the economy. Changes in the structure of the economy, for example, may also fail to fit expected relationships; nevertheless, they should never be considered errors. For instance, it is possible to confirm that there has been a surprising but valid change in the series owing to a known cause, such as a large individual transaction or a business closure. This information helps the national accountant understand the data and deal with queries from users. Some changes in the structure of the economy have the effect of making assumptions used in the national accounts compilation obsolete and so may require changes in methods. For example, the representativeness of an indicator that does not fully match the required coverage may deteriorate.

9.25 Atypical changes may cause concerns from users. Movements outside the normal historical range should always be identified and understood. When changes are relevant for the economy as a whole, they should be accompanied by clear explanatory notes in the press release. In all other cases, it is always better to know how to explain such cases so that a query from a user is not a surprise and an explanation can immediately be provided.

9.26 The causes of some data problems are obvious, while in other cases investigation is needed to identify the cause. Some can be resolved easily, while others involving data collection will take longer to implement; examples of the latter may include problems that require changes in survey coverage or questionnaire design, design of new imputation methods for nonresponse, or revised procedures for incorporation of new businesses in surveys. Even where it is not possible to fix or explain data immediately, it is important that the issues be identified for later investigation and resolution.

Methods for Identifying Data Problems

9.27 The most basic form of editing is done by just looking at the numbers as they will be published, without any additional calculations, tabulations, or charts—a practice referred to as "eyeball testing." Even with a limited presentation of data, a number of potential problems will be apparent to the careful eye:

a. different orders of magnitude and different numbers of digits,

b. numbers that change too much—excessive growth or decline,

c. numbers that do not change at all—no change at all may suggest that numbers have been copied into the wrong period,

d. numbers that are inconsistent with other economic data, and

e. numbers that change too little—a much slower growth than other items may point to a problem.

9.28 Eyeball testing does not use a computer or other tools to pinpoint problems, so it depends solely on the editor's ability to detect possible inconsistencies. As a result, many data problems will not be apparent and may be missed. Despite these limitations, such a basic examination can be implemented quickly and is much better than no editing at all. Someone who was not involved in the original calculations is more likely to notice potential problems. For example, the entire QNA team should have access to the final publication prior to release to spot possible inconsistencies or mistakes.

9.29 The final QNA results should always go through a rigorous system of logical and plausibility checks before publication. Many problems in the estimates are only revealed by comparing different variables of the accounts or by making additional calculations. This entails a more sophisticated and time-consuming form of editing. However, modern computer systems allow the implementation of complex editing tools in a very efficient and systematic way.

9.30 More advanced forms of analytical editing can be done with charts or tables. Usually, the interest in this case is in big changes rather than precise relationships. Charts are particularly suitable in this task because they can be read by glancing, especially to identify outliers. Line charts and bar charts are alternative presentations that give different emphases. Charts may sometimes take more time to set up than tables, but are worthwhile because of their usefulness. Tables allow errors to be traced more easily because an exact number is known, so they might be used to investigate a problem detected by a chart. Both charts and tables can easily be standardized and updated continuously during the editing process. Different formats each have their own uses, so it is desirable to have a range of presentations.

9.31 In general, editing procedures are best applied at both detailed and aggregate levels. In aggregate form, problems can be hidden by large values of data or by errors in offsetting directions canceling each other out. With more specific identification of the affected components, it is possible to focus on the cause of the problem. Some problems are only apparent at a detailed level, because they get swamped at a higher level of aggregation. In other cases, the level of "noise" or irregular movements in the series is high at a micro level, so problems may become more obvious at a higher level, as the noise in the series becomes relatively smaller. Later in this chapter, a simplified supply and use model is described to transform aggregate GDP discrepancies into detailed imbalances at the product level.

9.32 Problems are sometimes more apparent in volume and seasonally adjusted data. These presentations remove some sources of volatility and hence isolate remaining fluctuations. For example, an unadjusted series may have a strong seasonal pattern, with quarter-to-quarter changes so large that trends and irregularities are hidden.

9.33 Some logical and plausibility checks are presented in this section, which can be taken as a reference and adapted to the particular QNA compilation system implemented by each country.

Logical

9.34 Logical edits are those in which exact relationships must hold, based on mathematical identities or definitions, such as in the following examples:

a. Total is equal to the sum of components (e.g., GDP = Household final consumption + Nonprofit institutions serving households consumption + Government final consumption + Gross fixed capital formation + Changes in inventories + Acquisitions less disposal of valuables + Exports of goods and services − Imports of goods and services and Manufacturing = Food + Textiles + Clothing).
b. Commodity balances, which are checks of the relationship between supply and use when they have been derived independently. They can best be done as a part of a comprehensive supply and use framework in which balancing and interrelationships between components are dealt with simultaneously. Even without a comprehensive supply and use framework, however, balancing supply and uses of particular products is a useful way to find errors or inconsistencies between data from different data sources.
c. Definitions of specific terms (e.g., Implicit price deflator = Current price value/Constant price (or chained) value and Value added = Output − Intermediate consumption).
d. Year is equal to the sum of the quarters for original data. For seasonally adjusted, working-day adjusted, or trend-cycle data, this edit applies when the quarterly transformed data are benchmarked to the annual unadjusted data. Otherwise, the discrepancy between the sum of seasonally adjusted data and the annual unadjusted data should be monitored (see Chapter 7 for further details on how to assess the consistency between annual data and seasonally adjusted data).

9.35 Rounding errors may sometimes disturb these relationships slightly, but they should be relatively minor and not used as an all-purpose excuse for acceptance of inconsistency.

Plausibility

9.36 Edits of plausibility rely on expectations of how series should move in relation to past values of the same series and to other series. In contrast to logical edits, there is not an exact requirement that the data must satisfy; rather, data can be seen as being in a spectrum that goes from expected values to less expected but still believable values, to unusual values, and on to unbelievable values. This assessment requires an understanding of what is a realistic change: that is, the national accountant must have a good grasp of economic developments as well as an understanding of the statistical processes.

9.37 It is important to assess QNA indicators for their ability to track movements in the corresponding annual series. As explained in Chapter 6, the annual benchmark-to-indicator (BI) ratio shows the relationship between the two series. A stable annual BI ratio shows that the indicator is representative. Alternatively, a trend increase or decrease in the BI ratio points to bias in the movements of the indicator series. Volatile changes in the annual BI ratio point to problems that are less easily diagnosed and solved.

9.38 The following are some other editing calculations that can be made to assess the plausibility of data:

a. Percentage changes (e.g., for quarterly estimates, compared with one quarter or four quarters earlier) can be calculated. These can help identify cases where rates of growth or decline are excessive, or where one component is moving in a different way from a related series. It may be feasible to develop thresholds to identify unusual changes on the basis of past behavior. As well as being useful in editing, percentage change tables are a useful supplementary way of presenting data.
b. Changes in level (in addition to percentage changes) can also be used to check the magnitude of increase or decrease for variables expressed in value terms or for constant price data with the same base year.
c. Contributions to change, which show the factors behind growth in aggregates (rather than just growth of series in their own right), can reveal excessive positive or negative contributions from one specific industry, or one specific expenditure component.[2]
d. Commodity balances can be made.[3] If one item is derived as a residual, this item should present regularity over time and can easily be interpreted from an economic point of view.
e. Ratios of various kinds can be calculated (particularly where series have independent sources):
    i. Implicit price deflators—that is, the ratio of current price values to constant price values—are a kind of price index.
    ii. At a detailed level, if the value and volume measures have been obtained independently, a peculiar implicit price deflator movement could indicate incompatible trends between the current price and chain-linked (or constant price) source data.
    iii. At an aggregated level, it is useful to calculate the corresponding Laspeyres price indices. Comparison between the Laspeyres price indices and implicit price deflators points to the effect of compositional changes on the implicit price deflators. No extra data are required to calculate the Laspeyres price indices, and they are of analytical interest in their own right.
    iv. Productivity measures show the relationship between inputs and output/value added, and hence may point to problems in input or output data. The most common and simple measure is labor productivity: that is, output or value added in chain-linked form (or at constant prices) per employee or hour worked. For example, the output, value added, and employment series may look reasonable individually, but they could be moving in incompatible ways. In this case, the productivity measure will highlight the inconsistency in the trends by the implausible movement. Some countries publish labor or total factor productivity estimates; again, these are of analytical interest.
    v. Ratios between other closely related series (e.g., construction in gross fixed capital formation and construction output in production estimates; value added and output for the same industry; components to total ratios, such as manufacturing/total; and inventories/sales).
    vi. Other ratios between series. Less stable ratios will occur for series that are linked by

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[2] Calculated as $(x_t - x_{t-1}) / A_{t-1}$, where x is the component series and A is an aggregate. For example, if household consumption has increased by 5 since the previous period and GDP was 1,000 in the previous period, the change in household consumption makes a contribution to GDP growth of 0.5 percentage point. For further details on the calculation of contributions to change, see Chapter 8.

[3] These are already discussed under logical edits. If the supply and use data are complete, this is a logical edit. If the supply and use data are incomplete, this is more a test of plausibility.

behavioral relationships: for example, consumption and saving to income, and current account deficit to saving. However, changes in these ratios can point to data problems and also help national accounts compilers advise data users.

f. Implicitly derived series should be examined closely, as they may highlight data problems: for example, intermediate consumption when value added has been derived with an output indicator.

g. Revisions (since the previous publication or several publications earlier) should be examined.[4] Newly introduced mistakes will show up as revisions. Consistent patterns of revisions (i.e., upward or downward) suggest a biased indicator. Large, erratic revisions may indicate a problem with early data that can be investigated. The incorporation of annual benchmarks into quarterly estimates will cause revisions and could reflect problems in the sources or methods for either annual or quarterly data. To calculate and track down the causes of revisions, it is necessary to archive data from previous releases, by keeping printouts and copies of computer files or by saving earlier data in the computing system under separate identifiers.

9.39 It is not a coincidence that many of these tools for plausibility editing are also of interest to users of the statistics. Both editors and analysts are performing similar tasks of looking at how the data are moving and why. Performing these tests during the compilation work facilitates the task of addressing possible requests for clarification from users.

9.40 Discrepancies and residual items should receive particular attention because they are not derived directly, and problems in certain components are often highlighted by the balancing item. The next sections deal with the problem of addressing and balancing discrepancies between different measures of quarterly GDP.

Balancing Quarterly GDP Discrepancies

9.41 When there are two or more independent measures of an item, inconsistencies inevitably will arise. The inconsistencies could be between two measures of GDP estimated by different approaches or, in a detailed system, between the supply and use of a particular product. Balancing[5] is the process of dealing with these inconsistencies. This section discusses different options for reconciliation and the considerations that need to be taken into account in choosing among them. Balancing issues arise all the time in both annual and quarterly estimates. The approach to ANA reconciliation will typically be the starting point for QNA, although some different approaches may emerge because of the quarterly emphasis on speed and time-series maintenance. In addition, the QNA data will be strongly influenced by the balancing carried out in the annual data, because the annual balances (or imbalances) will be passed to QNA through the benchmarking process. The options available are balancing by detailed investigation, balancing by mathematical methods, or publication of discrepancies in varying ways.

9.42 One important type of balancing is the process of adjusting data at a detailed level within a full supply and use (or input–output [IO]) table framework or through commodity balances for key products. Supply and use tables (SUT) provide a coherent framework to identify inconsistencies at the detailed product level. Supply and use balancing is at its most useful when investigations are used to identify the cause of discrepancies. Even if supply and use data are not available in a comprehensive framework, a partial version in the form of commodity balances for particular products can provide some of the benefits of SUT for balancing. A few countries use a supply and use framework on a quarterly basis, typically at a less detailed level than annually and as a compilation tool that is not intended for publication. SUT can also be used as an editing tool for the quarterly GDP, as discussed in the next section.

9.43 Another type of balancing occurs when there are independent estimates of GDP by two or more approaches but without the details of a supply and use framework. In such cases, discrepancies become

[4] Chapter 12 presents an analytical framework to conduct a quantitative revisions analysis.

[5] In the previous version of this manual, the term "reconciliation" was used in place of "balancing." To avoid any confusion with the reconciliation techniques discussed in Chapter 6, the term "balancing" is preferred in this new edition. However, balancing and reconciliation can be given the same meaning in the context discussed.

apparent only when the data are aggregated, making well-based balancing difficult or impossible because the aggregate discrepancies provide no indications of which components are causing the discrepancies. Investigations may still prove useful, however, as patterns in the discrepancies may point to specific problems (e.g., reversed fluctuations point to timing problems, persistent differences of a similar size point to a bias in a major source, and procyclical differences may point to problems in measuring new businesses).

9.44 Some countries have a mix of methods in which supply and use balancing occurs on an annual or less frequent basis, while independent estimates are made quarterly. In these cases, the quarterly discrepancies will cancel out within the quarters of balanced years and generally tend to be smaller because of the benchmarking process.

9.45 A number of countries do not have an apparent problem of balancing, because they do not have SUT; they have only one approach to measuring GDP; or they have two or more approaches, but only one is derived independently, with one component in the other(s) derived as a residual. Besides the analytical interest of having different approaches, however, discrepancies can be useful pointers to data problems that would otherwise be undiagnosed.

9.46 For both supply and use and independent measures of GDP, investigation and resolution of the problems is the ideal method of balancing. The processes of confrontation and balancing at a detailed level can identify many issues and are highly regarded by national accounts compilers. The extent of adjustment that can be made should depend on the expertise of the statistical compilers. Adjustment should not be made lightly, but should be based on evidence and be well documented. There is potential for concern if uninformed guesses are made or adjustments are made with a view to meeting some political objective (or that accusations could be made that politically motivated manipulation has occurred). Adjustments should be monitored to see if they later need to be reversed.

9.47 For cases in which there is insufficient time, expertise, or information for investigation to achieve complete balancing, there are a number of alternatives for treating the discrepancies. There is no international consensus, however, and treatments must account for national circumstances.

9.48 One technique to remove discrepancies is the allocation of discrepancies to a single category by convention. The discrepancy is, then, no longer apparent. Usually, the chosen category is large (such as household consumption) or poorly measured (such as changes in inventories). In effect, the estimates are no longer independent, and one source is forced to equal the other. As a consequence, the information content of the chosen component is reduced or even lost. And although the discrepancy is hidden in this way, it is not solved. At least, the component should be properly labeled: for example, as "changes in inventories plus statistical discrepancy."

9.49 A related option for removing the remaining discrepancies is to allocate them by mathematical or mechanical techniques across a number of categories. The chosen categories could be a selected group or all categories. Methods may involve simple or iterative prorating; for example, an iterative prorating method (called "RAS") can be used for SUT and other multidimensional balancing situations. The selection of which categories to adjust by prorating and which categories to leave unchanged should be based on explicit assessments of which estimates were better. A more sophisticated approach can be designed to preserve the movements in the original series. The multivariate Denton technique presented in Chapter 6 (or the equivalent two-step approach) can be used to eliminate temporal and cross-sectional discrepancies with the least possible impact on the period-to-period rates.

9.50 Like allocation to a single category, allocation of the discrepancies across several categories may be achieved at the expense of damaging the time-series quality of the individual components. If an error that belongs in one component is distributed across a number of components (whatever is the reconciliation technique used), all the components will be less accurate. If the discrepancies are trivial, this may not be of concern. But if they are significant, these techniques merely hide the problem rather than solving it. It is a disservice to users to leave them unaware of the actual extent of uncertainty. Minimizing problems in data sources can also undermine the attempts of national accountants to highlight those problems and reduce the chance of bringing about improvements. Because of the greater significance of timing problems in source data and the reduced time for investigation of the causes of inconsistencies, the limitations of balancing are more serious in QNA than in ANA. As a result, some countries that have balanced ANA allow imbalances in QNA.

9.51 The alternative to balancing by investigation, allocation to a single component, or mathematical removal is to present the remaining discrepancies openly. Within that alternative, one presentation is to publish more than one measure of GDP or supply and use of a product. Alternatively, a single measure can be identified as preferred on the basis of a qualitative assessment of data sources or mathematical testing of the properties of the alternative measures (or a mixture of them). Explicit statistical discrepancy items would then be needed (in aggregate for independent measures of GDP and at the product level for supply and use), so that the sum of the items equals the preferred total.

9.52 The main concerns about showing explicit discrepancies are that they may cause confusion among users and criticism or embarrassment to the compilers. To the extent that the discrepancies represent problems that have identifiable causes and can be solved, the criticism is justified and investigations should have been carried out to make appropriate adjustments. To the extent that the discrepancies are trivial, mechanical techniques would be justified to remove them. In the remaining cases where the differences are significant and the causes unknown, however, it is better to admit the limitations of the data because the uncertainty is genuine. The ultimate objective must be to solve the problem, and being transparent to users about shortcomings is more likely to help bring about the required changes in data collection or compilation resources. While it is understandable that some compilers might be inclined to "sweep problems under the carpet," in the longer term, being open will avoid even more serious—and valid—criticism about secretiveness and covering up important problems.

9.53 The objective of soundly based balancing is the same in both ANA and QNA. Similarly, the options and considerations to be taken into account in choosing between them apply in both situations. There are, however, some procedural and practical differences. Procedurally, QNA balancing problems are likely to be most severe for the most recent quarters; because for earlier quarters, the same issues would already have been identified in the ANA. Benchmarking brings the benefits of annual balancing to QNA, so that additional quarterly balancing may be a lower priority. There are also practical considerations, because there is less opportunity to investigate discrepancies during quarterly compilation.

9.54 Benchmarking means that QNA will benefit indirectly from the balancing carried out on the annual data, so that discrepancies may be smaller and balancing less urgent. If the ANA are already balanced and the QNA are benchmarked, the need for separate balancing is reduced. For the balanced years, discrepancies within quarters will cancel out over the whole year and tend to be small. For quarters outside the annually reconciled period, the discrepancies will tend to be smaller, close to the benchmark years. For the most recent quarters that have no annual benchmark, if the indicators correctly track their benchmarks, previously identified causes of inconsistencies will already have resulted in adjustments that are carried forward. Accordingly, the QNA discrepancies will tend to be limited to those caused by noise, divergence between benchmarks and indicators, or data problems that have emerged since the last benchmark. Of course, if the annual data contain unreconciled inconsistencies, they will also be carried forward to the QNA, which will be at least as imbalanced as their ANA equivalents. The implications of benchmarking for balancing are discussed further in Chapter 6.

9.55 QNA are typically compiled with less time, information, and detail than ANA. The reduced time and information tend to restrict the capacity to investigate problems that have emerged in the most recent quarters. Timing errors and statistical noise may be difficult to resolve by investigation. These issues are more significant in QNA because they tend to cancel out over a whole year. In terms of user interests, analysis of QNA tends to strongly emphasize the time-series aspects of QNA data rather than structural relationships. Also, in a quarterly supply and use system, the tables are compilation tools and are not generally published in their own right, so that time-series consistency is given more weight than structural balance. Therefore, there is likely to be less investigation and more acceptance of unresolved discrepancies in a QNA system than an ANA system.

A Supply and Use Model for Editing the Quarterly GDP

9.56 Quarterly GDP is typically calculated by aggregating a limited number of components, derived either from the production side (i.e., gross value added of economic activities plus net taxes on products) or from the expenditure side (i.e., consumption plus capital formation plus net exports). In most countries, the production approach is chosen as the preferred approach for deriving the official quarterly GDP measure. The production-based GDP is then used as a predetermined variable in the expenditure breakdown. This situation generally leads to two consequences: one is to derive one of the expenditure items residually (such as changes in inventories or household consumption), the other is to present statistical discrepancies as a residual item between the production-based GDP and the sum of the expenditure components. Either way, the inconsistencies between expenditure and production components are not properly investigated and addressed. As a result, the quality of the quarterly GDP may be undermined.

9.57 One way to achieve consistent quarterly GDP data at a detailed product level is to compile SUT at the quarterly level. A set of SUT is considered the best framework for GDP compilation in the *2008 SNA*, at any frequency. Some countries with sophisticated national accounts systems derive the official quarterly GDP from quarterly SUT.[6] In effect, the main advantage of using a supply and use framework is to help fill data gaps of specific items with missing information, which could be a very complicated task in a QNA system based on aggregate variables. However, developing a quarterly supply and use system may be too demanding in terms of resources. Countries should be aware that preconditions for a successful development of quarterly SUT are to have a well-established system of annual SUT, sophisticated staff with significant SUT expertise, and willingness to revolutionize the existing QNA compilation system.

9.58 Alternatively, SUT can offer a convenient framework to evaluate the consistency of quarterly GDP data derived at a more aggregate level. SUT are progressively being adopted by countries as the main framework for calculating benchmark years of national accounts. Countries with sophisticated systems of national accounts are producing SUT every year, which are used to obtain detailed and consistent annual estimates of the GDP. The availability of SUT (either for a benchmark year or updated every year) should also be exploited for improving the quality of quarterly data.[7]

9.59 The validation process should be performed by means of a simplified quarterly supply and use model derived on the basis of assumptions from the most recent annual SUT. Some countries have recently developed quarterly supply and use models for editing the quarterly estimates.[8] This section draws from this experience and tries to present a systematic approach for editing the quarterly GDP using a quarterly supply and use model.

9.60 The main advantage of using SUT in the editing process of the quarterly GDP is that inconsistencies calculated at the aggregate level can be transformed into detailed imbalances between total supply and total use of specific products (or between total output and total input of specific economic activities, if the fixed IO ratio assumption is relaxed). This detailed view permits to pinpoint the major sources of inconsistencies and allows the compilers to identify the most critical areas of intervention. The editing process should be reiterated until the quarterly GDP data show a satisfactory degree of consistency in the quarterly supply and use model.

9.61 This editing tool can be helpful in assessing the consistency of both quarters that are benchmarked to closed years and quarters that are extrapolated from the latest annual benchmark. Although the quarterly data are benchmarked to consistent annual data, they may still lack consistency at the quarterly level due to seasonal effects, outliers, and other sub-annual effects. These effects may introduce distortions in the measurement of short-term changes of the GDP, with possible consequences in the identification of

[6] For example, the Netherlands has a long history of compiling supply and use tables at the quarterly level (see De Boer and others, 1999). Annual and quarterly aggregates are derived as the sum of detailed components in the quarterly supply and use tables.

[7] See Eurostat (2008) for a comprehensive description on supply and use tables in the national accounts. This section assumes that the reader is familiar with the supply and use methodology.

[8] Three examples of countries using a supply and use model as an editing tool for the quarterly GDP are Australia (Lichtwark, 2006), Canada (Tebrake, 2013), and United Kingdom (Compton, 2008).

business-cycle turning points. In extrapolation, a supply and use model for validation can be particularly useful in verifying that the quarterly aggregate GDP figures are internally consistent.

9.62 A small example is presented in this section to explain some basic ideas underlying the construction of a quarterly supply and use model for editing the quarterly GDP.[9] Example 9.1 shows a simple set of annual SUT, with a breakdown of four products and four economic activities (see the notes below the table for further details). Example 9.2 contains two independent estimates of the quarterly GDP by production (GDP-P) and by expenditure (GDP-E) for the subsequent year. The last row in the table shows the aggregate discrepancy between GDP-P and GDP-E. The objective of the example is to show how it is possible to develop a quarterly supply and use model from the available annual SUT that makes it possible to distribute the aggregate GDP discrepancy into specific product imbalances.

9.63 The quarterly supply and use model described here is applied to seasonally adjusted data in volume terms. A quarterly supply and use model should be based on ratios calculated from annual SUT. The next section discusses the most sensible assumptions when it comes to construct quarterly tables from annual ones. Annual-to-quarter assumptions work better for volume estimates than for nominal estimates, as the price component may be subject to sudden changes even in the short term. For example, large swings in international oil prices can modify remarkably the IO ratios of energy-intensive industries. Similarly, assumptions from annual SUT are better suited for seasonally adjusted data. Seasonal effects may change the annual relationships between variables, so it would be inappropriate to apply annual ratios to distribute quarterly patterns not adjusted for seasonality. It should be noted, however, that seasonally adjusted data may be revised frequently, especially for the most recent quarters. This could introduce noise in the validation process of supply and use models using seasonally adjusted data.

Construction of a Quarterly Supply and Use Model

9.64 The first step in the construction of a quarterly supply and use model is to create a domestic output table (at basic prices) from the production-based GDP estimates. The domestic output table distributes output by economic activity (columns) into primary and secondary products (rows). Quarterly gross output is usually calculated in the QNA system by economic activity, very often by assuming a stable relationship with gross value added (in volume terms).[10] A quarterly distribution of the output of economic activities can be made by taking the shares of primary and secondary products from the (most recent) annual SUT. This assumption should not be critical, because the mix of products produced by an industry (in volume terms and seasonally adjusted) should remain fairly stable in the short term. A quarterly domestic output table is derived in Example 9.3, using the aggregate quarterly GDP data given in Example 9.2 and the ratios calculated from the annual SUT given in Example 9.1.

9.65 The next step is to populate the remaining elements of the supply table. Quarterly data of imports are readily accessible with sufficient detail from the merchandise trade statistics and balance of payments data; therefore, it should not be complicated to fill the imports column with actual data. In absence of detailed data, the structure of imports from the annual SUT can be used to distribute total quarterly imports of goods and services (this assumption is used in the example). However, this assumption may not work well for economies with large shares of imported capital goods, which can cause swift changes in the mix of imports.

9.66 The supply table is completed with the transformation of basic prices into purchasers' prices, which is the valuation needed to conform the product supply to the use table. The first transformation required is to allocate trade and transportation margins (i.e., distributive margins) among the various

[9] For space reasons, the example shown in this section presents a small and very stylized set of supply and use tables. Furthermore, some assumptions may not adapt well to country-specific situations. In practical applications, the adoption of quarterly-supply models for editing the quarterly GDP should be more complex than the simplified framework presented in this chapter. Moreover, actual data should replace assumptions whenever they are available (e.g., exports and imports data are available from merchandise trade statistics).

[10] Some countries calculate directly gross value added in the QNA system. For the development of a quarterly supply and use model, the calculation of quarterly gross output (and quarterly intermediate consumption) is essential.

Example 9.1 Annual Supply and Use Tables

Supply Table		Agriculture (1)	Industry (2)	Distributive Services (3)	Other Services (4)	Total Supply at Basic Prices (5)	Imports (6)	Distributive Margins (7)	Net Taxes on Products (8)	Total Supply at Purchasers' Prices (9)
(1)	Agriculture	56.1	0.0	0.2	0.0	56.4	6.4	11.0	1.6	**75.4**
(2)	Industry	0.3	399.3	5.1	5.1	409.9	154.5	111.8	35.0	**711.1**
(3)	Distributive Margins	0.1	6.6	110.3	5.8	122.8	0.0	-122.8	0.0	**0.0**
(4)	Services	0.4	12.1	10.9	387.6	411.0	25.5	0.0	15.1	**451.6**
(5)	**Total**	**56.9**	**418.0**	**126.5**	**398.6**	**1,000.0**	186.4	0.0	51.6	**1,238.0**

Use Table		Agriculture (1)	Industry (2)	Distributive Services (3)	Other Services (4)	Total Intermediate Uses (5)	Household Consumption (6)	Government Consumption (7)	Gross Fixed Capital Formation (8)	Changes in Inventories (9)	Exports (10)	Total Final Uses (11)	Total Use at Purchasers' Prices (12)
(1)	Agriculture	14.6	17.0	1.6	2.6	35.8	22.8	0.0	0.4	2.5	13.9	39.6	**75.4**
(2)	Industry	5.6	239.2	20.1	48.0	312.9	132.3	4.7	89.6	6.6	165.0	398.2	**711.1**
(3)	Distributive Margins	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.0**
(4)	Services	1.1	51.5	36.2	100.9	189.6	126.2	98.5	13.5	0.0	23.7	261.9	**451.6**
(5)	**Total**	21.3	307.7	57.9	151.5	538.3	281.3	103.2	103.5	9.1	202.6	699.7	**1,238.0**
(6)	Gross Value Added	35.6	110.3	68.7	247.1	461.7							
(7)	**Total Output**	**56.9**	**418.0**	**126.5**	**398.6**	**1,000.0**							

(Rounding errors in the table may occur.)

Annual Supply and Use Tables for 2010

Example 9.1 shows a simplified system of supply and use tables for the year 2010. The detail level of the tables is four products (rows) and four economic activities (columns), including agriculture (column 1), industry (column 2), distributive services/margins (column 3), and other services (column 4). In the supply table, the domestic output table contains primary and secondary production activities. Total domestic output at basic prices is 1,000 units.

The supply table is completed with imports (column 6), redistribution of margins by product (column 7), and net taxes on products (column 8). Total supply at purchasers' prices is 1,238 units.

Rows from 1 to 5 of the use table show how the product supply is allocated to intermediate and final uses. Total use at purchasers' prices is 1,238 units, matching the total value in the supply table. By columns 1–5, the use table shows the output distribution by intermediate consumption (at purchasers' prices) and gross value added (at basic prices) for each economic activity.

The 2010 supply and use tables are balanced and provide benchmarks for the quarterly accounts.

products. This calculation can be done using the structure of margins by product from the annual SUT. Because the total amount of margins is known from the output table, the initial allocation of margins by product has to be reconciled with the total amount. A similar two-step transformation is done for taxes less subsidies on products. The initial allocation of net taxes based on the flows of output is reconciled with the total quarterly net taxes provided by government data. Example 9.4 shows the steps to calculate a quarterly supply table at purchasers' prices.

9.67 The intermediate consumption table should also be linked to the production-based GDP estimates. Intermediation consumption by industry should preserve the fixed (or stable) relationship between gross value added and gross output. Hence, total costs by industry are to be distributed based on the input structure in the annual SUT. A high degree

Example 9.2 Quarterly GDP by Production and by Expenditure

GDP by Production (GDP-P)					
Gross Output	q1 2011	q2 2011	q3 2011	q4 2011	*2011*
Agriculture	14.6	14.7	15.0	14.7	*59.0*
Industry	108.0	107.2	105.9	106.4	*427.5*
Distributive Services	32.7	32.6	32.9	32.9	*131.2*
Other Services	102.2	102.3	101.7	102.4	*408.5*
Total Output	**257.5**	**256.8**	**255.5**	**256.4**	***1,026.2***
Intermediate Consumption	q1 2011	q2 2011	q3 2011	q4 2011	*2011*
Agriculture	5.4	5.5	5.6	5.4	*21.9*
Industry	79.3	78.8	77.8	78.2	*314.1*
Distributive Services	14.9	14.9	15.0	15.0	*59.8*
Other Services	38.9	38.9	38.7	38.9	*155.4*
Total Intermediate Consumption	**138.6**	**138.0**	**137.1**	**137.6**	***551.2***
Gross Value Added	q1 2011	q2 2011	q3 2011	q4 2011	*2011*
Agriculture	9.2	9.3	9.4	9.2	*37.1*
Industry	28.6	28.4	28.1	28.2	*113.4*
Distributive Services	17.8	17.8	17.9	17.9	*71.3*
Other Services	63.3	63.4	63.0	63.4	*253.1*
Net Taxes on Products	13.2	13.1	13.3	13.2	*52.8*
GDP-P	**132.2**	**132.0**	**131.7**	**132.0**	***527.8***
GDP by Expenditure (GDP-E)					
	q1 2011	q2 2011	q3 2011	q4 2011	*2011*
Household Consumption	72.2	72.0	71.8	71.9	*287.9*
Government Consumption	26.0	26.1	26.1	26.2	*104.5*
Gross Fixed Capital Formation	26.9	26.8	26.5	27.2	*107.4*
Changes in Inventories	2.0	2.5	1.1	0.5	*6.1*
Exports	53.5	53.5	53.2	54.1	*214.4*
Imports	48.4	48.7	47.8	48.4	*193.3*
GDP-E	**132.3**	**132.2**	**130.9**	**131.5**	***526.9***
GDP-P – GDP-E	***–0.1***	***–0.3***	***0.7***	***0.6***	***0.9***

(Rounding errors in the table may occur.)

Quarterly GDP Estimates for 2011

Example 9.2 contains quarterly GDP data for the year 2011 disaggregated by production components (i.e., gross output, intermediate consumption, and gross value added by economic activities plus net taxes) and expenditure items (i.e., main final user categories). The classification of the quarterly GDP is consistent with the annual supply and use tables shown in Example 9.1. The quarterly data are assumed to be in volume terms, additive, and seasonally adjusted. The last column reports the annual sum of the corresponding quarterly values.

Gross value added (GVA) by industry is calculated as the difference between gross output and intermediate consumption plus net taxes. GVA is derived assuming stability between output and intermediate consumption.

The two GDP estimates are independently derived. The last line of the table shows the discrepancies between GDP-P and GDP-E. The annual discrepancy is 0.9 units, mostly concentrated in the last two quarters of the year (0.7 and 0.6, respectively). No product/industry breakdown of the discrepancies is available.

of homogeneity in the inputs is reasonable in the short run. Example 9.5 shows the construction of quarterly intermediate consumption tables.

9.68 The last step in the calculation of quarterly SUT is to break down the final demand components of the quarterly GDP by product. The use table should be based on quarterly estimates of expenditure components that are as much as possible independent from the production-based quarterly GDP estimates. The quarterly use table is presented in Example 9.6.

9.69 The quarterly total flows in the use table are distributed by product using (again) the simplest

Example 9.3 Quarterly Domestic Output Table at Basic Prices

Output Share by Product (%) for 2010		Agriculture (1)	Industry (2)	Distributive Services (3)	Other Services (4)
(1)	Agriculture	98.64	0.01	0.17	0.00
(2)	Industry	0.57	95.54	4.02	1.28
(3)	Distributive Margins	0.17	1.57	87.18	1.46
(4)	Other Services	0.62	2.89	8.63	97.26
(5)	**Total**	**100.00**	**100.00**	**100.00**	**100.00**

Output at Basic Prices for q3 2011		Agriculture (1)	Industry (2)	Distributive Services (3)	Other Services (4)	Total Output at Basic Prices (5)
(1)	Agriculture	14.8	0.0	0.1	0.0	14.8
(2)	Industry	0.1	101.2	1.3	1.3	103.9
(3)	Distributive margins	0.0	1.7	28.7	1.5	31.9
(4)	Other services	0.1	3.1	2.8	98.9	104.9
(5)	**Total**	**15.0**	**105.9**	**32.9**	**101.7**	**255.5**

(Rounding errors in the table may occur.)

Calculation of Quarterly Domestic Output Table for q3 2011

In this example, quarterly output is available only by economic activity. The first step in the calculation of the quarterly supply and use model is to create a domestic output table where the industry output is distributed by product. This is done by taking into account the primary and secondary activities in the 2010 annual supply and use tables shown in Example 9.1.

The 2010 output shares of industries by product are shown in the top table. For example, 98.64 percent of the agriculture output is made of agricultural products, 0.57 percent by industrial products (mining, manufacturing, electricity, and construction), 0.17 percent by margins, and 0.62 percent by other services.

The annual shares for 2010 are used to distribute the quarterly output by product. For sake of simplicity, only the table for q3 2011 (third quarter of 2011) is presented. Total output by economic activity in q3 2011 (shown in row 5 and taken from Example 9.2) is distributed according to the percentage shares shown in the top table (figures are rounded to one decimal place). For example,

Output of industrial goods produced by industry in q3 2011 $= 105.9 \times 0.9554 = 101.2$
Output of industrial goods produced by distributive services in q3 2011 $= 32.9 \times 0.0402 = 1.3$
Output of other services produced by agriculture in q3 2011 $= 15.0 \times 0.0062 = 0.1$.

Column 5 calculates the sum of output by product at basic prices.

assumption: namely, by assuming that the annual shares in the SUT for each demand category remain stable in the following quarters. This assumption can be satisfactory for household consumption, which presents fairly regular patterns dominated by frequent purchases (food, housing, transportation, etc.). However, this assumption may not hold true, even in the short term, for other demand categories. For example, purchases of certain capital goods may be very volatile, which can introduce substantial differences with respect to the supply and use shares. The same can happen with exports, especially for small-open economies. Once again, this assumption may work well only for quarterly seasonally adjusted data.

9.70 For changes in inventories, it is very unlikely that the product allocation in a year remain the same for following periods. Inventory levels can move very rapidly between quarters due to different phases in the economy, movements that can modify substantially the product shares estimated in the annual SUT. An alternative assumption for calculating quarterly inventories in the supply and use model is to link the

Example 9.4 Quarterly Supply Table at Purchasers' Prices

Total Supply for q3 2011	Total Output at Basic Prices (1)	Imports (2)	Total Supply at Basic Prices (3) = (2) + (1)	Distributive Margins: Distributive Margins from Annual Supply-use Ratios (4)	Distributive Margins: Reconciled with Total Margins in q3 2011 (5)	Distributive Margins: Difference (6) = (5) – (4)	Net Taxes on Products: Net Taxes on Products from Annual Supply and Use Ratios (7)	Net Taxes on Products: Reconciled with Total Net Taxes on Products in q3 2011 (8)	Net Taxes on Products: Difference (9) = (8) – (7)	Total Supply at Purchasers' Prices (10) = (3) + (5) + (8)
(1) Agriculture	14.8	1.7	16.6	2.9	2.9	0.1	0.4	0.4	0.0	19.9
(2) Industry	103.9	39.6	143.5	28.4	28.9	0.5	8.9	9.0	0.1	181.4
(3) Distributive Margins	31.9	0.0	31.9	–31.3	–31.9	–0.6	0.0	0.0	0.0	0.0
(4) Other Services	104.9	6.5	111.4	0.0	0.0	0.0	3.9	3.9	0.0	115.3
(5) Total	**255.5**	**47.8**	**303.3**	**0.0**	**0.0**	**0.0**	**13.2**	**13.3**	**0.1**	**316.6**

(Rounding errors in the table may occur.)

Calculation of Quarterly Supply Table at Purchasers' Prices for q3 2011

Example 9.4 shows the steps to derive a total supply table at purchasers' prices. Column 1 reports the gross output at basic prices from Example 9.3.

The distribution of imports by product is done according to the imports share by product of year 2010. However, a share distribution of imports and exports is often unnecessary in real-life applications. Quarterly data for imports and exports at a detail product level can be drawn from merchandise trade statistics. No adjustment for shipping and insurance costs is done for simplicity.

To transform basic prices into purchasers' prices, distributive margins should be reallocated to the products they apply to. This is done in two steps. First, distributive margins by product are calculated by applying the share of distributive margins over total supply at basic prices (domestic output plus imports) in 2010. The shares of distributive margins for agricultural and industrial products at basic prices in 2010 are as follows:

Margin share on agriculture products in 2010: 11.0/(56.4 + 6.4) = 11.0/62.8 = 17.52%
Margin share on industrial products in 2010: 111.8/(409.9 + 154.5) = 111.8/564.4 = 19.81%.

This share is applied to total agriculture and industry supply at basic prices in q3 2011: that is,

Margins for agriculture products in q3 2011: 16.5 × 0.1752 = 2.9
Margins for industrial products in q3 2011: 143.5 × 0.1981 = 28.4.

The resulting sum of distributive margins in q3 2011 (31.3) must be reconciled with the total margins estimated in the domestic output table (31.9). It is assumed that this total is determined at an aggregate level, without the use of detailed supply and use relationships. The difference (–0.6) is redistributed in column 5 proportionally to the size of agriculture and industrial margins.

A similar approach is taken for the distribution of net taxes on products. A preliminary distribution by product is generated by taking the 2010 supply and use ratios of net taxes over supply. The difference with total net taxes on products derived at an aggregate level (13.3, given in Example 9.2) is redistributed proportionally in column 8.

Column 10 derives the total supply at purchasers' prices as the sum of total supply at basic prices (column 3), distributive margins (column 5), and net taxes on products (column 8). This column will compare with the total uses at purchasers' prices derived in Examples 9.5 and 9.6.

opening and closing levels of inventories to the supply of products (output plus imports). The difference between the closing and opening stocks would give an estimate of the changes in each quarter. In the example, however, the quarterly distribution of changes in inventories based on the annual SUT is preferred for practical reasons.

Adjustments to Resolve Imbalances

9.71 Once all the elements of the quarterly SUT are generated and put into place, it is possible to compare and analyze the discrepancies between total supply and total use for each individual product. This is the main objective of using SUT for editing the quarterly GDP. Although the quarterly tables are constructed

Example 9.5 Quarterly Intermediate Consumption Table

Input Shares (%) for 2010		Agriculture (1)	Industry (2)	Distributive Services (3)	Other Services (4)
(1)	Agriculture	68.64	5.52	2.71	1.75
(2)	Industry	26.08	77.75	34.79	31.67
(3)	Distributive Margins	0.00	0.00	0.00	0.00
(4)	Other Services	5.28	16.74	62.51	66.59
(5)	**Total**	**100.00**	**100.00**	**100.00**	**100.00**

Intermediate Consumption Table for q3 2011		Agriculture (1)	Industry (2)	Distributive Services (3)	Other Services (4)	Total Intermediate Uses (5)
(1)	Agriculture	3.8	4.3	0.4	0.7	9.2
(2)	Industry	1.4	60.5	5.2	12.2	79.4
(3)	Distributive Margins	0.0	0.0	0.0	0.0	0.0
(4)	Other Services	0.3	13.0	9.4	25.8	48.5
(5)	**Total**	**5.6**	**77.8**	**15.0**	**38.7**	**137.1**

(Rounding errors in the table may occur.)

Calculation of Quarterly Intermediate Consumption Table for q3 2011

On the use side, the first step is to calculate an intermediate consumption table for each quarter. Given the lack of information on intermediate inputs (even at the annual level), this table can only be derived on the basis of assumptions. The top table displays the input coefficients by industry derived from the 2010 supply and use tables shown in Example 9.1. Each column shows the percentage share of input (in percentage points) over total input costs by industry.

The q3 2011 total intermediate consumption by industry (row 5 in bottom table) are split according to the input shares of 2010. For example, the breakdown of intermediate costs of other services (38.7) are derived as follows:

Cost of agricultural products for other services industry:	38.7 × 0.0175 = 0.7
Cost of industrial products for other services industry:	38.7 × 0.3167 = 12.2
Cost of other services products for other services industry:	38.7 × 0.6659 = 25.8.

Column 5 derives by summation the total amount of intermediate use by product.

with several assumptions, they can provide a very useful insight into the sources of aggregate discrepancies arising from the aggregate quarterly GDP estimates. In Example 9.7, the aggregate quarterly discrepancies are distributed into product discrepancies by calculating the difference between total supply and total use at purchasers' prices.

9.72 Product detail of the discrepancies reveals the areas in the accounts that generate the GDP inconsistencies. Specific actions should be taken to address and reduce the largest imbalances for each quarter. Changes should be introduced to the quarterly GDP estimates by production, the quarterly GDP estimates by expenditure, or both. After such changes are made, the quarterly supply and use model should be rebuilt to analyze their effects on the product imbalances. This process should be iterated until the quarterly GDP data are deemed consistent in the quarterly SUT framework.

9.73 Product imbalances can arise for several reasons. It is a task for QNA compilers to understand their causes and find the most suitable remedy. The most frequent causes of inconsistency are lack of coherence between source data used in the production and expenditure approaches, residual seasonal effects in the seasonally adjusted data, differences in the price

Example 9.6 Quarterly Final Use Table

Product Shares (%) for 2010		Household Consumption (1)	Government Consumption (2)	Gross Fixed Capital Formation (3)	Changes in Inventories (4)	Exports (5)
(1)	Agriculture	8.09	0.01	0.41	27.12	6.88
(2)	Industry	47.04	4.54	86.59	72.43	81.42
(3)	Distributive Margins	0.00	0.00	0.00	0.00	0.00
(4)	Other Services	44.87	95.46	13.00	0.45	11.70
(5)	**Total**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Final Use Table for q3 2011		Household Consumption (1)	Government Consumption (2)	Gross Fixed Capital Formation (3)	Changes in Inventories (4)	Exports (5)	Total Final Uses (6)
(1)	Agriculture	5.8	0.0	0.1	0.3	3.7	9.9
(2)	Industry	33.8	1.2	22.9	0.8	43.3	102.0
(3)	Distributive Margins	0.0	0.0	0.0	0.0	0.0	0.0
(4)	Other Services	32.2	25.0	3.4	0.0	6.2	66.9
(5)	**Total**	**71.8**	**26.1**	**26.5**	**1.1**	**53.2**	**178.8**

(Rounding errors in the table may occur.)

Calculation of Quarterly Final Use Table for q3 2011

The quarterly final use table is based on the quarterly GDP estimates by expenditure shown in Example 9.2. The total quarterly amount of each demand category is distributed using the product shares from the final use table of 2010, which are shown in the top table of Example 9.6.

For example, the household consumption expenditures by product in q3 2011 are derived as follows:

Household consumption of agricultural products: $71.8 \times 0.0809 = 5.8$
Household consumption of industrial products: $71.8 \times 0.4704 = 33.8$
Household consumption of other services products: $71.8 \times 0.4487 = 32.2$.

A clarification on the distribution of changes in inventories is worth noting. For sake of exposition, it is assumed that the total changes in inventories is distributed using the share of changes in inventories from the previous year. This assumption is clearly unrealistic, even in the short term. Changes in inventories can be very volatile and may change from one quarter to the next. A better assumption could be to estimate the opening and closing stocks of inventories on the basis of quarterly output, and then derive the change as the difference between the closing stock and the opening stock of inventories by product. Even better, the column of changes in inventories should be populated with exogenous information on the quarterly changes in inventories from economic activities (primary commodities, oil, motor vehicles, etc.)

Column 6 contains the total final use by product at purchasers' prices.

and volume effects, ad hoc intervention to specific components, and diverging extrapolations of related production and expenditure components.

9.74 During the iterative process, it may also be necessary to modify the assumptions from the annual SUT to better fit the quarterly estimates. For example, a large discrepancy between supply and use may call for a stronger accumulation of inventories than normal. A modification of the IO ratio can also be required when the aggregate estimates (and the underlying source data) signal a systematic imbalance between total supply and final uses. Sometimes, it could also be necessary to bring the production data in line with the expenditure estimate. The adjustment process should of course take into account the relative reliability of the estimates. Ideally, components that

Example 9.7 Quarterly Discrepancies from the Supply and Use Model

Supply and Use in q1 2011		Total Supply at Purchasers' Prices (1)	Total Intermediate Uses (2)	Total Final Uses (3)	Total Uses at Purchasers' Prices (4) = (2) + (3)	Discrepancies (5) = (1) – (4)
(1)	Agriculture	19.4	9.2	10.2	19.4	*0.1*
(2)	Industry	183.8	80.6	103.5	184.1	*–0.2*
(3)	Distributive Margins	0.0	0.0	0.0	0.0	*0.0*
(4)	Other Services	115.9	48.8	67.0	115.8	*0.1*
(5)	Total	**319.2**	**138.6**	**180.7**	**319.2**	***–0.1***
Supply and Use in q2 2011						
(1)	Agriculture	19.5	9.2	10.3	19.5	*0.1*
(2)	Industry	183.2	80.2	103.6	183.8	*–0.7*
(3)	Distributive Margins	0.0	0.0	0.0	0.0	*0.0*
(4)	Other Services	116.0	48.7	67.0	115.6	*0.3*
(5)	Total	**318.6**	**138.0**	**180.9**	**318.9**	***–0.3***
Supply and Use in q3 2011						
(1)	Agriculture	19.9	9.2	9.9	19.1	*0.8*
(2)	Industry	181.4	79.4	102.0	181.5	*0.0*
(3)	Distributive Margins	0.0	0.0	0.0	0.0	*0.0*
(4)	Other Services	115.3	48.5	66.9	115.3	*0.0*
(5)	Total	**316.6**	**137.1**	**178.8**	**315.8**	***0.7***
Supply and Use in q4 2011						
(1)	Agriculture	19.5	9.1	9.8	18.9	*0.6*
(2)	Industry	182.4	79.8	102.9	182.7	*–0.3*
(3)	Distributive Margins	0.0	0.0	0.0	0.0	*0.0*
(4)	Other Services	116.1	48.7	67.1	115.8	*0.3*
(5)	Total	**318.0**	**137.6**	**179.9**	**317.5**	***0.6***

(Rounding errors in the table may occur.)

Detailed Quarterly Discrepancies between Total Supply and Total Use for q1 2011–q4 2011

Example 9.7 integrates the quarterly supply and use tables obtained for all the quarters of 2011. Total supply is reported in column 1, whereas total use (as the sum of intermediate and final uses) is derived in column 4. The quarterly supply and use discrepancies by product are shown in column 5. It can be seen that the total quarterly discrepancies (shown in row 5) match the quarterly GDP discrepancies presented in the last row of Example 9.2. However, with a quarterly supply and use model, compilers have a chance to look at the discrepancies distributed by product.

This tool makes it possible to identify areas of possible intervention to address and reduce the GDP discrepancies. In this particular example, the large discrepancies in q3 2011 and q4 2011 are due to an excessive supply (or lack of demand) of agricultural products. Changes to production and expenditure components in the quarterly (aggregate) GDP system can be tailored to make the supply and use of agricultural products more consistent with each other.

are based on less solid information should be altered more than components based on comprehensive source data.

9.75 At the end of this process, small discrepancies in the quarterly supply and use model can be allocated to one GDP component (e.g., a large component such as household consumption). Alternatively, reconciliation techniques can be used to eliminate all the discrepancies analytically. Such techniques should adjust the estimates in a way such that the initial movements in the detailed components are preserved. Chapter 6 presents reconciliation solutions to perform this task in an optimal way.

Further Considerations

9.76 A priority when using SUT for editing the quarterly GDP is that all the assumptions made should maximally preserve the time-series properties of the QNA and avoid any breaks between quarters. Using seasonally adjusted data facilitates the application of annual ratios to distribute quarterly data. However, annual ratios taken from SUT of contiguous years (when available) can be substantially different. This could create steps between the last quarter of one year (based on a set of ratios from that year) and the first quarter of the following year (based on different SUT). In such cases, instead of using fixed quarterly ratios, the annual ratios in the two different years should be interpolated to smooth out the transition between the two levels.

9.77 The construction of fully balanced (or nearly balanced) quarterly SUT in volume terms can also help analyze the consistency of the QNA figures at current prices. The final quarterly SUT at previous year's prices (or at constant prices) can be reflated with available price indices (producer prices, consumer prices, and imports and exports prices). Discrepancies in the resulting quarterly SUT at current prices can identify inconsistencies in the price statistics at a detailed product and industry level. Furthermore, the results from the quarterly supply and use model can be compared with the nominal estimates derived from the QNA system. In this way, a quarterly supply and use model can also be beneficial for improving the estimate of the GDP deflator.

9.78 For QNA data unadjusted for seasonal effects, a quarterly supply and use model based on annual assumptions poses greater challenges. The relationship between economic variables can be highly seasonal. For example, the share of purchases of tourism services during a holiday period is certainly higher than the annual average. However, if proper assumptions about the seasonal variation can be made, a quarterly supply model for unadjusted data can help reveal inconsistencies between the seasonality of production and expenditure data. For example, seasonal peaks and troughs are expected to appear in the same quarters along the supply and use rows. A quarterly supply and use model built from unadjusted data could reveal inconsistencies when related QNA variables are based on indicators with diverging seasonal patterns.

9.79 The level of detail for a quarterly supply and use model should be chosen with pragmatism. Theoretically, one may wish to build quarterly tables with hundreds of rows and columns to improve the robustness of the assumptions. However, the implied work for developing and maintaining large systems of quarterly SUT may be unsustainable. Quarterly SUT should be simplified versions of existing annual tables. The detail level of the QNA system is certainly to be considered when deciding the number and type of products and economic activities of the quarterly supply and use model.

9.80 When the quarterly GDP is calculated only from the production approach, a quarterly supply and use model can be used to develop a rudimentary estimate of quarterly GDP by expenditure. Many countries do not produce quarterly GDP by expenditure because of lack of source data (i.e., lack of a continuous household consumption). Commodity-flow assumptions from available annual SUT (i.e., fixed shares in the use distribution) can be used to allocate the production-based estimates between the different uses. With this approach, however, the resulting GDP estimate by expenditure would be constructed from production-based GDP (no discrepancy would appear between the two estimates). Consequently, the quarterly GDP by expenditure could not be considered an independent measure of the GDP.

Summary of Key Recommendations

- *Editing (or checking) procedures should be put in place to review all the different stages of the QNA calculation process and make sure that the final results satisfy all the national accounts relationships and provide a credible measurement of the economy.*
- *Editing procedures may result in changes in the estimates, which may involve fixing errors or adopting alternative sources and methods. However, all the changes should be documented with supporting evidence. The editing work should never be an excuse for manipulating data.*
- *Editing should be an integral part of the QNA compilation process. The compilation schedule needs to allow time for editing and subsequent investigation and revision of data.*
- *The editing process should be based on a number of logical and plausibility checks at all level of the QNA process (input data, intermediate results, and final estimates). Automated routines should be developed to monitor the QNA results quickly and continuously during the compilation process.*
- *In general, editing procedures are best applied at both detailed and aggregate levels. When annual supply and use tables are available, a quarterly supply and use model should be considered to transform the aggregate GDP discrepancies into detailed product imbalances. A detailed view facilitates the identification of the most critical areas of intervention for improving the quality of the quarterly GDP results.*

Bibliography

Compton, S. (2008), "Populating Quarterly Constant Price Supply and Use Tables with Seasonally Adjusted Data," Office for National Statistics, Newport, UK, September.

De Boer, S., W. van Nunspeet, and T. Takema (1999), "Supply and Use Tables in Current and Constant Prices for the Netherlands: An Experience of Fifteen Years," Working Paper, Statistics Netherlands.

Eurostat (2008), "Manual of Supply, Use and Input-Output Tables," Methodologies and Working Papers.

Lichtwark, P. (2006), "A Supply and Use Model for Editing the Quarterly National Accounts," Australian Bureau of Statistics, Research Paper 5258.0.

Tebrake, J. (2013), "Compiling Canada's Quarterly Gross Domestic: Statistics Canada's Use of Quarterly Supply-Use Tables," paper presented at the OECD Working Party of National Accounts, Statistics Canada, October.

United Nations, European Commission, International Monetary Fund, and Organization for Economic Co-operation and Development (2008), *The System of National Accounts, 2008*, New York: United Nations.

10 Early Estimates of Quarterly GDP

Statistics agencies publish early estimates of quarterly gross domestic product (GDP) in response to a strong demand for timely macroeconomic statistics by users. Early estimates are generally produced on the basis of a partial set of information and a greater use of statistical methods to fill the data gaps. This chapter provides methodological guidelines and practical advice on how to calculate early estimates of quarterly GDP in the broader context of quarterly national accounts (QNA), how to assess their quality, and how to communicate these estimates to the users.

Introduction

10.1 Early estimates of quarterly GDP are developed to satisfy the demand for timely macroeconomic statistics by users (in particular, policymakers). An early estimate of quarterly GDP is generally released within few weeks after the end of the reference quarter, in contrast with two to three months usually required for a complete publication of the QNA.[1] The first estimate of quarterly GDP receives a great deal of attention by users and the media, because it provides the first signal from the system of national accounts about recent developments in the economy. For example, the early GDP estimate is often picked up to determine in real time whether a country is entering a recession or experiencing an economic boom. Given the relevance of early estimates, compilers of QNA should take particular care in the way they produce and communicate them to the users.[2]

10.2 Early estimates of quarterly GDP should be seen as complementary information of detailed and comprehensive QNA estimates, not as their substitute. Countries producing early estimates tend to release aggregate information, sometimes only the GDP growth rates. An early estimate can only provide a preliminary measurement of the economy on the basis of an incomplete amount of information available at the time of its publication. However, they cannot provide the same level of comprehensiveness, consistency, and detail that are typically expected by a full-fledged system of QNA and are subject to a larger risk of revision. The complete version of the QNA should always be published after the release of early estimates, possibly within a quarter from the reference period. This is necessary to incorporate new and updated information in the quarterly source data and provide users with additional details about changes in production and expenditure GDP components.

10.3 Early estimates of quarterly GDP should be compiled using the same methodological framework adopted for later estimates. These include both data sources, methods, and compilation techniques. Ideally, the only difference between early estimates and later estimates should lie on the amount of source data they rely on. Early estimates are based on a partial set of source data. At the time of the early estimate, the quarterly source data are generally incomplete. Consider the case of an early estimate published 30 days after the end of the reference quarter. At that time, monthly indicators used for the QNA may be available only for one or two months of the reference quarter. The missing information in the source data (e.g., the missing months) should be covered by statistical methods or assumptions. Early estimates differ

[1] For the quarterly GDP, the IMF's Special Data Dissemination Standards specifies a maximum lag of one quarter after the reference period.

[2] The methodology discussed in this chapter can also be used to develop monthly GDP estimates. Monthly national accounts compilation raises no methodological issues compared with QNA. However, higher volatility in the monthly data may make it more difficult to pick up underlying trends. Furthermore, additional resources are needed to compile GDP on a monthly basis and generally the need for techniques to fill in data gaps is much higher.

from subsequent estimates, because they use a higher proportion of statistical methods and assumptions to complete the missing information.

10.4 Because they are based on a partial set of information, early estimates have a higher degree of uncertainty than later estimates. Data gaps may be filled using a wide range of techniques, from very basic assumptions (i.e., use the previous observation) to sophisticated time-series or econometric models. Generally, when computing the standard QNA estimates, the results obtained from these techniques are replaced with actual data, already made available. Inevitably, incorporating new and updated source data leads to revisions to the early estimates. Therefore, it is very important to assess the accuracy of the various assumptions and models used in order to minimize revisions and increase the reliability of early estimates.

10.5 Data gaps for early estimates may be covered using a variety of methods and assumptions. The best solution depends on the type of missing information. As far as possible, early estimates should be based on direct measurements of detailed items of the accounts. However, even in countries with well-established QNA based on extensive set of short-term indicators, there may be some items of the accounts for which no timely direct or indirect indicators are available at the time of the early estimate. When no information is available, the missing information should be estimated on the basis of past trends or other assumptions based on related items of the accounts. Although these methods are necessary to fill the data gaps and reach the necessary coverage for the GDP calculation, compilers should use great caution in applying any of these techniques. Overreliance on such assumptions may fail to detect sudden changes in the direction of the economy, which may compromise the serviceability of the GDP as a real-time indicator for turning points and business-cycle analysis.

10.6 Early estimates of GDP should be compiled using the same approach and at the same detail level of later estimates. A more aggregate compilation level may cause additional revisions, because it would require a different aggregation process of the components. In some cases, however, countries may opt for a simplified compilation system for early estimates. Source data for production and expenditure components may not be available at the time of early estimates, whereas they could be available for the regular publication of QNA. In such case, compilers may decide to focus on the approach with the largest amount of information.

10.7 In contrast, publication details of early estimates should be different from later estimates. The release of early estimates may cover only selected items of the accounts (e.g., only total GDP growth) or be presented in a more aggregated form (e.g., only main economic activities). Publication of less detail shows a greater level of uncertainty in disaggregated data and emphasizes the limitations of early estimates to users. Publication of detailed data should take into account the reliability of underlying source data and the possibility of significant revisions with the publication of the standard estimates.

10.8 The publication of early estimates should follow a clear and transparent communications policy. The press release should clearly state that early estimates are subject to a larger risk of revisions than later estimates. The additional uncertainty lies in the difference between the imputations made for the early estimates and the quarterly source data that arrive subsequently. Ideally, compilers should provide the user with a quantitative assessment of the expected amount of revisions between early estimates and subsequent estimates: for example, by comparing the GDP rate of change obtained in both cases. This can be done on the basis of early estimates already published or internal calculations (when the early estimate is released for the first time). Metadata should indicate the amount of missing information and the main assumptions and methods used to fill the data gaps.

10.9 Early estimates should not be confused with forecasts. Early estimates are derived using as much contemporaneous information available as possible, while forecasts only rely on past values to derive future ones. Forecasts of national accounts data should not be a task for QNA compilers. Forecasting models are often based on behavioral equations that relate variables based on economic theory (e.g., output and interest rates). In contrast, early estimates of the GDP (and also later estimates) should maintain a close link between the national accounts variables to be estimated and their source data. In some cases, econometric models exploiting behavioral relationships with leading indicators can be used to validate the results of the early estimation process. However, because these models are not based on strict accounting principles, econometric/forecasting models should not be used as a substitute for statistical measurement and should remain outside the scope of QNA compilation. Behavioral relationships change over time, and they are not suitable to replace measurements. As these models require different skills from those used in national accounts compilation, forecasts are best undertaken by other agencies or other specialized units within the compiling agency.

10.10 The next section offers some considerations on how to choose an appropriate release lag of early estimates. "Filling Data Gaps for GDP Indicators" section illustrates methods and assumptions that can be used to fill the missing information, and discusses how to assess the quality of the methods used. Finally, "Communicating Early Estimates" section provides guidance on how to communicate early estimates to the users.

How Early? Balancing the Trade-off Between Timeliness and Reliability

10.11 A key decision when a country decides to produce early estimates of quarterly GDP is to determine their timeliness: namely, the lapse of time between the end of the reference quarter and the release of the early estimate. If the estimate is released too early, it may miss too much information about the quarter and be subject to large revisions when a fuller set of source data is available for subsequent estimates. Unreliable early estimates should never be published, as providing inaccurate signals about the current state of the economy can create more problems than benefits for the users and undermine the credibility of compilers. If released too late, the early estimate may not be relevant for users, as the publication of the regular, more accurate, estimates would take place in only a few days or weeks. Private companies may decide to build their own system of early estimates based on available short-term indicators, which could generate confusion between official and private estimates of the GDP. Compilers should strike the right balance between timeliness and reliability of the early estimate. This section discusses some factors that should be considered in taking this decision.

10.12 First, compilers should verify the coverage of source data available at different release lags from the end of the quarter. The shorter the lag, the smaller the amount of information available. After a few days, it is very likely to receive only the first month of the quarter for some monthly indicators, while quarterly indicators may be completely missing. At 30 days, there could be one or two months available plus the timeliest quarterly indicators. At 45 days, the information set of the QNA may be full for agriculture, manufacturing, and a few service activities, although revised data may be available in time for the regular estimates. Once three or four possible release lags are identified, the exact share of source data available at each lag can be calculated for each item of the GDP (e.g., if only a month is available, the share is 0.33). Then, a weighted average of these shares can be calculated, taking as weights the relative GDP size of the corresponding national accounts items. This weighted share can provide a proxy measurement of how much source data for the GDP calculation is available at the different release lags. Compilers may decide, for example, that an early estimate can be published only with a coverage of 50 percent of GDP sources and choose the shortest release lag that allows to achieve that coverage.

10.13 Timeliness of early GDP estimates should also take into consideration the release schedule of other macroeconomic statistics that are used in the compilation. Other statistical frameworks follow different timeliness requirements from those of the national accounts. Balance of payments data or government finance statistics, for example, are important pieces of information for the GDP compilation by expenditure. When these statistics are released with long delays (say, 90 days from the reference quarter), an early estimate can only be based on production data and it may not be possible to publish the GDP by expenditure. Discussion with other compiling agencies (Central Bank, Ministry of Finance, etc.) is advisable to verify if preliminary, confidential data can be provided ahead of the official publication. If possible, a coordinated release schedule of macroeconomic statistics should be designed to minimize future revisions of the GDP estimates.

10.14 A very useful tool to analyze the reliability of early estimates at different release lags is the analysis of revisions. For early estimates, the best revision stage is the difference between the early estimate and the second estimate. This stage quantifies the impact of monthly and quarterly source data that arrive immediately after the release of the early estimate. Summary statistics of the revisions can be calculated and compared at the different release lags. Release lags showing small revisions and no systematic direction should be preferred. The revisions analysis should be conducted for detailed GDP components, using the same disaggregation as in the regular estimates, so that it is possible to trace back which items cause changes in the revisions statistics at the different lags. A detailed assessment may indicate, for example, which components are more reliable than others. It could also indicate, for example, that only an early estimate of the aggregate GDP is sufficiently reliable to be published to the users (see Chapter 12 for a formal illustration and example of revisions analysis).

10.15 From the user's point of view, it is desirable to receive as timely information as possible on the quarterly GDP. Important policy decisions may be taken with a fixed and regular schedule during the year. For example, the central bank may convene a meeting at the end of each month to decide its monetary policy stance. As the quarterly GDP is a fundamental ingredient in the monetary policy decision process, there could be a push for statistics agencies to release an early estimate ahead of these meetings. Furthermore, statistical regulations established by regional or international organizations may impose strict requirements on timeliness for the first release of quarterly GDP to their member countries.[3]

10.16 On the other hand, users should accept and account for the relatively higher degree of uncertainty of early estimates. Revisions to early estimates are indispensable to incorporate monthly and quarterly source data that arrive after the publication. The absence of revisions between early estimates and subsequent estimates in a given quarter should be considered with great caution, as regular estimates of QNA generally use a more complete set of source data, which leads to more accurate results. Estimates that are released too early could be too unstable and create confusion in the users. If there is a strong sentiment against revisions to national accounts data in the country, compilers should consider longer release lags for early estimates or, if there is space to do so, not producing an early estimate at all.

Filling Data Gaps for GDP Indicators

10.17 To produce an early estimate of GDP, all gaps in the quarterly source data should be filled. Missing data for GDP indicators should be estimated using statistical methods and assumptions that demonstrate a high degree of accuracy and robustness in reproducing the true values of the indicators. Using inaccurate methods may compromise the reliability of quarterly GDP and the credibility of the compiling agency, which may be forced to communicate large and systematic revisions in subsequent GDP estimates or, even worse, may be tempted to disregard new and updated source data to avoid revisions.

10.18 Ideally, all data gaps should be filled in at the level of indicator series. Estimates should be based on the statistical and economic features of the indicators, and not on the QNA items that are produced using these indicators. For example, when a production index is used to extrapolate value added of an industry, the missing months of the production index should be estimated, not the quarterly value added. This approach allows the compilers to follow the standard procedures used in the QNA, including benchmarking and seasonal adjustment. Working at the indicators level and maintaining the same compilation system used for later estimates guarantee that revisions between early estimates and later estimates are due exclusively to changes in the source data. Furthermore, compilers can keep track of the imputations made and discuss them with data providers, which could lead to improvements in the estimation accuracy of the methods.

10.19 Deriving estimates of missing information using past trends only should generally be avoided. The objective of QNA is to provide accurate signals about the current developments in the economy. Replicating short-term trends from previous observations may introduce an artificial smoothness in the estimates, and may fail to incorporate sudden changes in the economy. Past trend extrapolations should be avoided in particular for current price data, which mixes together different evolutions of prices

[3] In the European Union, member countries are invited to submit their "flash" estimates of quarterly GDP within 30 days after the end of the quarter. However, this is not a requirement in the ESA 2010 data transmission program. For more information on flash estimates of the European Union, refer to Eurostat (2016a, 2016b).

and volumes. Price statistics are generally very timely, and when not, price indices for similar or related products may provide acceptable proxies to complete the missing information. Past trends may be an option only for those indicators showing a very stable pattern over time.

10.20 Frequency and timeliness of indicators are two other important elements to consider. Monthly indicators present the advantage that partial information for the quarter can be available at the time of the early estimate (i.e., one or two months of the quarter). This reduces the impact of methods and assumptions on the early estimate, as only partial information for the quarter needs to be estimated. For this reason, any estimation methods or assumptions used for early estimates should be applied to monthly indicators. Consequently, monthly indicators should not be aggregated into quarterly ones (a preference for monthly series has been expressed also in Chapter 8 for the adjustment of calendar effects). Moreover, quarterly indicators that are available with a long delay should be identified and analyzed carefully. If these indicators move forward important components of the GDP, bad-quality imputations and assumptions used for the early estimate may lead to large revisions in later estimates of quarterly GDP.

10.21 Additional indicators could also be considered to complement the source data used for early estimates. It could be useful to expand the list of possible indicators and consider economic and financial indicators that are not used in the regular QNA compilation. In particular, indicators that are available with a short delay may be particularly suitable in the context of early estimates. Possible examples are business and consumer sentiment surveys, Internet-based search indicators, or financial and monetary statistics. The predictive ability of such indicators should be tested to verify whether they can improve the estimation accuracy of early estimates.

10.22 Finally, compilers of early estimates should pay continuous attention to what is happening in the economy. A strike, a drought, a government reform, a major sport event, or a financial crisis may cause sudden shifts in past trends of quarterly GDP and should be taken into account promptly in the national accounts estimates. It is good practice to read the news and understand how major economic events reflect in the national accounts and, in particular, be recorded in the GDP. At the time of the early estimate, these events may not be recorded in the limited source data available. Ad hoc intervention to early estimates may be necessary to limit future revisions of the quarterly GDP. Clearly, these adjustments should be documented and communicated clearly to the users to avoid any suspicious of manipulation.

Methods

10.23 Data gaps for early estimates of GDP fall into two main groups. The first group comprises cases with related information available. Within this group, the most common situations are the following:

a. use of related indicators that directly relate to the missing information either from outside or within the QNA system, and with available information for the complete quarter; and
b. use of the same data sources as in regular estimates, but containing only partial information, either by lower sample coverage or by shorter time spans (two out of three months for instance).

The second group comprises those situations where no related information can be used to produce plausible results. Methods that are applicable in the two cases are discussed below.[4]

10.24 The methods discussed in this section may also apply for filling data gaps for later publications of QNA. These gaps are more significant for early estimates of GDP because a larger proportion of information is missing and needs to be estimated. It is important to maintain consistency between the methods used in early estimates and later QNA estimates. For instance, in many countries, the quarterly activity of agriculture is derived from annual forecasts, which are temporally disaggregated by means of a particular method. If no revisions on the annual figure (or in the related indicator) occur, then both early and later GDP estimates should be based on the same methodology.

10.25 As a general principle, all the available information should be used at the highest frequency. If quarterly figures are derived from monthly data, data gaps should be filled at the monthly level. The

[4] This chapter presents basic methods to fill data gaps. A more comprehensive discussion on methods for early estimates is available in Eurostat (2016a, 2016b).

quarterly indicator should be derived by aggregating available months and projected months.

Methods with Related Information Available

10.26 The best situation is when there exists related information that can be exploited to fill the gaps of GDP indicators. These types of information might not be completely in line with the concept intended to be estimated, but they may be strongly related with it. One example is the use of input data or sales as proxies of output. Preliminary results from surveys may also be available with a partial coverage. Using actual information allows to "nowcast" the current value of the indicator: that is, deriving the most recent periods using related contemporaneous information. This information could be extremely helpful to improve the reliability of early estimates.

10.27 Particular attention should be given to the case when preliminary/advance survey results or administrative data are available. Preliminary results are usually based on reduced samples or incomplete response so totals are not comparable as such, and should not be used directly for extrapolation since the activity levels derived from reduced samples are likely to be lower than those derived from the full samples for previous ones. Then, intermediate procedures are to be applied in order to derive comparable figures. Two procedures can be used in these cases: (i) grossing-up procedures to expand the results of the sample to population levels or (ii) use paired units of a sample in different periods and assume the same behavior for the rest of population.

10.28 Specialists from survey units usually deal with sampling and grossing-up procedures. However, national accountants should be aware of the procedure used to derive the preliminary source data for the early estimates. The grossing-up procedure should be based on the same re-weighting methods used for later survey results to minimize the size of revisions. The common approach is to gross up survey data provided by respondents by using comprehensive totals from a business register or a population census.

10.29 Matched pair procedures are particularly relevant when partial administrative data are received for the early estimate. This is a task that QNA compilers may be required to do directly if administrative data are transmitted from other agencies to the national accounts unit. Generally, only a small number of units is available for the current quarter after a short delay. This subset of fast responders cannot directly be compared with the larger samples in previous quarters. Responding units in different periods should be linked using unique identifiers available in the register, such as tax code or personal identification numbers. Percent changes from the previous year (or the previous quarter) of economic variables such as turnover, employment, etc. should be calculated based on the matched responding units by economic activity. This information can be used to extrapolate the relevant QNA variable.

10.30 When setting up an early estimate system, compilers should consider all the sources of economic information available with short delay (even those that are not considered in the regular QNA compilation). A continuous review of available information should be conducted to improve the reliability of the early estimates. Proxy indicators may complement the set of existing QNA indicators, or help predict the missing information for the early estimate.

10.31 In absence of external related information, compilers may decide to exploit behavioral relationships within the QNA system to estimate missing information in the indicators. For instance, agricultural output from the QNA can be used to project the output indicator for foods processing industries (or vice versa).

10.32 There are several ways to use related information to fill data gaps, from simple extrapolation using related indicators to more complex econometrics models. Simple extrapolation using related indicators consists in applying the movement of a related series to derive the unavailable current value of the indicator. To avoid any bias due to differences in seasonality, the (annual) trend of the indicator series should be moved forward using the annual change in the related series:

$$\hat{I}_T = \frac{R_T}{R_{T-s}} \times I_{T-s}, \tag{1}$$

where

$\hat{I}_T$ is the estimate of the indicator for the current period,

R_T is the related series in period T, and

s is the periodicity of the series (4 for quarterly and 12 for monthly data).

10.33 When seasonally adjusted information is available, a period-to-period extrapolation may provide more accurate results than using the annual trend. As explained in Chapter 1, year-on-year movements may fail to detect turning points in the series. Alternatively, quarterly/monthly extrapolation could be used:

$$\hat{I}_T^{SA} = \frac{R_T^{SA}}{R_{T-1}^{SA}} \times I_{T-1}^{SA}, \quad (2)$$

where

$\hat{I}_T^{SA}$ is the seasonally adjusted estimate of the indicator for the current period and

R_T^{SA} is the seasonally adjusted related series in period T.

The seasonally adjusted estimate can be converted into unadjusted data using the seasonal factor for period T available from the seasonal adjustment procedure (such as X-13ARIMA-SEATS or TRAMO-SEATS)[5]:

$$\hat{I}_T = \hat{I}_T^{SA} \times SF_T. \quad (3)$$

10.34 Econometric models can also be specified to predict the missing indicator using related information. These types of models aim at filling the gaps by modeling the statistical relationship between the QNA indicator series and the related series. For example, a typical model used for short-term forecasting is the autoregressive distributed lags model:

$$\hat{I}_T = \alpha + \beta_1 I_{T-1} + \beta_2 R_T + \beta_3 R_{T-1} + \varepsilon_T, \quad (4)$$

where the current value of the indicators is explained by its lagged values and current and lagged values of the related series. Modeling techniques, however, require knowledge about time series and econometrics, and must be used with great caution. Misspecified models could produce odd results and reduce the reliability of the early estimates. If such models are required for a large proportion of GDP, it may be appropriate to assign this responsibility to another agency or a unit specialized on time-series methods and forecasts within the compiling agency. This would avoid undermining the credibility of official national accounts.

Methods with No Related Information Available

10.35 If no related information is available, for the entire quarter or for one or two months, the best solution is to use time-series extrapolation techniques to estimate the missing information. In normal situations, such methods can produce reliable forecasts in the short term. However, time-series models are unable to detect sudden changes of the underlying trend in the series due to unpredicted economic events. Their good forecasting accuracy stems mainly from their ability to repeat patterns of the series, such as recent trends and seasonality. Thus, the use of these methods should be limited and used as a last resort.

10.36 Autoregressive integrated moving average (ARIMA) models represent the best choice for forecasting QNA indicators in absence of related information. Chapter 8 provides some details on ARIMA models and their specification for seasonal adjustment purposes. Forecasts using ARIMA models are automatically produced by standard seasonal adjustment software, such as X-13ARIMA-SEATS or TRAMO-SEATS. The default options used by these programs generally produce satisfactory results. Users may also account for calendar-related effects in the corresponding period (such as leap year, Easter or Ramadan, or country specific holidays) and improve forecasting accuracy. ARIMA forecasts are available in the output results of these programs and can also be produced without running seasonal adjustment. As mentioned earlier, ARIMA models should be estimated on monthly series to complete the current quarter; if the indicator is quarterly, an ARIMA model should be used to generate a forecast for the entire quarter.

10.37 In some particular cases, simple mechanical extrapolation techniques could produce satisfactory results, and ARIMA models might not be necessary:

- If there is no clear trend or seasonality in the movements of the series (either in volume or price terms), one may simply repeat the last observation or set the value for the missing

[5] Equation (3) assumes a multiplication seasonal adjustment. For additive models, the seasonal component should be added to the value of the seasonally adjusted indicator. See Chapter 7 for the difference between additive adjustment and multiplicative adjustment.

period equal to a simple average of a number of past periods (e.g., the previous two months or the entire year).

- When a series shows strong seasonal effects but no clear trends, one may simply repeat the value of the variable in the same period of the previous year or set the value for the missing observation equal to the average for the same period in several of the previous years.
- If there is a clear trend in the series but no pronounced seasonal variation (e.g., for seasonally adjusted series), the past trend may be projected using a weighted average of the period-to-period rates of change for the last observations—for example, by using a weighted average for three last observations as follows:

$$\hat{I}_T = I_{T-1}\left[\frac{3}{6}\cdot\frac{I_{T-1}}{I_{T-2}} + \frac{2}{6}\cdot\frac{I_{T-2}}{I_{T-3}} + \frac{1}{6}\cdot\frac{I_{T-3}}{I_{T-4}}\right]. \tag{5}$$

- With both a clear trend and strong seasonal variation in the series, one simple option may be to extrapolate the value of the series in the same period in the previous year, using a weighted average of the rates of change from the same period in the previous year for the last observations as an extrapolator—for example, by using a weighted average for three last observations as follows:

$$\hat{I}_T = I_{T-s}\left[\frac{3}{6}\cdot\frac{I_{T-s-1}}{I_{T-s-2}} + \frac{2}{6}\cdot\frac{I_{T-s-2}}{I_{T-s-3}} + \frac{1}{6}\cdot\frac{I_{T-s-3}}{I_{T-s-4}}\right]. \tag{6}$$

Assessment

10.38 Methods used for early estimates should be assessed on the basis of their ability to predict the true values of indicators. The estimates obtained should be compared with actual data on a continuous basis. When different methods are available, statistical measures should be used to choose the most accurate approach. Although this is a procedure generally carried out in the implementation stage of the early estimate, the reliability of early estimates should be monitored on a continuous basis especially when new sources become available.

10.39 Real-time exercises should be conducted for some time before publishing early estimates to verify the reliability and robustness of the chosen methods. Testing the early estimation system for past observations allows the compiler to have an indication of the expected size and direction of revisions of subsequent estimates. In this way, it would be possible to identify ahead of publication areas of intervention for improving the reliability of early estimates (and reduce future revisions). For this reason, it is desirable initially to produce estimates on an experimental, unpublished basis to make these assessments.

10.40 A simple measure to assess alternative methods is to estimate the mean difference (*MD*) between the estimated value $\hat{I}_t$ and the actual value I_t of the indicator:

$$MD = \frac{1}{n}\sum_{t=1}^{n}(\hat{I}_t - I_t). \tag{7}$$

where *n* indicates the number of periods estimated. If the value of *MD* is around zero, the method produces unbiased results. If *MD* is large and positive (negative), the early estimate is expected to overestimate (underestimate) the value of the indicator (and the early estimates of GDP). The quality of early estimates deteriorates as *MD* moves away from zero. Methods with *MD* close to zero should be preferred.

10.41 The mean squared difference (*MSD*) can be used to measure the expected size of revisions. *MSD* calculates the average of squared differences between estimated values and true values of the indicators:

$$MSD = \frac{1}{n}\sum_{t=1}^{n}(\hat{I}_t - I_t)^2. \tag{8}$$

Methods with lower *MSD* values should be preferred.

10.42 When a full estimation system for early estimates is in place, compilers should calculate an expected size of revisions between the early estimate and the second estimate of the quarterly GDP growth (and possibly other key macroeconomic variables released with the early estimate). This can be done using standard revisions measures (see Chapter 12). Revisions to early estimates should be small and mainly related to the additional information acquired between the time of publication and the second release. If revisions are too large, users may lose confidence in the preliminary information provided and raise concerns about the credibility of the compiling agency. An acceptable size of revisions should be determined based on specific country situations. Fast-growing countries may expect larger revisions to GDP than countries with stagnant growth. On the other hand, small economies may experience significant revisions in percent changes due to the small size of their GDP level.

Communicating Early Estimates

10.43 Transparency is a key aspect of communications policy for early estimates. Lack of detailed information on methods and sources used may generate mistrust in the quality of early estimates from users. Once early estimates are compiled and disseminated, they become a key variable for general users and policymakers. Thus, good practices on dissemination and revision issues should be put in place, since an additional set of official GDP series will be available in advance of the standard QNA results. Data sources and methods used in the compilation of early estimates of GDP should be well documented and made available to users. Furthermore, metadata should indicate information on timeliness and level of detail of the early estimate.

10.44 Early estimates of quarterly GDP attract a large amount of media coverage. The focus at this stage is to get an accurate top level GDP growth estimate. Much time and efforts should be spent on explaining the strengths and weaknesses of the early estimate to users. The GDP numbers should be presented to a wide internal audience, made of economists, national accounts, statisticians, and data experts. Regular articles on revisions should be released to highlight the relatively good performance of the estimate. The press release should be scheduled early in the morning to avoid miscommunications by the media.

10.45 Sources of revisions to the early estimate should be indicated clearly when the second estimate of quarterly GDP is released. Such analysis helps users understand the factors underlying revisions and interpret possible changes in the recent development of the economy. In particular, clear explanations should be given to users when there are large differences.

10.46 A lower publication detail is justified on the grounds that there is greater uncertainty in disaggregated data. A reduced breakdown of the GDP also emphasizes the limitations of early estimates to users. Early estimates should cover at least the headline GDP figure in volume terms. The main interest of QNA users is on the short-term developments of quarterly GDP, rather than on the levels; therefore, the main focus should be on period-to-period changes. If only unadjusted data are available, the year-on-year rate of change of GDP should be published. A few aggregate GDP components should be published to explain the main drivers of GDP growth (e.g., one-digit level of ISIC Rev. 4 or main expenditure aggregates). Compilers should also consider publishing detailed items that are based on reliable information, particularly when they are very relevant for the economy (e.g., mining or refinery industries in oil-exporting countries). Ideally, early estimates should include the same types of information released in subsequent QNA publications (i.e., original series, seasonally adjusted, trend cycle, current prices, constant prices or chain-linked, etc.). However, preference should be given to the most relevant information for the users. In many countries, quarterly seasonally adjusted rate of change of the GDP is the preferred information.

10.47 Metadata for early estimates should include all additional sources of information and methods that are used to fill data gaps. Because early estimates of GDP broadly follow the QNA methodology, a large part of the metadata (sources, compilation methods, and classification) can be taken from the available metadata for the standard QNA. However, compilation of early estimates of GDP relies more heavily on estimates of missing information compared to the standard QNA compilation. In particular, metadata should indicate the relative size of estimated components by production and by expenditure components of GDP.

10.48 Given the provisional status of early estimates, it is necessary to develop a revision policy that fully integrates their dissemination into the broad system of ANA and QNA estimates. Revisions to early estimates are essential to incorporate new and updated source data made available after their release. Early estimates that are never revised may draw criticisms and dubious over the quality of the entire national accounts system. To avoid reputational and credibility risks, revisions to early estimates due to new or updated information should be published at the subsequent publication of the QNA. Revisions to early estimates should also follow a fixed and predetermined calendar, so that users are informed in advance about the timing of possible changes in the GDP estimates.

10.49 A quantitative assessment of revisions to early estimates should be given in the press release. When they are published for the first time, compilers may indicate an expected range of revision on the basis of internal tests that preceded the first publication (or refer to a research paper where these tests are described in detail). After some time, compilers should calculate and publish revisions statistics based on previously published early estimates. With this information, users should be able to appreciate the direction and size of revisions in the past, and possibly make judgments about the expected revision process of current and future early estimates.

Summary of Key Recommendations

- *Compilers of QNA produce early estimates of quarterly GDP in response to a strong demand of users for a rapid measurement of macroeconomic developments.*
- *Early estimates should be based on a partial set of source data, using the same compilation approach used for later estimates of the QNA. A greater use of statistical methods and assumptions is required to estimate missing observations at the time of the early estimate.*
- *In deciding the timing of early estimates, compilers should balance the trade-off between timeliness and reliability. Key factors to consider are timeliness of source data, expected size of revisions, and needs from users.*
- *The provisional status of early estimates should be stated clearly in the press release. Metadata on specific sources and methods used for early estimates should be publicly available for transparency reasons.*
- *Revisions studies should be conducted to analyze the revision process of early estimates and assess their reliability. Compilers should use these studies to identify and address systematic errors in the early estimates. Summary revisions measures should also be communicated to users to provide a measure of reliability based on the history of previously published estimates.*
- *Dissemination of early estimates should be coordinated with the publication calendar of national accounts data. Early estimates should include at least the headline GDP, and when possible the main production or expenditure components. The level of detail may be reduced due to a greater recourse to estimation methods.*

Bibliography

Eurostat (2016a), "Overview of GDP Flash Estimation Methods," Statistical Working Papers, Publications Office of the European Union, Luxembourg.

Eurostat (2016b), "Euro Area and European Union GDP Flash Estimates at 30 Days," Statistical Working Papers, Publications Office of the European Union, Luxembourg.

11 Work-in-Progress

A fundamental national accounting principle is that production should be measured at the time it occurs and be valued at the prices of that time. Work-in-progress is significant for some activities, particularly construction and agriculture. In practice, measuring work-in-progress can be challenging. This chapter discusses the main concepts of work-in-progress and provides guidance on its application in the quarterly accounts.

Introduction

11.1 Work-in-progress concerns production that goes beyond one period. Measurement of such production poses the problem that a single process has to be split into separate periods. Because of the shorter accounting period, these difficulties are relatively more significant for quarterly national accounts (QNA) than for annual national accounts (ANA).

11.2 The general national accounting principle is that production should be measured at the time it takes place and be valued at the prices of that time. In most cases, this treatment presents no problems, because the production process is short and thus output can be measured from the value of the finished product. When the production process transcends a single accounting period, however, production needs to be shown in two or more periods. This production results in output of unfinished products, which is called work-in-progress in both business and national accounting. As stated in the *2008 SNA*, "it would distort economic reality to treat output as if it were all produced at the moment of time when the process of production happens to terminate" (paragraph 6.90). Also, where prices have changed during the production process, the price paid at the end will include holding gains (or possibly losses) that need to be excluded in order to have a correct measure of production.

11.3 There are many activities in which production cycles go outside a single period. Even with very short processes, there can be work-in-progress. Some activities have quite long production cycles and so work-in-progress is particularly important. These activities include the following:

a. *Agriculture, animal husbandry, forestry, and fishing.* In agriculture, crops may grow over several seasons. Similarly, growing livestock, cultivating timber, cultivating fruit, viticulture, and fish farming are all cases where production occurs over more than one period before the final output is marketed. Also, wool is usually collected only once a year.

b. *Manufacturing.* Ships, submarines, airplanes, and some heavy equipment have long production cycles.

c. *Construction.* The production cycle is often quite lengthy, varying from a few months for a house to many years in the case of a civil engineering project.

d. *Services.* Examples in this category are movies, architectural services, and large sport events.

11.4 This chapter first explores the general reasons why work on unfinished products is considered output. Subsequently, the principles of measurement and some practical solutions are discussed. Briefly, the solution for measuring of work-in-progress is to use output measures based on quarterly input costs in conjunction with values or markups for the whole process. Where such costs are not available, proxies such as fixed proportions can be used.[1]

11.5 Recording work-in-progress poses special difficulties for agriculture and related industries, because of the uncertainties intrinsic to the dependence of the

[1] As well as its direct effect on measuring output, work-in-progress also has consequential effects on income accounts, capital accounts, and balance sheets. These effects are discussed in the Annex 11.1.

production process on forces of nature and because of the volatility of prices. Also, because the concept of work-in-progress is not generally applied in the recordkeeping in these industries, its application in national accounts is exposed to criticism denouncing it as artificial.[2] It has been suggested that most of the problems involved in applying work-in-progress concepts to agriculture could be solved through the application of seasonal adjustment, but it should be emphasized that recording work-in-progress and seasonal adjustments are unrelated issues and that recording work-in-progress affects the unadjusted estimates. These issues are discussed in paragraphs 11.38–54.

Why Should Work-in-Progress Be Measured?

11.6 Inclusion of work-in-progress affects many components of the accounts, but in a consistent way, so that it does not create discrepancies. In addition to the effect on output, there is an equal effect on operating surplus/mixed income and other income aggregates. On the expenditure side, output in the form of work on unfinished products is classified either as fixed capital formation or as changes in inventories of work-in-progress. It is part of fixed capital formation if it consists of construction work done on contract and put in place in stages or if it consists of capital goods produced on own account by their eventual final user. In all other cases, including speculative construction (i.e., without a contract and not for own final use) and most agricultural production, work-in-progress is included in changes in inventories. Financial transactions are unaffected, except in the case of construction work on contract, because resulting changes in estimates on saving are fully absorbed in the estimates on fixed capital formation or changes in inventories for the same institutional unit. In the case of production of a capital good under contract, however, the full effect on saving for the producer will be carried over to the financial account in the form of payments received from installments and other accounts receivable accrued.

11.7 Proper recording of work-in-progress has the added advantage of removing production-related holding gains and losses from the estimates, which should also be done in ANA. The potential danger of leaving holding gains and losses in the estimates can be large, especially if inflation is substantial. If production processes do not exceed the accounting period for the ANA, the holding gains and losses involved in work-in-progress risk being ignored in the compilation of these accounts. An important message to the compilers of ANA is that they should also remove holding gains and losses from their estimates on sub-annual production processes, not only to ensure consistency between ANA and QNA, but also to achieve correct ANA estimates.

11.8 Production is "an activity in which an enterprise uses inputs to produce outputs" (*2008 SNA*, paragraph 6.10). Thus, production is a process that leads to a distinct product, but the recording of inputs and outputs in the accounts is not determined by the time that the finished product becomes available for use. Paragraph 6.90 of the *2008 SNA* explains this further as follows:

> For simplicity, the output of most goods or services is usually recorded when their production is finished. However, when it takes a long time to produce a unit of output, it becomes necessary to recognize that output is being produced continuously and to record it as "work-in-progress."

11.9 While it is useful to emphasize that production is a process rather than the resulting product, the definitions are circular to the extent that the recognition and measurement of production depend on the meaning of output. In the *2008 SNA*, output does not mean finished products but can be any goods or services that "can be sold on markets or at least be capable of being provided by one unit to another" (*2008 SNA*, paragraph 1.40). For instance, an unfinished construction project and a crop growing in the field both have the quality of having value that can, at least potentially, be provided to another unit, and hence output can be recognized and measured.

11.10 In the absence of recognition of work on unfinished products as output, inputs would appear in different periods from the corresponding output. As a

[2] Examples can be mentioned in which prices do reflect the value of work-in-progress. One such example is keeping sheep for wool, where the price of sheep reflects the harvestable amount of wool (prices plunge immediately after shearing).

result, value added could be negative in some periods and disproportionally large in other periods. Thus, the meaning of value added for the affected periods would be open for debate.[3]

11.11 An objection is sometimes made that recording work on unfinished products as output brings intransparency to the accounts. That is, it involves unnecessary complexity and artificiality and distorts the view of income generation and saving, because output does not generate money inflows before it is sold. Two arguments counter this view. First, transactions in the national accounts need not necessarily involve actual money flows; well-known examples are barter transactions and wages in kind. Second, one could also argue that disregard of work-in-progress results in artificiality because outlays on production would show up without any apparent link to output.

11.12 It is sometimes suggested that recording work-in-progress is relevant on the level of individual units, but for the total economy, or even specific industries, aggregation would cancel out the effects of not recording work-in-progress. This would only apply in the situation of very stable period-to-period production processes, however, which is highly unlikely to reflect real conditions, particularly in the context of QNA.

Measurement of Work-in-Progress

Economic Concepts

11.13 The starting point for the theoretical and practical issues in measurement of production is economic theory. The general principle of valuation in economics is use of the transaction price. In a very few cases, an incomplete project may be marketed, such as when an unfinished building project or a farm with crops in the field changes hands. It is far more common, however, that products are not sold until finished, so transaction prices are generally not available for the unfinished product. It is, therefore, necessary to adopt a convention to value the production in each period.

11.14 The usual principle to value an item when there is no transaction is the market-equivalent price. The market equivalent is what buyers would be prepared to pay if they wished to obtain the unfinished product or what suppliers would need to be paid to produce it. This value is equivalent to the total input costs for each period plus a markup. Because there is no separate markup for each quarter, the markup must be the ratio of output to costs for the whole production cycle. In other words, the net operating surplus is estimated as earned over the production cycle in proportion to costs in each period.

11.15 In the rest of this section, the application of the convention of valuing work-in-progress carried out in a certain quarter as input costs plus a markup is discussed in a business and national accounting context. The section also discusses methods to use when data are incomplete and how to account for the effects of changes in prices during the production period.

Business Accounting Treatment of Work-in-Progress

11.16 Business accountants face the same problem of splitting incomplete production cycles into accounting periods. Estimation of the value of work put in place is part of an accrual accounting system. Businesses seeking to measure their own performance need to value the work put in place to match output with expenses and avoid lumpiness in their accounts. In the absence of observable prices, business accounts must also depend on input costs, with or without some markup.

11.17 However, there are two areas of difference between business accounting practice and economic concepts. First, business measures of income do not distinguish between holding gains and production, whereas this difference is fundamental in economic analysis. Second, because of the doctrine of prudence in business accounting, work may be valued at less than the expected price (i.e., without a markup or with an underestimated markup), so that profits are not counted fully or at all until they are realized. This delay in recognition of profits causes lumpiness at the completion of the work, but time-series consistency is less important to business accounting.

11.18 There are three alternative arrangements for work on products with long production cycles:

- own final use,
- contract, and
- speculative basis (i.e., the final client is not known).

[3] Note that negative value added can legitimately occur (such as where the marketable product is small in relation to inputs—for instance, the start-up phase of a business or other loss-making situations). However, it is not desirable that negative value added appears simply because of failure to recognize that a productive process was occurring.

11.19 For work for own final use, the producer is the final user: for example, an electricity company builds its own generating plant or distribution network. In this situation, there is no transaction price, even on completion. Accordingly, output is measured by the enterprise itself, ideally at a market-equivalent price or, more typically, on the basis of input costs, including capital costs and overhead. If measured from costs, the data are already recorded on an ongoing basis by the producer, and there is no more difficulty in measuring production in each period than there is in measuring the total project.

11.20 For contract work, there are different possible payment arrangements. A price may be fixed in advance or variable, or paid by installments or at the end of the job. Progress payments are installments that relate to the amount of work done. To the extent that progress payments closely match work done, they already measure output on an ongoing basis. However, if payments are infrequent, delayed, or have a substantial bonus component at the end, they give a misleading time series, and a cost-based measure would provide a better measure of production.

11.21 For work done on a speculative basis, there are no ongoing receipts and usually the final value of the product is unknown until after completion. This situation is common in manufacturing and construction. In addition, many agricultural products resemble speculative manufacturing or construction, in that there is no sale or identified buyer until after the product is completed. In contrast to manufacturing and construction, however, estimates of work-in-progress are not normally made by farmers in their own accounts.

11.22 Measures of work-in-progress are often available, particularly from larger and more sophisticated producers. Such estimates have the advantage that the data are transparent and estimation is done at a detailed level with specific information. However, such data are not automatically suitable. For example, progress payments or installments may not match work done because of long lags or because there is a large component of bonus for the completion of the job. Or it may also be too costly to collect business data quarterly: for example, if building work is done by many small operators who are reluctant to complete statistical questionnaires. Or the quarterly data may be too lumpy if the profit is only included at the time of sale. In these circumstances, it is necessary to derive estimates for national accounts by making adjustments to business estimates.

Measurement in a National Accounts Context

11.23 The *2008 SNA* recommendations on the economic valuation of incomplete products discussed in section "Economic Concepts" are partly compatible with business practices. The *2008 SNA* recommends following the businesses' own estimates if they approximate production, mentioning progress payments on a contract (paragraph 6.112) and capital goods for own final use (paragraph 6.125). When no acceptable quarterly output data are available from businesses, the *2008 SNA* principle is to measure production of incomplete products from costs for each period, raised by a markup that relates to the whole production cycle.

11.24 Changes in prices during the production cycle affect the measurement of production. When prices are changing, the eventual value at the time of completion will differ from the sum of the value of work-in-progress carried out in the production quarters, because the prices of that kind of product have changed between the time of production and the time of completion. The difference represents holding gains or losses. In order to measure production, price changes between the time of production and the time of sale must be removed from selling prices. These problems can be avoided by compiling constant price estimates first (to put all the flows on a consistent basis) and subsequently deriving the current price estimates on the basis of the constant price estimates. (This deflate-then-reflate method is found in related areas of inventory valuation and capital stock measurement where valuation also includes prices from different periods.)

11.25 The measure of input costs should be as complete as possible. The input costs should include compensation of employees, intermediate consumption, other taxes less subsidies on production, and costs of using land and capital (rent, consumption of fixed capital, and interest). In cases where owners and unpaid family members are an important source of labor, it is desirable to derive a value for these inputs as well. In practice, the data on costs may be incomplete and so the markup needs to be adjusted accordingly. Obviously, some of these input costs are part of value added (for instance, compensation of employees) and some are implicitly included in operating surplus/mixed income (for instance, rent and interest). This does not preclude them, however, from being costs of production that must be taken into account when estimating output from the cost side.

11.26 Allocation of output on the basis of costs does not always apply in full. From the rationale for work-in-progress—namely, allocating output to periods in which production is occurring—it logically follows that no output should be allocated to periods in which there is no ongoing production process, even if there are ongoing costs. This applies in particular to the cost of using land and capital, which may not correspond to the actual production process. For instance, interest on a loan financing a piece of equipment accrues over the period of the loan, no matter whether the equipment is used. An example of a situation in which this may apply is agriculture, where production may stop completely during certain periods. Food-processing industries that are dependent on harvests coming in are also an example. In these cases, it is important to clearly define the production periods (for instance, in Nordic climates, the agricultural production periods may include autumn when land preparation takes place, exclude winter when no activities take place, and commence again in spring with seeding, fertilizing, etc.).

11.27 Example 11.1 brings together the measurement issues discussed so far. It covers an ex post situation: that is, after the completion of the product when the final price is known. Data on input costs are also available. In the example, the final price and cost data are used to derive a markup ratio for the whole project. The example shows the derivation of output estimates and, from that, the calculation of holding gains.[4]

11.28 From the example, it is important to note that holding gains are excluded from production measures. Hence, the output is 5,040 in the example, not 5,800. A substantial rate of price increases is assumed, so the holding gains are quite large in the example. It should also be noted that the cost/markup ratio is derived at constant prices (i.e., 4,000/3,000) and not at transaction prices (i.e., 5,800/3,780), because the latter include holding gains. It is also worth noting that the quarterly estimates of output, by definition, follow the same quarterly pattern as the costs. It can be seen that the recognition of work-in-progress results in a less lumpy series for output. It is not a substitute for seasonal adjustment or calculation of a trend-cycle series, however, because the series will still be subject to any seasonality or irregularity in the cost series.

11.29 Having established the general principles of measurement, we will now consider some of the permutations arising from different data situations. The situations covered include deriving the markup when there are (a) other payment times, (b) quantities available but not values, and (c) forecasts available instead of actual prices for the final product. When markups for a particular period are not available, other sources of markups are considered. Where cost data are not available, the use of a cost profile is proposed.

11.30 In some cases, payment is not made at the completion of the product. It may be made at the beginning of work or in several installments. An advance payment reflects prices of the beginning of the period. If the price is paid in installments, such as progress payments for construction work, the payments are from

[4] The examples in this chapter are designed to show concepts and may not be realistic from the point of view of data availability.

Example 11.1 Work-in-Progress: Ex Post Approach

(a) Total Value of Project
(b) Quarterly Costs

Objectives of example:

(a) To illustrate the allocation of a total on the basis of costs
(b) To illustrate the inclusion of holding gains in the total value

Consider a speculative construction project taking place between January and December 2011. It is completed and sold at the end of December 2011 for $5,800. The objective is to produce output estimates for each quarter and exclude holding gains from the output estimates. A high rate of price increases is assumed in order to highlight the effect of holding gains.

Example 11.1 Work-in-Progress: Ex Post Approach *(continued)*

Primary Data

	q1 2011	q2 2011	q3 2011	q4 2011	q1 2012
Output/input price index (average 2010 = 100)	110.0	120.0	130.0	140.0	150.0
Production costs at current prices:					
Intermediate consumption	160	340	530	300	
+ Compensation of employees	300	310	340	400	
+ User costs for use of land and capital, etc.	200	250	300	350	
= Total production costs at current prices	660	900	1,170	1,050	

To simplify the calculations, the same price index is used for inputs and outputs; in principle, separate price measures should be used.

Step 1. Derive value of the project at average 2010 prices

Deflator value at the end of q4 2011 1/2(q4 2011 + q1 2012) = 145.0
Value at average 2010 prices 5,800/1.45 = 4,000

The value of the project at average 2010 prices is estimated by deflating the sales value with a price deflator that reflects changes in prices of similar projects from average 2010 to the end of q4 2011. The price index given measures the average price level in each period of similar construction products relative to their average price in 2010. Assuming a smooth change in prices over time, the deflator value at the end of q4 2011 can be estimated as approximately (140+150)/2 = 145.

Step 2. Derive costs at constant prices

	q1 2011	q2 2011	q3 2011	q4 2011	Total
Production costs at 2010 prices	600	750	900	750	3,000

In Step 2, input estimates at constant prices are derived by deflating the current price values.

Step 3. Derive the output/cost ratio

Output/cost ratio at average 2010 prices, the markup ratio (1.333), is derived as the value of the project by total costs (4,000/3,000).

The output/cost markup ratio is calculated for the project. It has to be derived at constant prices to exclude holding gains.

Step 4. Derive output at constant and current prices

	q1 2011	q2 2011	q3 2011	q4 2011	Total
Output at average 2010 prices	800	1,000	1,200	1,000	4,000
Output at current prices	880	1,200	1,560	1,400	5,040

Quarterly output at 2010 prices is derived by raising the value of costs at 2010 prices by the output/cost ratio. Quarterly output at current prices is derived by reflating the estimates of output at 2010 prices.

Step 5. Derive value of the stock of work-in-progress at current prices

	Value of Work Put in Place Current Prices ($)	Holding Gains in Subsequent Quarters				Value at Time of Sale ($) December 2011
		q1 2011	q2 2011	q3 2011	q4 2011	
q1 2011	880	40	80	80	80	1,160
q2 2011	1,200		50	100	100	1,450
q3 2011	1,560			60	120	1,740
q4 2011	1,400				50	1,450
Total	5,040	40	130	240	350	5,800

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The derivation of holding gains is shown in this step. In this example, the output price index shows that the prices of similar construction projects increased continuously during 2011. Thus, the prices are higher at the end of each quarter than in the beginning or middle of the quarter. As a result, the total cumulated value of work put in place ($5,040) differs from the project sales value ($5,800), because prices have risen between the time of construction and time of sale: that is, the sales price includes both output and holding gains.

For example, the work put in place in q1 is worth $800 at 2010 prices, but $880 at average q1 prices (i.e., 800 × 1.1), $920 at the end of q1 (i.e., 800 × (1.1 + 1.2)/2), $1,000 at the end of q2 (i.e., 800 × (1.2 + 1.3)/2), $1,080 at the end of q3 (i.e., 800 × (1.3 + 1.4)/2), and $1,160 at the end of q4 (i.e., 800 × (1.4 + 1.5)/2).

several different periods and, hence, different price levels. In each case, by converting the payments to constant prices (using the price index of the time of payment), the measurement can be put on a consistent basis and the calculations can be made accordingly. (if progress payments closely match production costs and timing, they should be used directly to estimate output.)

11.31 In some cases, the data available on the final product are in quantity terms: for instance, a house measured in square meters or a crop in tons. The principles of measurement are the same as in Example 11.1, except that the constant price values are derived by multiplying the volume measure by a price per unit in the base year. Current price values can be derived by multiplying the volume measure by a price per unit in the current period. In the case of some crops, there are special problems in measuring prices in periods between harvests; these issues are discussed in paragraphs 11.38–54 of this chapter.

11.32 Forecasts may need to be used for incomplete work if the value of the final product is not yet known. While national accountants do not normally use forecasts, unfinished production may require forecasts, and such forecasts are often available. For example, builders often forecast a value of a project at the time of seeking building approval. Also, in many countries, the Ministry of Agriculture (or another government agency) makes forecasts of the output of a certain crop. (These usually are in volume terms, but sometimes also in value terms.) These crop estimates are typically based on an estimate of the acreage under cultivation combined with yield estimates. Estimates of acreage under cultivation could be based on surveys or on aerial and satellite photography; yield estimates could be based on average crop yields and revised on the basis of expert views and trends. It may be surmised that in many agricultural countries, this kind of information is available. In some cases, it may be necessary for the national accounts compilers to make forecasts themselves. While forecast values differ in being more uncertain and more subject to revision, the method for calculation of quarterly output is the same as the ex post situation. Of course, when actual data become available, the data should be revised and the difference between the forecast and actual value assessed for accuracy and signs of bias.

11.33 When there is no actual or forecast estimate of the finished value, the *2008 SNA* recommends estimation of output on the basis of costs plus an estimate of a markup from another source without elaborating how this markup is to be derived. Possible sources are studies on standard margins used in a particular industry, a previous year's data, or comparable recently completed projects. Example 11.2 demonstrates how such methods could work in practice.

11.34 The concept and measurement of quarterly production are the same in Examples 11.1 and 11.2. Only the source of the markup ratio is different: in Example 11.1, a markup ratio for the particular project is

Example 11.2 Work-in-Progress: Ex Ante Approach

(a) Quarterly Costs
(b) Markup Ratio

Objective of example: To illustrate the calculation of work on the basis of costs and markup

Primary Data

	q1 2011	q2 2011	q3 2011	q4 2011
Output/input price index (average 2010 = 100)	110.0	120.0		
Production costs at current prices (wages and salaries, raw materials, etc.)	660	900		
Industry standard average markup over costs, 33.3% after excluding holding gains	1.333 (in ratio form)			

Step 1. Derive output at current and constant prices

	q1 2011	q2 2011	q3 2011	q4 2011
Production costs at average 2010 prices	600	750		
Output at average 2010 prices	800	1,000		
Output at current prices	880	1,200		

The data are the same as for the first two quarters in Example 11.1.

Production costs at constant prices are derived by deflating the current price value (e.g., for 2011 q1, 660/110 × 100).

Output at average 2010 prices is derived by multiplying the production costs at 2010 prices by the markup ratio (e.g., for 2011 q1, 600 × 1.333 = 800).

Output at current prices is derived by reflating the constant price value (e.g., for 2011 q1, 800 × 110/100).

Example 11.3 Work-in-Progress: Cost Profile Approach

(a) Estimate of Output Quantities
(b) Cost Profile

Consider a crop that takes four quarters to grow, from preparation of the cultivation area beginning in the first quarter of 2011 to harvesting in the fourth quarter of 2011.

Primary Data

	q1 2011	q2 2011	q3 2011	q4 2011	q1 2012
Output price index (average 2010 = 100)	110.00	112.00	114.00	116.00	118.00
Cost profile	0.20	0.25	0.30	0.25	
Total estimated crop	1,000 tons				
Average value per ton for similar crops in 2010	5.0				

Step 1. Derive total output at constant prices

Value at average 2010 prices 1,000 × 5.0 = 5,000

Step 2. Derive quarterly output at current and constant prices

	q1 2011	q2 2011	q3 2011	q4 2011	Total
Output at average 2010 prices	1,000	1,250	1,500	1,250	5,000
Output at current prices	1,100	1,400	1,710	1,450	5,660

First, the value of the crop at average 2010 prices is estimated by multiplying the physical data on the volume of the crop by the obtained data on average value per ton in 2010: that is, 1,000 × 5 = 5,000.

Second, output estimates at constant prices are derived by distributing the estimated value of the crop at average 2010 prices over the quarters in proportion to the assumed production intensity. For instance, the constant price estimate for q1 2011 is derived as 0.2 × 5,000 = 1,000.

Third, output estimates at current prices are derived by inflating with the output price index. For instance, the estimate for q1 2011 is derived as 1,000 × 1.1 = 1,100.

Note that the harvest value (at end-of-production prices) could be derived as 1,000 × 5 ×(1.16 + 1.18)/2 = 5,850. The difference between the harvest value and the estimate of output at current prices is holding gains (5,850 – 5,660 = 190). (One of the difficulties surrounding the inclusion of agricultural work-in-progress is that output differs from harvest value, which may seem counterintuitive to many users.)

derived in Steps 1–3; in Example 11.2, it is taken from previous data. The estimates made ex ante, as in Example 11.2, would need to be revised when actual prices and volumes became available.[5] The technique shown in Example 11.1 could then be used, so that the markup ratio assumed in advance could be replaced by the actual one. If markup ratios vary substantially from year to year, as is often the case for agriculture, the revisions may be quite large. This danger looms large in situations in which output depends on exogenous factors, as is the case for agriculture and related industries (for instance, if a locust plague necessitates an extraordinary use of pesticides for a certain crop). In such cases, a markup based on a forecast of the annual crop should be preferred to markups based on previous data.

11.35 Another common data situation is that quarterly cost data are unavailable; in that case, a cost profile can be used instead. Actual data on input costs may not be available because of collection costs or because businesses do not keep separate records of costs for each project. An alternative in such situations is to make an estimate for each quarter's share of total costs: that is, a cost profile. It could be based on statistical observations on input intensities in recent periods or on expert views. Statistical observations could be obtained through small-scale surveys, because cost patterns in industries of concern are often fairly standard between units and also fairly stable. For instance, in agriculture, the cost pattern is strongly dependent on the growth phases of crops, and in construction, the pace of production is strongly dictated by an inherent sequence of activities. If a production process is strongly dictated by physical or biological factors, expert opinions may suffice to establish a cost profile. If stable, the same profile could be used for all periods. If all of this is not available, a very simple production profile, such as an equal distribution over time, could be used as a default. The cost profile should be calculated from the constant price data on production costs.

11.36 Use of a cost/production profile is shown in Example 11.3. A cost profile is derived from the

[5] In some cases, such as the production of movies, no actual market price is available at the end of the production process and the value has to be derived through an estimate of discounted future receipts. (This estimate is more likely to be effective for aggregates than for an individual movie.) This is further explained in chapter 20 of the *2008 SNA*.

data in Example 11.1—the production cycle lasts four quarters, with 20 percent in q1 (i.e., 600/3,000), 25 percent in q2, 30 percent in q3, and 25 percent in q4. By definition, the cost profile has the same pattern as the resulting production estimate at constant prices.

11.37 The cost profile method is often used for construction in conjunction with data on building permits. In cases where only volume indicators such as square meters are available, the values are derived by average prices per unit obtained from a benchmark survey or expert assessment. If value data are available, the value concept needs to be identified—current prices or forecast end-of-period prices. The cost profile should take into account the lags between approval, commencement, and completion. It may also account for low work periods such as monsoons and holiday/vacation periods. The expected value should be adjusted for projects that are approved but not implemented. Also, it might be desirable to estimate work-in-progress on individual large projects on a case-by-case basis; compilers of source statistics might be best placed to do this.

Special Issues for Agriculture

11.38 The general principles of recording production on an ongoing basis also apply to agriculture. The principles of consistency between related transactors, transactions, and stocks of the accounts also apply to agriculture. In some economies, own-account production of biological resources that take longer than one year to mature may be significant. If biological resources are grown for harvest or for slaughter, not recording work-in-progress would result in a misallocation of production across years. If grown for capital formation, not including this production in output as work-in-progress would result in an underestimation of gross domestic product (GDP).[6]

11.39 Cultivated biological resources encompass a number of types of product and production processes. Production results in different account entries and lengths of time over which production occurs, depending on the products and their intended uses.

[6] An incomplete view in the accounts would also occur with production of repeat products being recorded derived from fixed assets that were never recorded.

11.40 For tree, crop, and plant resources,

a. If grown for harvest, such as grains, vegetables, and timber grown for harvesting (plantation forestry), growth through the production period should be recorded as output in the production account, change in inventories, and work-in-progress in the capital account. Growth to maturity for timber grown for harvest may take several years.

b. If grown for their repeat products, such as grape vines and trees grown for their fruit, nuts, or sap, growth to maturity should be recorded as output in the production account and gross fixed capital formation in the capital accounts if grown on own account. If not grown on own account, growth should be recorded in output and work-in-progress inventories for specialists who grow such products for sale, such as plant nurseries, unless bound by a contract of sale as explained in paragraph 11.20 of this chapter. Note that this process may take several years. Once the tree, crop, or plant resources have reached maturity, output is measured in terms of the repeat products they produce (grapes, nuts, etc.), and consumption of fixed capital should be recorded for the decline in value of the assets due to their physical deterioration, normal obsolescence, or normal accidental damage.

11.41 For animal resources, including fish,

a. If grown for slaughter, the treatment is the same as for plant resources grown for harvest. Note that some animals may take more than one year to grow to maturity.

b. If grown for their repeat products, such as breeding animals, dairy cattle, sheep and goats grown for their wool and milk, and working animals for transportation and farm work, the treatment is the same as for plant resources yielding repeat products, including the consideration of whether grown on own account or by specialists. Example 11.4 shows how the work-in-progress principle applies to cattle farming.

c. Consumption of fixed capital should, conceptually, be recorded from when the animals reach maturity until the end of their economic life, at which time the disposal of a fixed asset is recorded.

Example 11.4 Work-in-Progress for Livestock

(a) Compile a perpetual inventory model of the production of live animals
(b) Adjust the output estimate of live animals by weight gain to derive the work-in-progress output

This example relates to raising cattle for meat.

The opening inventory in q1 2011 is 68 head of cattle, including 64 breeding cows and 4 bulls. The farmer maintains the same stock over time. All the breeding females calve once during the year, with a gestation period of three quarters.

For this example, it is assumed that the cows get pregnant at the beginning of q2 and the calves are born at the beginning of q1. On average, each calf weighs 30 kg at birth, so the calf grows by 10 kg each quarter over three quarters prior to birth.

All calves are sold once they are one year old (mid-quarter) and the weight gain for calves is 40 kg per quarter. No animals are purchased or died during the period. The relevant output price for livestock is the farmgate price per kilogram for live weight (LW) of the animals. In 2010, the LW was $5 per kg. The average quarterly price index is given as follows:

Price index	q4 2010	q1 2011	q2 2011	q3 2011	q4 2011	q1 2012	q2 2012	q3 2012	q4 2012	q1 2013
LW price index (average 2010 = 100)	100	102	104	106	108	110	112	114	116	118

Step 1: Produce livestock inventory model

The first step is to calculate a quarterly model of livestock inventory. Given the assumptions, the same number of calves are born and sold in the first quarter every year. As a result, the closing inventory (68) exactly matches the opening inventory.

Livestock Inventory (Number)	q4 2010	q1 2011	q2 2011	q3 2011	q4 2011	q1 2012	q2 2012	q3 2012	q4 2012	q1 2013
Opening Inventory		132	132	132	132	132	132	132	132	132
Born(+)		64	0	0	0	64	0	0	0	64
Sold (–)		64	0	0	0	64	0	0	0	64
Closing Inventory	132	132	132	132	132	132	132	132	132	132

Step 2: Calculate the value of output and changes in stock at 2010 constant prices

To calculate the output value at constant prices, the weight gain of cows and calves in each quarter should be multiplied by the fixed $5 per kg price in 2010. The weight gain of cows is an indirect measure of the growing process of calves. In the SNA, an immature animal should be recorded as gross fixed capital formation (*2008 SNA*, paragraph 10.91). Once the calves are born, their weight gain is treated as changes in inventories. At constant prices, both weight gains should be valued using the fixed price of the base year. Output is derived as the sum of gross fixed capital formation, changes in inventories, plus the sales of calves (which are made in q1 by assumption).

It should be noted that the value of sales in q1 more than compensates the loss in weight of cows and calves due to the start of a new calving cycle. The output estimate is stable during the year, because the output sold in q1 is accounted for in the rest of year by considering the weight gains of cows and calves. It should also be noted that the sales of calves should be recorded as intermediate consumption of the meat processing industry.

Constant Prices ($ '000)	q4 2010	q1 2011	q2 2011	q3 2011	q4 2011	q1 2012	q2 2012	q3 2012	q4 2012	q1 2013
Cows (LW 400 kg × 64 cows × $5)		128.0				128.0				128.0
Cows (LW 405 kg × 64 cows × $5)			129.6				129.6			
Cows (LW 415 kg × 64 cows × $5)				132.8				132.8		
Cows (LW 425 kg × 64 cows × $5)	136.0				136.0				136.0	
Calves (1.5 months old – 50 kg)		16.0				16.0				16.0
Calves (4.5 months old – 90 kg)			28.8				28.8			
Calves (7.5 months old – 130 kg)				41.6				41.6		
Calves (10.5 months old – 170 kg)	54.4				54.4				54.4	
Use closing stock of current quarter less closing stock of previous quarter to value:										
Gross fixed capital formation (Value of weight gain of cows)		(8.0)	1.6	3.2	3.2	(8.0)	1.6	3.2	3.2	(8.0)
Changes in inventories (Value of weight gain of calves)		(38.4)	12.8	12.8	12.8	(38.4)	12.8	12.8	12.8	(38.4)
Sale of calves 12 months (190 kg)		60.8				60.8				60.8
Change in value due to weight gain of cows from one quarter to the next plus weight gain of calves:										
Output value		14.4	14.4	16.0	16.0	14.4	14.4	16.0	16.0	14.4

Example 11.4 Work-in-Progress for Livestock *(continued)*

Step 3: Calculate the value of output and changes in stock at current prices

The value of changes in stock at constant prices derived in Step 2 is converted into current prices using the average price change for the relevant quarter. The gross fixed capital formation and changes in inventories estimates are derived as the difference between the current price value in a quarter and the current price value in the preceding quarter. Holding gains from the previous quarter should be eliminated. The current value of sales is also assumed to follow the LW price index.

For example, the current price value of gross fixed capital formation in q1 2011 is the difference between the current price value of cows in q1 2011 (130.6) and the current price value of cows in q4 2010 revaluated to eliminate holding gains (136.0 × 1.02 = 138.7).

By construction, the output deflator exactly reproduces the changes in the output price index used in the model.

Current Prices ($ '000)	q4 2010	q1 2011	q2 2011	q3 2011	q4 2011	q1 2012	q2 2012	q3 2012	q4 2012	q1 2013
Cows (400 kg, incl. holding gains)		130.6	133.1			140.8	143.4			151.0
Cows (405 kg, incl. holding gains)			134.8	137.4			145.2	147.7		
Cows (415 kg, incl. holding gains)				140.8	143.4			151.4	154.0	
Cows (425 kg, incl. holding gains)	136.0	138.7			146.9	149.6			157.8	160.5
Calves (1.5 months old, incl. holding gains)		16.3	16.6			17.6	17.9			18.9
Calves (4.5 months old, incl. holding gains)			30.0	30.5			32.3	32.8		
Calves (7.5 months old, incl. holding gains)				44.1	44.9			47.4	48.3	
Calves (10.5 months old, incl. holding gains)	54.4	55.5			58.8	59.8			63.1	64.2
The work-in-progress valuation of output is then allocated to gross fixed capital formation and changes in inventories as follows:										
Gross fixed capital formation		(8.1)	1.7	3.4	3.5	(8.8)	1.8	3.7	3.8	(9.5)
Changes in inventories		(39.2)	13.4	13.6	13.9	(42.2)	14.4	14.6	14.8	(45.3)
Sales		62.0				66.9				71.7
Output value		14.7	15.1	17.0	17.4	15.9	16.2	18.3	18.6	16.9
Output deflator (2010q4 = 100)		102.0	104.0	106.0	108.0	110.0	112.0	114.0	116.0	118.0

11.42 It may be feasible to use one of the methods discussed in the previous section, typically a cost profile in conjunction with actual totals (for previous years) or forecasts (for the current year).

11.43 However, the degree of uncertainty about the eventual output makes the treatment somewhat more problematic for agriculture and related industries, both for practical and conceptual reasons. This has caused many countries not to apply the work-in-progress concepts in the case of agriculture.

11.44 Weather is the major component of uncertainty in agriculture. There are variations in temperature, rainfall, and sunlight, with droughts, hurricanes, and floods being the extremes. Also, in some cases, insect or other animal plagues may be important. The degree of uncertainty varies significantly among countries and may affect some products more than others.

11.45 One aspect of uncertainty is that estimates made before the harvest or completion of production need to be based on forecasts of both volume and price data. This is particularly the case in the QNA, where the emphasis on timeliness implies that the estimates for preharvest quarters will have to be made well in advance of harvest time. If the value is uncertain, there are concerns about potentially large revisions in the national accounts. If growing period to maturity spans several years, the potential impact of these sources of uncertainty on final harvest volumes and prices may be significant. Consequently, the transparency and application of the national accounts revision policy is important, since revisions will be necessary. For some countries, significant revisions are not well understood or well accepted by some users as being an integral and inevitable element of the statistical process. In these cases, it may be very difficult to convince users of the importance of making estimates of work-in-progress.

11.46 Another aspect of uncertainty concerns catastrophic events. The treatment of output losses in the national accounts is quite different between normal events and catastrophes. For normal events, the losses are reflected in reduced output, because only the output that materialized is recorded. For catastrophes, output is measured as if nothing happened and the losses are recorded on the other changes in volume of assets account. Recording a crop or growth of animals that never materialized in output because of a catastrophe is counterintuitive.

11.47 The *2008 SNA* restricts catastrophic events to singular events of a general nature: for example, major earthquakes, volcanic eruptions, tidal waves, exceptionally severe hurricanes, drought, and other natural disasters (paragraph 12.46). Limitation of catastrophic events to singular events of a general nature means, among other things, that losses of crops or animals through frequent floods and droughts should not be regarded as catastrophic losses, no matter how devastating they are for crops under cultivation. The *2008 SNA* definition of catastrophic events leaves room for interpretation, however, which may hamper international comparability and generate anomalous differences over time. For example, higher production would be recorded when floods and droughts are classified as catastrophic than for when they are considered to be in the normal range.

11.48 A further aspect of uncertainty concerns the prices to assign production in non-harvest periods. This issue of price uncertainty arises in both ex post and, even more, ex ante data. There may be no or only a very limited market for crops or animals in the non-harvest periods, so that the prices are more uncertain and have to be extrapolated (ex ante) or interpolated (ex post). The prices of crops[7] or animals in non-harvest periods may be available but may be misleading to the extent that they also include storage and holding costs or the off-season scarcity of fresh produce. In such cases, the observed prices would not be relevant for valuing the harvest. As a solution, some downward adjustment based on past years' off-season patterns may be derived, or the observed prices could be replaced by interpolation or extrapolation of harvest prices. In addition, prices of subsequent years' crops or animals may be quite unrelated, so estimation of the work-in-progress on the new harvest with prices of the old may be misleading. The supply-and-demand situation often differs considerably among crops, so that the prices may be completely different. For instance, if an abundant crop is followed by a meager one, the price of the second crop at harvest time may jump compared with the price of the first crop. Obviously, in such a case, the current price estimates need to be revised, but the price development of the first crop is not valid for the revision of the quarterly estimates. A relatively simple solution to this problem, ex post, would be to derive new indices relevant for the production quarters of the new crop by an interpolation between the price of the previous crop at harvest time and the price of the present crop at harvest time. Ex ante, forecast price data are required until actual data become available.

11.49 Consideration of behavioral aspects is relevant to the inclusion of agricultural work-in-progress in national accounts estimates. If the economic agents themselves react to the uncertainty of prices and volumes by behaving as if the work-in-progress carried out were not output (and thus not generating income), then the estimates will not help in understanding economic developments. The consistency of data across transactors, transactions, and stocks becomes important in this regard.

11.50 By measuring production before the producers do, statisticians may be exposed to the accusation of counting the chickens before they hatch. Unlike many other producers, farmers do not normally record their own work-in-progress. One singular aspect of this would be the imputation of income flows before they are realized, and possibly even in cases in which they are not realized. As a result, the concerns about artificiality and complexity of methods are particularly strong in the case of components of agriculture that are particularly prone to uncertainty. For that reason, in the case of agriculture, recording production simply as the harvest value, in the periods of harvest, may be considered. However, for some production, there may be no harvest, or the harvest becomes a different activity (e.g., growth of grape vines and fruit trees, breeding animals to maturity, or logging of plantation forests). In

[7] If no local prices are available, world-market prices could be considered; however, these prices may not be indicative for local supply in a particular country. The situation may be exacerbated in some countries if the informal sector is dominant in agriculture and market transactions are relatively rare.

which case, GDP will be underestimated unless output as work-in-progress is recorded at the time it occurs.

11.51 Whether a harvest or work-in-progress approach is used for agriculture, the resulting output series will often be lumpy. In the case of the harvest approach, the output will often be concentrated in one or two quarters, while the others may have little or no output. In the case of the work-in-progress approach, discontinuities will occur between crop years, effectively because of the change in the output/cost markup ratio. With either approach, the lumpiness is the valid and necessary result of the production concept adopted in conjunction with the intrinsic limitations of presenting an annual process in a quarterly form. It would be feasible to smooth out the lumpiness in the series by mathematical techniques, but in the context of nonseasonally adjusted data, this would not be justified by the economic concept of production and would just cover up the issue. Users, however, may prefer the seasonally adjusted or trend-cycle series for some purposes.

11.52 Because of their special features, quarterly data on agricultural production need to be interpreted carefully. The data are necessarily artificial when a yearly, multiquarter, or multiyear process is split into quarters. If a cost profile is used to implement a work-in-progress approach, the quarter-to-quarter movements are driven by the cost profile used rather than by new information on output. In this case, a pro rata methodology is acceptable and the resulting step effect correctly reflects the change in level of production between growing seasons. These steps should not be removed in the original series through benchmarking techniques as recommended in Chapter 6. However, because the cost profile is a seasonal pattern, it will be removed by the seasonal adjustment process, provided seasonal adjustment of the data is applied, although careful analysis of the process and results will be essential.[8]

[8] If there are zero-production periods, a nonmultiplicative method of seasonal adjustment must be used. See Chapter 7 for a discussion of seasonal adjustment techniques.

11.53 Techniques of presentation of the data may help users deal with the difficulties associated with measurement of quarterly output from agriculture. In view of the multiple uses of quarterly accounts, there may be alternative solutions to the conceptual and practical problems. In this respect, three recommendations can be made. First, document the methodology carefully so users are able to form their own opinions. Although this will not enhance the accuracy of the figures, it will at least enable a view on whether they are suitable for particular purposes. Second, to serve users who deem the allocations unsuitable or do not care for allocations anyway, specify and quantify the allocations. Third, present the data with sufficient details to allow users to exclude the work-in-progress if they wish.

11.54 In conclusion, as a general principle, the *2008 SNA* states that agricultural work-in-progress should be included in output. However, the uncertainty and data issues associated with agricultural work-in-progress are often more severe than in other cases, so the decision on whether to include it needs to take into account the circumstances and analytical benefits in each country:

- For agricultural products that have a high degree of uncertainty about the relationship between inputs and the final yield, economic and user views may be more inclined to adopt a treatment like contingent assets. For products that have a very close relationship between inputs and final yield, there is a strong case for recognizing work-in-progress and measuring it realistically.
- A country that is just beginning QNA may be more inclined to adopt an initial method that is simple to explain and implement, with a view to moving to more sophisticated methods at a later stage. This chapter has shown quarterly allocation of annual data as a method that can be implemented simply in any country.

Summary of Key Recommendations

- *In the QNA, work-in-progress should be recorded for economic activities in which the production cycle goes beyond the quarter. Work-in-progress can be particularly important for agriculture, manufacture of ships and airplanes, and construction activities.*
- *Work-in-progress output should be valued at market-equivalent prices. The market equivalent price is what buyers would be prepared to pay if they wished to obtain the unfinished product or what suppliers would need to be paid to produce it. This value is equivalent to the total input costs for each period plus a markup.*
- *The measure of input costs should be as complete as possible. The input costs should include compensation of employees, intermediate consumption, other taxes less subsidies on production, and costs of using land and capital (rent, consumption of fixed capital, and interest). In practice, the data on costs may be incomplete, and so the markup needs to be adjusted accordingly.*
- *As a general principle, the 2008 SNA states that agricultural work-in-progress should be included in output. However, the uncertainty and data issues associated with agricultural work-in-progress are often more severe than in other cases, so the decision on whether to include it needs to take into account the circumstances and analytical benefits in each country.*

Annex 11.1 Recording Work-in-Progress in the *2008 SNA* Sequence of Accounts

A11.1 Although estimation of work-in-progress primarily concerns output, a consistent system such as the national accounts should also consider other transactions that relate to work-in-progress, as well as balances (such as value added). This annex explains which other transactions and balances are affected. A numerical illustration of the effects of work-in-progress on main aggregates in the *2008 SNA* sequence of accounts and balance sheets is provided in Example A11.1. The example demonstrates that significant effects can be found throughout the full sequence of accounts.

A11.2 In the general case, where work-in-progress is not sold until the product is finished, the two initial entries in the accounts are (a) output and (b) changes in inventories (increases) in the case of agriculture, manufacturing, services, and speculative construction, as well as capital formation in the case of own-account capital formation. After the product is finished and sold, two further transactions are recorded: (a) changes in inventories (decreases) and (b) changes in financial assets. In the case of production of a capital good under contract, four entries have to be recorded: (a) output for the producer, (b) fixed capital formation for the user, (c) increase in financial assets for the producer, and (d) decrease in financial assets for the user.

A11.3 In the production account of the producer, besides output, the only entry that is affected by work-in-progress is value added; the other entries—intermediate consumption, taxes and subsidies on production, and consumption of fixed capital—are not. Because inputs are actually made, there is no conceptual problem in allocating them to relevant periods. Value added is derived as a balance and, thus, estimates will result automatically from the measurement of output. Consumption of fixed capital is not an issue in this context because, per axiom, it is assumed to take place on a continuous basis (for a discussion of consumption of fixed capital in a QNA context, see Chapter 4). Taxes and subsidies on production are not affected because these are to be recorded at the time the output is sold, transferred, or used (see *2008 SNA*, paragraph 7.84).

A11.4 In the generation of income account of the producer, the effect on value added in the production account will be carried over to operating surplus/mixed income, because wages as such are not affected by work-in-progress. Similarly, in the allocation of primary income account, the impact on operating surplus/mixed income will directly carry over to the closing balance, primary income, because none of the transactions on this account are affected by work-in-progress. The same applies to transactions on the secondary distribution of income account, in that, again, only the closing balance of this account, disposable income, will be affected.

A11.5 On the use of income account of the producer, the changes in disposable income would be fully absorbed by savings because consumption is not affected. The effect on saving for the producer would, in the case of work undertaken on own account, not carry over to the financial account because increased savings would be absorbed by offsetting changes in inventories or capital formation on the capital accounts for the same institutional unit. In the case of production of a capital good under contract, however, the full effect on savings for the producer will be carried over to the financial account in the form of payments received from installments and other accounts receivable accrued.

A11.6 The other changes in assets accounts can be affected in two ways. First, because prices of the goods in inventories change over time, the resulting holding gains or losses have to be recorded on the revaluation account. Second, if work-in-progress is lost because of catastrophic events, this has to be recorded on the other changes in volume of assets account.

A11.7 Finally, the balance sheets of the system show the stocks resulting from the changes on the current and accumulation accounts. The output of unfinished products is recorded as inventories of work-in-progress unless it is sold. At the time the product is finished, a reclassification has to be made from inventories of work-in-progress to inventories of finished goods, and at the time the product is eventually sold, this sale will be reflected on the balance sheets through lower inventories, with a concomitant effect on financial assets and liabilities.

Example A11.1 Effects of Work-in-Progress on Main Aggregates in the *2008 SNA* Sequence of Accounts and Balance Sheets

(Data in bold refer to treatment *with* work-in-progress)

In this example, the results obtained in Example 11.1 are presented in the format of *2008 SNA* sequence of accounts. The accounts show how, with work-in-progress recorded, each quarter would have had a positive value added; whereas, without work-in-progress recorded, the first three quarters would have had a negative value added and only the fourth would have had a positive value added. The accounts also show that without recording work-in-progress, a holding gain (caused by inflation) would have been included in output and value added. Furthermore, the example demonstrates that the increased saving is fully absorbed by increased inventories, so that the financial transactions (in this example, loans) are unaffected. (This example concerns an economic activity for which no installment payments are made that would affect the financial accounts.)

	Current Accounts			
	Intermediate Consumption		Output	
q1	160	**160**	0	**880**
q2	340	**340**	0	**1,200**
q3	530	**530**	0	**1,560**
q4	300	**300**	5,800	**1,400**
The year	1,330	**1,330**	5,800	**5,040**
	Value Added			
q1	–160	**720**		
q2	–340	**860**		
q3	–530	**1,030**		
q4	5,500	**1,100**		
The year	4,470	**3,710**		
	Compensation of Employees			
q1	300	**300**		
q2	310	**310**		
q3	340	**340**		
q4	400	**400**		
The year	1,350	**1,350**		
	Saving			
q1	–460	**420**		
q2	–650	**550**		
q3	–870	**690**		
q4	5,100	**700**		
The year	3,120	**2,360**		

Capital Transactions, Financial Transactions, and Balance Sheets

	Opening Balance Sheet		Transactions				Holding Gains		Closing Balance Sheet	
			Additions		Withdrawals					
Nonfinancial Assets (Inventories)										
Quarterly Data										
q1	0	**0**	0	**880**	0	**0**	0	**40**	0	**920**
q2	0	**920**	0	**1,200**	0	**0**	0	**130**	0	**2,250**
q3	0	**2,250**	0	**1,560**	0	**0**	0	**240**	0	**4,050**
q4	0	**4,050**	5,800	**1,400**	0	**0**	0	**350**	5,800	**5,800**
Annual Data	0	0	5,800	**5,040**	0	**0**	0	**760**	5,800	**5,800**
Financial Liabilities (Loans)										
Quarterly Data										
q1	0	**0**	460	**460**	0	**0**	0	**0**	460	**460**
q2	460	**460**	650	**650**	0	**0**	0	**0**	1,110	**1,110**
q3	1,110	**1,110**	870	**870**	0	**0**	0	**0**	1,980	**1,980**
q4	1,980	**1,980**	700	**700**	0	**0**	0	**0**	2,680	**2,680**
Annual Data	0	**0**	2,680	**2,680**	0	**0**	0	**0**	2,680	**2,680**
Net worth										
q1	0	**0**	–460	**420**	0	**0**	0	**40**	–460	**460**
q2	–460	**460**	–650	**550**	0	**0**	0	**130**	–1,110	**1,140**
q3	–1,110	**1,140**	–870	**690**	0	**0**	0	**240**	–1,980	**2,070**
q4	–1,980	**2,070**	5,100	**700**	0	**0**	0	**350**	3,120	**3,120**
Annual Data	0	**0**	3,120	**2,360**	0	**0**	0	**760**	3,120	**3,120**

Bibliography

United Nations, European Commission, International Monetary Fund, and Organization for Economic Co-operation and Development (2008), *The System of National Accounts, 2008*, New York: United Nations.

12 Revisions

Quarterly national accounts (QNA) are subject to revisions. To satisfy timeliness requirements, the first estimate of a quarter generally relies on an incomplete and partial dataset. When more comprehensive source data are made available, previously published estimates must necessarily be revised. Revisions should be explained and clearly communicated to the users. This chapter describes how to design a sound, coordinated, and transparent revisions policy of the QNA. Necessary ingredients for a sound revisions policy are a compilation and release schedule, an advance release calendar, and a communications strategy. Furthermore, a framework for conducting revisions analysis should be developed to measure and assess the reliability of quarterly estimates.

Introduction

12.1 Revisions are an essential part of good QNA compilation practice. Revisions are necessary to incorporate improvements in source data, methods, international standards, and classifications that are continuously made available. They provide users with data that are as timely and accurate as possible. Resource constraints, in combination with user needs, cause tension between the timeliness of published data on the one hand and reliability, accuracy, and comprehensiveness on the other hand. To reduce this tension, typically, preliminary data are compiled on a timely basis; later, revised estimates are produced when more and better source data become available. Good management of the process of revisions requires the existence of a well-established and transparent revision policy.

12.2 It is important to emphasize that revisions are conducted for the benefit of users: namely, to provide users with data that are as timely and accurate as possible. Revisions provide the possibility to incorporate new and more accurate information, and thus to improve the accuracy of the estimates, without introducing breaks in the time series. Although repeated revisions may be perceived as reflecting negatively on the trustworthiness of official statistics, delaying the incorporation of new data in the published estimates may increase the magnitude of later revisions (in particular, if these go in the same direction). Furthermore, not passing on known revisions reduces the actual trustworthiness of data even more, because the data do not reflect the best available information, and the public may know this or find this out (for instance, the public may wonder why a revision in the monthly production index is not reflected in the QNA).

12.3 It is essential to revise preliminary QNA data to take account of new and better information for the reasons stated above. Further, attempting to avoid revisions by producing accurate but very untimely, and thus less useful, data may not make the best use of the information available. If the official QNA compilers fail to serve users' needs, other organizations may compile their own estimates, resulting in confusion from conflicting estimates to the point that many users may consider the official data irrelevant. Obviously, that will result in reduced prestige and respect for the official QNA compilers.

12.4 Revisions to past data are not without potential problems and may draw criticism if not properly handled. Revisions to past data are inconvenient to users because they entail revisions to their databases and applications. More important, frequent revisions—particularly to data for the most recent periods—may cause users to feel uncertain about the current economic situation and thus uncertain about what policy actions should be taken. Some of this uncertainty may be unavoidable and merely reveal the fact that the information base for the estimates for the most recent periods is limited and thus that the data should be used with care. Some of the uncertainty, however, may be caused unnecessarily by the way the revisions are carried out or presented. On the other hand, unjustified differences between national accounts estimates and their source data may cause users to doubt the competence of the national accounts compilers with serious—and justified—criticism of the national accounts data as a result.

12.5 To deal with the issues surrounding revisions and to avoid unnecessary criticism, a well-designed and carefully managed revision policy is needed. Essential features of a well-designed revision policy are predictability and openness, advance notice of causes and effects, and explanation, as well as easy access to sufficiently long time series of revised data. This chapter elaborates on the elements that make for a well-established revision policy.

User Requirements and Resource Constraints

12.6 The trade-off between timeliness on the one hand and accuracy and reliability on the other is caused by a conflict between different user requirements in combination with limitations in statistical resources. National accounts data are used for multiple purposes that have partly conflicting requirements. To allow corrective policy actions to be taken in time, policymakers and other users need a coherent, comprehensive, and reasonably accurate picture of the current economic situation that is as up-to-date as possible. For other purposes, such as time series and structural analysis of past events, users require long time series of very detailed annual national accounts (ANA) or QNA data. Finally, users are interested in both the period-to-period rates of change in the series and their levels. The resources available for statistical purposes, however, are limited. Collection of sufficiently accurate and detailed source statistics is time consuming and expensive both for the statistical office and for the respondents, and compilation of comprehensive, accurate, and detailed national accounts is in itself time-consuming and expensive. Also, frequent collection of comprehensive and detailed data may impose an unwarranted burden on respondents, who themselves may not even have such data on a timely and short-term basis.

12.7 As a result, only a limited set of monthly or quarterly source data is typically available on a very timely basis. More detailed and more comprehensive monthly or quarterly source statistics become typically available on a less timely basis, while the most detailed, comprehensive, and reliable source data that may be annual or less frequent data become available with varying delays long after the reference year. To provide sufficiently reliable benchmark data, many countries conduct periodic "benchmark censuses," collecting very detailed and reliable annual data every five or ten years. These are often linked to periodic compilation of supply and use tables (SUT). The monthly and quarterly data commonly are based on smaller samples and less complete sample frames than the corresponding annual data. Finally, the annual data may be based on audited business accounts through comprehensive questionnaires that facilitate a thorough checking and editing of the reported data, while the quarterly data may be collected using simpler questionnaires that allow less extensive checking and editing.

Waves of Source Data and Related Revision Cycles

12.8 Quarterly accounts are subject to three "waves" of statistical source data that become available. Each of these waves may lead to revisions of earlier estimates and the incorporation of more details in the published accounts. In accordance, three revision cycles may be distinguished:

a. A *quarterly revision cycle* is determined by the evolution of the short-term statistics as used in the QNA.
b. An *annual revision cycle* is caused by incorporation of annual source data or ANA estimates based on a separate ANA compilation system into the QNA through benchmarking.
c. Finally, a *periodic major revision cycle* originates from incorporating data from periodic benchmark censuses, revised international guidelines, and other changes that cannot be incorporated on a continuous basis because of resource constraints.

Revisions may, of course, also be caused by compilation errors, which need to be corrected when found.

12.9 The evolution of short-term statistics used in the QNA may cause revisions for two reasons:

(a) corrections or changes in specific short-term source data and (b) incorporation of additional, somewhat less timely, short-term data. Changes in short-term source data can be caused by late responses received after initial publication of source statistics and by the use of prepublished data that are still open to change. To increase the timeliness of the QNA, the first estimates may have to be based on an incomplete set of short-term source data. Monthly and quarterly source data become commonly available with varying delays. Thus, when preparing the first estimates, only data for two months of the last quarter may be available for some series, while data may be missing altogether for other series. To fill these source data gaps, provisional estimates are generally based on simple trend extrapolation or on alternative indicators that are more timely but less reliable. During the course of the current year, these provisional estimates must be revised to incorporate more and better data as the less timely short-term source statistics become available.

12.10 An early (or "flash") estimate of the quarterly gross domestic product (GDP) should always be revised during the same quarter to incorporate more complete and updated short-term indicators that become available after its publication. An early estimate serves a very crucial need for policymakers, who necessitates a prompt measurement of the current economic developments. However, timely but unreliable official estimates may lead to wrong decisions. Substantial changes to an early estimate should be introduced as soon as possible, because policy decisions may change in accord with the revised estimate. Countries producing early estimates should release at least one more release of the same quarter before the next quarter commences. The timing of the early and revised estimates should be decided on the basis of the timing of arrival of the short-term indicators.

12.11 Incorporation of more reliable annual data into the quarterly estimates implies several revisions to the QNA estimates over time for two reasons. First, the annual data themselves may be revised. Second, for technical reasons, the benchmarking procedure will result in revisions to quarterly data for earlier years in addition to the year(s) with new annual data. As explained in Chapter 6, these additional revisions to past estimates are needed to avoid introducing breaks (the "step problem") in the QNA time series between successive pairs of years. Benchmarking of QNA on more reliable annual data has the advantage of conveying the accuracy and reliability of the annual data to the QNA and allows for a degree of comprehensiveness that the short-term source data by themselves do not admit. Annual source data may become available throughout the year or clustered around a few times of the year.

12.12 Periodic major revisions may be needed to the complete quarterly and annual time series or to a large part of the time series. Over time, periodic benchmark censuses may be conducted, new types of annual source data may become available, and improved compilation methods may be developed, all indicating a need for level adjustments. In addition, international guidelines are periodically revised. To introduce these improvements without creating breaks in the quarterly and annual time series, the complete time series—or a large part of the time series—must be revised at the same time. Ideally, this should be done on a continuous basis, series by series; however, resource constraints often do not permit such a frequent backcasting approach. Simplified ratio-based backcasting techniques may help in dealing with this problem. When such major revisions are released, it is desirable to provide to the user continuous time series of key QNA aggregates (such as the quarterly GDP) of at least five years of length.

Compilation and Release Schedule

12.13 A crucial part of a well-established and transparent revision policy is devising an appropriate compilation and release schedule. When establishing a compilation and release schedule, it is important to decide (a) how timely the initial quarterly estimates should be, (b) how frequent new quarterly source data should be incorporated, (c) how early and how frequent annual source data should be incorporated, (d) how frequent regular major revisions should be conducted, and (e) how long the revisions period should be extended.

12.14 Major elements in determining the compilation and release schedule are (a) timing of arrival of major data sources and the source data revision policy; (b) timing of preparation of important economic political documents; (c) attitudes toward the trade-off between timeliness and accuracy, as well as toward size and frequency of revisions; (d) dissemination modes; and finally (e) workloads and the design of the national accounts compilation system.

12.15 To minimize the number of revisions needed without suppressing information, it is advisable to coordinate statistical activities. The revision schedule is, or should be, largely driven by the arrival of source data, and coordinating their arrival would substantially help reduce the number of revisions needed. Tying introduction of new concepts and methods, or new international guidelines, to the time of other planned revisions would also help reduce the number of revisions. Although the timing of censuses and new surveys may not be at the discretion of national accountants, they may have a strong say in this and they are well advised to use their influence to achieve maximum consistency with their revision policy.

12.16 Account needs to be taken of the coordination of QNA with related economic policy documents, such as the general government budget and other important documents related to the parliament's or legislature's budget discussions. Release of new estimates shortly after the government budget has to be presented or in the midst of a budget debate may cause problems (although this should not change the release schedule once it has been fixed).

12.17 As discussed in the previous section, care should be taken to prevent that initial estimates for a quarter are prepared and released too early. Improved timeliness could require use of a higher proportion of incomplete source data, resulting in an unacceptable reduction in the accuracy of the estimates and larger revisions. The information content of estimates based on very incomplete source data may be limited and, in some cases, more misleading than informative. In those cases, the users would be better served by less timely initial estimates for a quarter.

12.18 Finally, the design of the national accounts compilation system has important implications for how frequently it is possible and appropriate to incorporate new source data. Large and complicated compilation systems with detailed and extensive balancing and reconciliation procedures (e.g., based on quarterly or annual compilation of integrated SUT and a complete set of integrated sectoral accounts) make it costly to incorporate new source data very frequently.

12.19 Timeliness of release of the initial estimates for a quarter varies greatly from country to country, mainly reflecting different perspectives on the timeliness–accuracy–revision trade-off. Early releases of QNA data among statistically advanced countries come within 45 days after the reference quarter. In other countries, a more common release time for the initial estimates is around two to three months after the end of the quarter.[1]

12.20 Initial estimates for the fourth quarter should clearly be separated from the annual estimates. In the fourth quarter, there is typically a shift of focus in the presentation from the estimates of the quarters to the estimates for the full year. While the main focus may be on the estimates for the full year, the fourth-quarter data need to be published in their own right, because failing to do so will cause users who need integrated annual and quarterly data to wrongly derive the fourth quarter as the difference between the annual total and the sum of the three previously published quarters. To provide very early annual estimates, some countries release their initial estimates earlier after the end of the fourth quarter than for other quarters. If the initial estimates for the fourth quarter are released earlier than for other quarters, it is necessary to highlight the lower quality of the fourth-quarter estimate: for example, by noting its revisions in previous years and the specific shortcomings in the data used.

12.21 How frequently new quarterly source data are incorporated varies. Countries that release their initial estimates within a month after the reference quarter typically release revised and more detailed estimates shortly thereafter. These early estimates are often revised once or twice in the first quarter after the reference quarter. The estimates may be open to quarterly revisions thereafter. A more common practice, followed by countries that are less timely in releasing their initial estimates, is to revise the estimates quarterly linked to the preparation and release of the initial estimates for the following quarters. To reduce the number of revisions, it may be tempting to allow the estimates to be revised only once during the ongoing year. However, temporarily suppressing information may result in larger revisions later. Suppression of

[1] The Special Data Dissemination Standard (SDDS) specifies timeliness for the initial QNA estimates at three months after the end of the quarter.

information may also sometimes be technically difficult to implement and thus may result in compilation errors. The preferred practice is to let all estimates be open to revision during the ongoing year. This is particularly relevant for seasonally adjusted data, which may change substantially just with the addition of a new observation in the series (see Chapter 7 for technical details on revisions due to seasonal adjustment).

12.22 Annual source data can be incorporated into the QNA estimates either series by series, when the new annual source data for a series become available, or simultaneously for all series. The choice mainly depends on the design of the ANA and QNA compilation systems. The series-by-series approach has the advantage of allowing new annual information to be incorporated in as timely a manner as possible. Some countries compile their quarterly and annual estimates using basically the same time-series-oriented compilation system—typically without detailed and extensive balancing and reconciliation procedures—making this approach the natural choice. However, most countries use a separate system for compiling their annual estimates, which makes it natural to filter the annual source data through the annual accounting system before incorporating the information into the QNA estimates. In those circumstances, to avoid inconsistencies between quarterly and annual accounts, the simultaneous approach may be the natural choice. Some countries use a combination of the two approaches. In any case, because the QNA system is an accounting system highly interconnected, compilers should make sure that changes due to new or updated annual source data are reflected consistently across QNA series.

12.23 Countries with an independent ANA compilation process typically revise their annual estimates from two to four times before the books are closed until a major revision is undertaken. These regular revisions to the annual estimates are normally undertaken once a year, although a few countries conduct them more frequently. The timing within the year of these annual revisions varies widely. The emphasis is typically on providing accurate and detailed data for structural analysis, with less emphasis on timeliness. They are nearly always more detailed than the QNA and may encompass a more complete set of the

Box 12.1 Compilation and Revision Schedule: An Example

Revisions to Estimates for a Quarter of Year *y*

Quarterly Revisions

- Early GDP estimate: up to 1 month after the end of the quarter.
- Initial estimate: 2–3 months after the end of the quarter.
- Revised estimate: 5–6 months after the end of the quarter.
- All estimates may be open to revisions during the current year.

First Annual Round of Revisions:

		Annual Data for	Quarterly Accounts
3–12 months after the end of year *y*	year *y*	Preliminary annual estimates based on a separate annual accounting system	Revised quarterly estimates of year *y* + 1 + Revised quarterly estimates for year *y* and *y* – 1
	year *y* – 1	"Final" annual estimates based on a separate annual accounting system	+ Revised quarterly pattern through year *y* – 2 to *y* – 4 to avoid steps between year *y* – 1 and *y* – 2

Subsequent Annual Rounds of Revisions:

13–24 months after the end of year *y*	Incorporation of "final" annual estimates for year *y* and preliminary estimates for year *y* + 1 based on a separate annual accounting system
25–36 months after the end of year *y*	Incorporation of "final" annual estimates for year *y* + 1 and preliminary annual estimates for year *y* + 2
37–48 months after the end of year *y*	Incorporation of "final" annual estimates for year *y* + 2 and preliminary annual estimates for year *y* + 3

The last two rounds of revisions are caused by technical properties of the recommended benchmarking methods (more rounds with minor revisions may in some cases be needed).

The "final" annual estimates may be revised later as needed, if new data become available or improved methods are developed.

integrated economic accounts, including SUT. All these features make backcasting a demanding task and thus restrict the frequency with which level adjustment originating from new data sources and new methods can be incorporated.

12.24 Box 12.1 gives an illustration of a possible compilation and release schedule followed by countries with independent ANA compilation systems. In this example, the annual accounts are revised only once; but in many countries, the annual accounts are revised several times before they are declared final. These subsequent revisions of the ANA should also be put through in the QNA so that the number of revisions of QNA eventually depends on the number of revisions of the ANA. If a major overhaul of the ANA system is performed later, it should also be put through in the QNA time series. It should be noted that in the benchmarking procedures recommended in this manual, revisions of past years will also necessitate revisions in the quarters of later years, including the quarters of the current year.

12.25 An important element of the revisions policy is to establish a revisions period: namely, the number of quarters that should be revised at each revision stage. The revisions period varies depending on the type of revisions. For revisions due to quarterly and annual sources, the revisions period of QNA estimates should cover at least the quarters and years with revisions to the source data. As mentioned earlier, the application of benchmarking and seasonal adjustment techniques may require extending the revisions period backward for avoiding steps between unrevised and revised periods. For benchmarked data, the QNA revisions period should comprise (at least) two years prior the first revised annual data; revisions to more distant years tend to be small and negligible and could be more difficult to explain to users. For seasonally adjusted data, the revisions period should be longer than the revisions period of unadjusted data to accommodate changes in the estimated seasonal factors (see Chapter 7 for specific details on revisions policy of seasonally adjusted data). In the case of major revisions, the entire QNA series should be revised as far back as possible. The starting period of the new series should be communicated clearly, so that the user is aware that previously published series for earlier periods are not directly comparable with the new series.

12.26 Sometimes, a change in the revisions policy may be required to respond to unforeseen circumstances. For example, a major mistake in the treatment of source data should be fixed as soon as possible, possibly with an extraordinary QNA release not planned in the calendar. Revisions due to mistakes should be mentioned in the communication to users to underline that they are not part of the regular revision cycle but an adjustment of a one-off error. During periods of strong changes in the economy, it may be necessary to increase the frequency of revisions to incorporate new and updated quarterly source data as soon as they become available. Unexpected changes in the source data may also justify a change in the QNA estimates, or an extension of the revisions period. All of these changes are warranted to improve the accuracy of the current estimates for the benefit of users. However, users may misinterpret changes in the revisions policy and question the integrity of the statistics agency. To avoid such risk, it is extremely important to develop a communications strategy of QNA revisions. Elements of a clear and effective communications policy are detailed in the next section.

Communications of Revisions

12.27 To inform users and avoid unmerited criticism, revisions should be communicated in a clear and transparent way. A number of important elements should be taken into account when communicating revisions to the users:

- Give advance notice of revisions to the national accounts data. Advance communication is critical when the revision is expected to produce significant changes to the levels and rates of change of the quarterly GDP and other macroeconomic aggregates. Compilers should proactively outreach to the users before, during, and after any benchmark revisions of the QNA. Users should be notified in advance about major revisions with significant impact on the current estimates. For planned revisions, an advance notice should be given in the QNA press release of the quarter preceding the revision.

- Provide sufficiently long, consistent time series. At least five years of continuous quarterly series for the most important QNA aggregates should always be available to the public. Five years of data is typically a minimum requirement for macroeconomic or forecasting models. Revised time series should be accessible with a sufficient level of detail, so that users can appreciate the differences in scope and coverage with the previously published estimates.

- Publish well-known release dates through an advance release calendar, as prescribed by the IMF's Special Data Dissemination Standard and enhanced General Data Dissemination System.
- Provide elements to appreciate the reliability of the estimates and the degree of potential future revisions, possibly through a revisions analysis as explained in the next section.
- Provide detailed data in an easily accessible format (e.g., structured query from a data warehouse or preformatted spreadsheets).
- Publish tables showing the revisions to the data with accompanying text explaining their causes.

12.28 Users should be properly informed of the quality of the estimates and the degree of revisions to expect on predetermined dates in the future. Properly informing users of the quality of the estimates involves giving them candid and easily available documentation of sources and methods for the different versions of the quarterly estimates, clearly showing the main flows of source data leading to revisions. When releasing revised estimates, best practice is to simultaneously publish articles summarizing the main revisions and their causes since the previous release (see Box 12.2 for an illustration). Best practice also involves periodically conducting and publishing studies of long-term trends in the revision patterns. Summaries of these studies may accompany the regular quarterly release of data to remind users that data are subject to revisions. Specific details on how to produce revisions studies are given in the next section. Finally, statistics agencies should organize meetings with the main users of the QNA to explain the regular revision process and announce major revisions sufficiently ahead of publication.

12.29 It is particularly important to inform users properly of the quality of the estimates when releasing QNA estimates for the first time. For a good indication of the degree of future revisions of the main aggregates to expect, the complete compilation process should be simulated based on historic data before releasing the new estimates. That is, the proposed QNA compilation system should be used to produce QNA estimates for the past years as if one were back in time and were producing the initial preliminary estimates for those years (see the discussion of the "tracking exercise" in Chapter 2). This exercise can provide a first assessment of reliability of the QNA system, which compilers may decide to communicate to users when the QNA data are officially launched.

12.30 Finally, providing easy access to the revised time series on a sufficiently detailed level should substantially ease the inconvenience for users of frequent revisions. This involves electronic release of the complete, detailed time series, not only the aggregated data for the most recent periods, which will make it easier for users to keep track of the revisions and update their databases. It should be emphasized that a

Box 12.2 Presentation of Revisions: An Illustration Based on Country Practices

Changes in This Issue

Data for the mining and manufacturing industries have been revised as a result of the incorporation of new annual census results for the previous year. As a result, value added for most industries has been revised upward in the previous and current years.

Retail output and household consumption have been revised for the most recent two quarters following the processing of late questionnaires. The most recent quarter has been revised down slightly as a result.

Changes in the Next Issue

Release date: xxxxx.

The methodology for estimating financial services will be revised in line with new international standards. The conceptual issues and quantitative effects are discussed in a research paper available on request.

Summary Tables of Revisions

Table 1: Revisions to Levels of GDP in Currency Units: Eight Most Recent Quarters

Table 2: Revisions to Percentage Changes in Volume GDP: Eight Most Recent Quarters

release of complete time series for all revised periods is needed because users often use QNA data in a time-series format and need to be alerted to any changes in data for past periods. Not providing them with revised historic data will create breaks in the time series they use, which will seriously hamper the serviceability of the data. As mentioned earlier, a minimum requirement for QNA users is at least five years of continuous series of the key macroeconomic aggregates.

Revisions Analysis for Assessing QNA Reliability

12.31 The analysis of revisions is an ideal framework for assessing the reliability of QNA estimates. The analysis of revision aims at measuring quantitatively the characteristics of the revisions process of QNA estimates. In the QNA, the first estimate of a quarter is always based on a partial set of information. For this reason, preliminary QNA estimates are rightly subject to a number of revisions in subsequent publications. These revisions can take different directions for each quarter, depending on the nature of the revision at each stage of publication. To understand the quantitative impact of revisions, the full revisions process is conveniently summarized by means of descriptive statistics of the quarterly revisions history. Such descriptive statistics—called *revisions indicators*—form the basis to conduct a revisions analysis of QNA variables.

12.32 Monitoring revisions indicators is relevant for both compilers and users of QNA data. For users, a set of revisions indicators offer a standardized framework to assess the reliability of preliminary estimates with respect to later, revised estimates. Evidence of bias[2] (or lack thereof) from the revisions history can help users make better decisions. For example, modelers may decide to incorporate systematic elements from past revisions in an effort to improve their projections. Policymakers may decide to hold off on important decisions until more consolidated estimates are made available. At the same time, revisions indicators may help compilers identify failures in the QNA estimation process. A systematic bias in the early estimate of a specific QNA variable may indicate the necessity to improve the source data or revise the current estimation method.

12.33 A real-time database is essential to calculate revisions indicators. A real-time database is a tabular representation of the QNA series as originally published by the authorities. When the frequency of publication corresponds to the frequency of measurement (e.g., a quarterly series published once per quarter), the table assumes the characteristic form of a triangle. In such cases, a real-time database is also known as revisions triangle. Example 12.1 provides an illustration of a real-time database (or revisions triangle) using artificial data. The rows contain the quarterly rates of change as published at different release dates; the columns refer to the sequence of estimates related to the same quarter. A revisions triangle shows that a published QNA series comprises estimates that have reached a different revision stage: the latest quarter is published for the first time, while more distant quarters have already undergone several revisions and are likely to be more reliable than recent quarters.

12.34 Real-time databases can be prepared for any types of data (e.g., seasonally or not seasonally adjusted, current prices or in volumes) and forms of presentation (e.g., levels, changes, ratios, etc.). Each form may highlight interesting aspects of the revisions process. However, developing and maintaining real-time database is costly and time consuming. Priority should be given to those data and presentations that are more relevant to the users. Because QNA are mainly used for assessing short-term movements in the economy, a key variable for QNA real-time databases is the quarterly seasonally adjusted GDP growth. Real-time databases of unadjusted data may be relevant to single out revisions due to changes in the basic sources (net of seasonal adjustment effects). Revisions triangles of main expenditure and production components of the GDP can also be essential to understand the driving factors of the headline GDP revisions. Finally, revisions to the levels can be useful to assess the impact of benchmark revisions of national accounts to the QNA levels.[3]

[2] In the revisions literature, the term "bias" is used to indicate a systematic pattern in the revision to the preliminary estimates. A downward bias occurs when the preliminary estimate understates the later estimate and is subsequently revised upward. Conversely, an upward bias occurs when the preliminary estimate overstates the later estimate and is subsequently revised downward.

[3] The Organisation for Economic Co-operation and Development (OECD) has developed spreadsheet templates for creating real-time databases from monthly and quarterly data. The OECD also provides templates for calculating revisions indicators from real-time databases. Such templates are available for download on the OECD website. For further details, see McKenzie and Gamba (2009).

Example 12.1 Real-Time Database

Release Month \ Reference Quarter	q1 2010	q2 2010	q3 2010	q4 2010	q1 2011	q2 2011	q3 2011	q4 2011	q1 2012	q2 2012	q3 2012	q4 2012
June 2010	1.2											
September 2010	1.4	0.8										
December 2010	1.4	1.2	0.2									
March 2011	1.5	1.3	0.3	1.4								
June 2011	1.4	1.3	0.1	1.1	0.5							
September 2011	1.3	1.4	0.2	1.1	0.7	0.2						
December 2011	1.3	1.3	0.5	1.0	0.8	0.4	0.5					
March 2012	0.8	0.8	0.7	0.4	0.7	0.3	0.1	1.2				
June 2012	0.8	0.9	0.7	0.3	0.8	0.3	0.1	1.2	0.6			
September 2012	0.8	0.9	0.7	0.4	0.6	0.4	0.1	1.3	0.8	0.1		
December 2012	0.7	1.0	0.7	0.4	0.6	0.5	0.0	1.3	0.7	–0.4	0.6	
March 2013	0.6	1.1	0.5	0.6	0.5	0.9	0.0	1.0	1.0	–0.4	0.3	0.9
June 2013	0.6	1.1	0.5	0.6	0.5	0.7	0.2	1.1	1.1	–0.6	0.3	0.6

Example 12.1 shows a real-time database (or revisions triangle). The example refers to (artificial) quarterly rates of change of a QNA aggregate expressed in seasonally adjusted form. It assumes a timeliness of two to three months from the reference quarter, one estimate per quarter, and an open revisions policy for previously published estimates.

The revisions triangle can be read in different ways. By row, the table shows the series of quarterly rates as published at each release month. For example, the June 2010 publication (first row) reports the first estimate of the quarterly rate of change for q1 2010 and the September 2010 publication (second row) shows the estimates of q1 2010 and q2 2010 released at that time; and so forth. It can be noted that each row (e.g., each time series) comprises estimates with different maturity.

By column, the revisions triangle shows the revisions history of one specific quarter. For example, the fourth column shows that the initial estimate of q4 2010 (1.4%) has been revised downward several times until it stabilizes two years after the first release at a much reduced rate (0.6%).

Finally, the triangle can also be analyzed diagonally. The main diagonal includes all the first estimates of the quarters, the secondary column the second estimates, and so forth. The diagonal view is very important in the calculation of revisions indicators between two specific estimation points in time (e.g., first estimate versus second estimate), as shown in Example 12.2.

12.35 Mathematically, a revision R_t for a generic quarter t is calculated as the difference between a later estimate L_t and a preliminary estimate P_t: that is,[4]

$$R_t = L_t - P_t. \tag{1}$$

Suppose there are n quarterly revisions available. A revisions history $\{R_t\}$ is the sequence of quarterly revisions for the n quarters: that is,

$$\{R_t\} = (R_1, R_2, \ldots, R_n).$$

12.36 Revisions (equation (1)) can be calculated between any two stages of estimation. The first estimate of a quarter always receives the greatest level of attention from the users, and it is the one that is most likely assessed against later estimates. In a revisions triangle, the sequence of first estimates is contained in the main diagonal of the triangle. A comparison between the first estimate and the second estimate (usually released three months after the first estimate) provides the impact of new and updated source data received during this period. Longer revision horizons are useful in the impact of annual source data on the quarterly estimates. When annual data are received after a considerable amount of time (more than one year), it is helpful to compare the estimate released after one year with the estimate release after two years. Finally, a comparison with the latest published series (i.e., last row of the revisions triangle) may be helpful to measure how the current quarterly information compares with previously published quarterly estimates. The latest series, however, includes estimates of different maturity.

12.37 Example 12.2 presents three different revisions histories from the data shown in Example 12.1: second estimates versus first estimates, estimates

[4] Revisions are also calculated in relative terms. See Annex 11.1 for an explanation.

Example 12.2 Revisions Indicators

Revisions	First Estimate (1)	Second Estimate (2)	Second Estimate versus First Estimate (3) = (2) – (1)	Estimate After One Year (4)	Estimate After One Year versus First Estimate (5) = (4) – (1)	Latest Estimate (6)	Latest Estimate versus First Estimate (7) = (6) – (1)
Reference Quarter							
q1 2010	1.2	1.4	0.2	1.4	0.2	0.6	–0.6
q2 2010	0.8	1.2	0.4	1.4	0.6	1.1	0.3
q3 2010	0.2	0.3	0.1	0.5	0.3	0.5	0.3
q4 2010	1.4	1.1	–0.3	0.4	–1.0	0.6	–0.8
q1 2011	0.5	0.7	0.2	0.8	0.3	0.5	0.0
q2 2011	0.2	0.4	0.2	0.4	0.2	0.7	0.5
q3 2011	0.5	0.1	–0.4	0.0	–0.5	0.2	–0.3
q4 2011	1.2	1.2	0.0	1.0	–0.2	1.1	–0.1
q1 2012	0.6	0.8	0.2	1.1	0.5	1.1	0.5
q2 2012	0.1	–0.4	–0.5			–0.6	–0.7
q3 2012	0.6	0.3	–0.3			0.3	–0.3
q4 2012	0.9	0.6	–0.3			0.6	–0.3
Mean Revision *(MR)*			–0.04		0.04		–0.13
Mean Absolute Revision (*MAR*)			0.26		0.42		0.39
Standard Deviation of Revision (*STDR*)			0.30		0.52		0.45
Range of Revision (*RR*)			0.90		1.60		1.30

Example 12.2 arranges the quarterly estimates from the real-time database in Example 12.1 conveniently for the calculation of revisions indicators. Column 1 shows the sequence of first estimates for the period q1 2010–q4 2012. Column 2 shows the second estimates for the same quarters. The revisions are calculated in column 3 as the different between the second estimate (i.e., later estimate) and the first estimate (i.e., preliminary estimate). Columns 5 and 7 show the revisions to the first estimate made after one year and in the latest release (June 2013), respectively.

Revisions indicators are reported in the bottom part of the table. Taking the case of first estimate versus second estimate as illustration, the mean revision (*MR*) is obtained as the simple average of revisions:

MR (second estimate versus first estimate): $\frac{1}{12}\left[0.2+0.4+0.1+(-0.3)+\ldots+(-0.3)\right]=-0.04.$

The mean absolute revision (*MAR*) is calculated as the simple average of the absolute value of revisions:

MAR (second estimate versus first estimate): $\frac{1}{12}\left[|0.2|+|0.4|+|0.1|+|-0.3|+\ldots+|-0.3|\right]=0.26.$

The standard deviation of revision (STDR) is calculated by taking the square root of the sum of squared revisions divided by the number of revisions minus one:

STDR (second estimate versus first estimate): $\sqrt{\frac{1}{11}\left[(0.2)^2+(0.4)^2+(0.1)^2+(-0.3)^2+\ldots+(-0.3)^2\right]}=0.30.$

Finally, the range of revision (*RR*) is the difference between the maximum revision and the minimum revision:

RR (second estimate versus first estimate): $0.4-(-0.5)=0.90.$

released after one year versus first estimates; and latest series versus first estimates.

12.38 Revisions indicators are calculated as descriptive statistics of a revisions history $\{R_t\}$. Each statistic aims at measuring a specific characteristic of the revision process. In general, direction, size, and dispersion of revisions are the most salient features of a QNA revisions process. The following is a list of the most common indicators used for the analysis of revisions of QNA estimates:

a. *Mean Revision* (*MR*). It is the simple average of $\{R_t\}$. It is a measure of *direction* of revisions. An *MR* value close to zero indicates that there are no directions in the revisions. In this case, the preliminary estimate shows no bias compared with later estimates. When the *MR* is positive, the preliminary estimate is on average below the later estimate (downward bias); when the *MR* is negative, the preliminary estimate is on average above the later estimate (upward bias).

b. *Mean Absolute Revision* (*MAR*). It is the simple average of $\{R_t\}$ taken in absolute values. The *MAR* disregards the sign of revisions. It can be zero when positive, and negative revisions perfectly offset each other. The *MAR* is a measure of the *size* of revisions. It is usually taken as a measure of reliability of QNA estimates. The larger the *MAR* value is, the less reliable the preliminary estimate is compared with later ones.

c. *Standard Deviation of Revision* (*STDR*). It is calculated as the standard deviation of $\{R_t\}$. It is a measure of *dispersion* of revisions around the mean value. The smaller the *STDR* value, the closer are the revisions to the *MR* value. A high *STDR* value indicates large fluctuations in the reliability of early estimates between quarters or across years.

d. *Range of Revision* (*RR*). It is the difference between the maximum revision and the minimum revision in $\{R_t\}$. Always nonnegative, the *RR* value provides an immediate quantification of the spectrum of revisions occurred in the past.

12.39 Example 12.2 shows the calculations of these indicators using the artificial data of Example 12.1. Further, a mathematical formulation of the revisions indicators is provided in Annex 12.1.

12.40 A glimpse at revisions indicators can provide an immediate insight into the characteristics of the revisions process. In Example 12.2, for instance, the small values of the *MR* indicator (less than one percentage point) indicate that the preliminary estimate is relatively unbiased compared to later estimates. However, the *MAR* values show that it is reasonable to expect revisions to the first estimate with a magnitude of 0.2–0.3 percentage points after three months and 0.4–0.5 percentage points after one year. The *STDR* indicator also signals an increase in the dispersion of revisions from the second estimate to the estimate published after one year (0.26 versus 0.42 points).

12.41 Real-time databases and revisions indicators should be developed and regularly maintained as part of the QNA compilation process. Their availability makes it possible to monitor constantly the reliability of the published data and promptly identify shortcomings in the QNA estimates. When sufficient resources are available, real-time databases and revisions indicators for the GDP and its main components should also be made available to the public.[5] A summary of the GDP revisions indicators should be given in the QNA press release, so that the general user can immediately appreciate the level of reliability of the preliminary estimates and the characteristics of the quarterly GDP revision process. Occasionally, more in-depth revisions studies should be conducted to determine the underlying causes of the GDP revisions and discuss how to reduce systematic characteristics of the revisions process related to data sources and statistical methods.

[5] Revisions triangles are provided by a number of countries with advanced QNA systems. The United Kingdom was the first country that disseminated revisions triangles of the GDP on a structured and regular basis.

Summary of Key Recommendations

- *Revisions are an essential part of good QNA compilation practice. Revisions provide the possibility to incorporate new and more accurate information in the QNA, and thus to improve the accuracy of the estimates, without introducing breaks in the time series.*
- *Series that are revised regularly to reflect new and better information are more accurate than those subject to little or no revision.*
- *To avoid unnecessary criticism, a well-designed and carefully managed revision policy is needed. Essential features of a well-designed revision policy are predictability and openness, advance notice of causes and effects, and explanation, as well as easy access to sufficiently long time series of revised data.*
- *Quarterly accounts are subject to three "waves" of statistical source data: (a) quarterly source data, (b) annual source data, and (c) periodic census data. Periodic benchmark revisions are also used to introduce revised international standards, major methodological updates, and changes in classifications.*
- *A crucial part of a well-established and transparent revision policy is devising an appropriate compilation and release schedule, which should specify timeliness, frequency of update, and revisions period of the preliminary estimates.*
- *Revisions should be communicated in a clear and transparent way. Users should be notified well in advance of any major revisions with significant impact on the current estimates. When a benchmark revision of national accounts is released, a minimum of five years of continuous series for the quarterly GDP and its main components should be made available to the public.*
- *Revisions analysis of QNA data is essential to monitor the reliability of the estimates and advise users on the range of uncertainty. Real-time databases (or revisions triangles) and revisions indicators should be developed and regularly maintained as part of the QNA compilation process. Best practices also involve periodically conducting and publishing revision studies of QNA data and disseminate real-time databases and revisions indicators of key QNA aggregates to the public.*

Annex 12.1 Revisions Indicators

A12.1 A revisions history can be summarized using standard descriptive statistics. This chapter discussed and explained the most common indicators used in the revisions analysis of QNA variables (i.e., mean revision, mean absolute revision, standard deviation of revision, and range of revision). By offering a mathematical presentation of these indicators, this annex aims to facilitate their implementation in the QNA compilation system as routine diagnostics of QNA reliability.[6] The following indicators can also be applied to analyze revisions of the annual accounts or for other economic indicators available monthly.

A12.2 Given a generic quarter t, a revision R_t is defined as the difference between a later estimate L_t and a preliminary estimate P_t: namely,

$$R_t = L_t - P_t. \tag{A1}$$

The estimates L_t and P_t should be expressed in the same unit of measurement. Equation (A1) is generally used for measuring revisions on rates of change (quarter-to-quarter, or year-on-year). Alternatively, a relative measure of revision $\bar{R}_t$,

$$\bar{R}_t = \frac{\left(L_t - P_t\right)}{L_t}, \tag{A2}$$

is used to calculate the revisions in terms of the later estimate (usually in percentage form). Equation (A2) is suitable for measuring revisions in the levels of estimates. In the QNA, however, the main interest of compilers and users is on the measurement of quarterly (or annual) changes. For this reason, this annex focuses on the absolute measure of revisions (equation [A3]) as the basis for the calculation of revisions indicators. However, all the formulae presented apply equally to equation (A2).

A12.3 Let us assume a sample of n revisions: that is, $\{R_1, R_2, \ldots, R_n\}$. The mean revision ($MR$) is calculated as the simple average of the revisions:

$$MR = \frac{1}{n}\sum_{t=1}^{n} R_t\ . \tag{A3}$$

The MR is an indicator of direction of revision. A positive MR indicates an average upward revision to the preliminary estimate (or alternatively, an average downward bias in the preliminary estimate), while a negative MR indicates an average downward revision to the preliminary estimate (i.e., average upward bias in the preliminary estimate). Ideally, the MR should be as close as possible to zero.[7]

A12.4 The mean absolute revision (MAR) is the simple average of the absolute value of revisions:

$$MAR = \frac{1}{n}\sum_{t=1}^{n}\left|R_t\right|. \tag{A4}$$

The MAR indicator measures the average size of revisions. The MAR is generally a positive number. It is zero only when all revisions are null.

A12.5 The relative MAR ($RMAR$) is calculated as the ratio between the MAR and the average value of the preliminary estimates:

$$RMAR = \frac{\sum_{t=1}^{n}\left|R_t\right|}{\sum_{t=1}^{n}\left|P_t\right|}\ . \tag{A5}$$

The $RMAR$ is very useful for comparing the size of revisions between variables with different magnitude (e.g., countries, sectors, etc.).

A12.6 The standard deviation of revision ($STDR$) is the square root of the sum of squared revisions divided by $(n-1)$:

$$STDR = \sqrt{\frac{1}{n-1}\sum_{t=1}^{n}\left(R_t - MR\right)^2}\ . \tag{A6}$$

The $STDR$ indicator is a measure of dispersion of revisions. A small $STDR$ indicates that revisions are close to the mean value.

[6] For a comprehensive list of revision indicators, see Di Fonzo (2005) and McKenzie (2006).

[7] Standard t-tests can be used to verify the statistical significance of revisions: that is, if the mean absolute revision value is statistically different from zero. For a discussion on specific tests developed for revisions analysis, see Jenkinson and Stuttard (2004).

A12.7 The range of revision (*RR*) is the difference between the maximum revisions and the minimum revision:

$$RR = \max\{R_t\} - \min\{R_t\}. \qquad (A7)$$

The *RR* indicator is also a measure of dispersion. It shows the widest range of revisions occurred in the sample. Because it could be affected by the presence of extreme revisions in the sample, it should always be presented along with the *STDR* measure.

A12.8 Finally, revisions in the direction of change and acceleration versus deceleration can measure the robustness of preliminary estimates. Direction of change counts the number of times (in percent form) that preliminary and later estimates for each quarter have the same sign: that is,

$$\begin{aligned}&[(L_t - L_{t-1}) > 0 \text{ and } (P_t - P_{t-1}) > 0] \text{ or}\\ &[(L_t - L_{t-1}) < 0 \text{ and } (P_t - P_{t-1}) < 0],\end{aligned} \qquad (A8)$$

where
L_t and P_t are levels of a QNA variable and
t are quarters in a prespecified interval.

Percentages are calculated by dividing the number of quarters where condition (A8) is met over the total number of quarters in the interval. Percentages close to 100 percent indicate that preliminary estimates P_t correctly detect the same direction of change of later estimates L_t. Acceleration versus deceleration verifies the same condition (A8) on $[(L_t - L_{t-1}) - (L_{t-1} - L_{t-2})]$ and $[(P_t - P_{t-1}) - (P_{t-1} - P_{t-2})]$: that is, the difference between two subsequent changes. When this difference is positive, the change of the variables is accelerating; on the other hand, when the difference is negative, the change is decelerating. The acceleration versus deceleration measures the percentage of times that preliminary estimates and later estimates provide the same indication of acceleration versus deceleration during an interval.

Bibliography

Di Fonzo, T. (2005), "The OECD Project on Revisions Analysis: First Elements for Discussion," OECD Short-term Economic Statistics Expert Group, June.

Jenkinson, G. and N. Stuttard (2004), *Revisions Information in ONS First Releases*, Economic Trends No. 604, Newport, UK: Office for National Statistics, pp. 70–72.

McKenzie, R. (2006), "Undertaking Revisions and Real-Time Data Analysis Using the OECD Main Economic Indicators Original Release Data and Revisions Database," OECD Statistics Working Papers, February.

McKenzie, R. and M. Gamba (2009), "Data and Metadata Requirements for Building a Real-Time Database to Perform Revisions Analysis," contribution to the OECD/Eurostat task force on "Performing Revisions Analysis for Sub-Annual Economic Statistics," available at http://www.oecd.org/std/40315408.pdf.

OECD (2014), "Revisions in Quarterly GDP of OECD Countries: An Update," OECD Working Party on National Accounts, November.

Zwijnenburg, J. (2015), "Revisions of Quarterly GDP in Selected OECD Countries," *OECD Statistics Brief*, 22(July): 1–12.

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