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IMF Estimates of Potential Output: Theory and Practice[1]

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Abstract

The concepts of potential output and the output gap are central to the IMF's analytical work in providing policy recommendations to member governments. This key role has stimulated research at the IMF to develop and refine estimation techniques. This paper summarizes the methodology and results of IMF research on potential output, which has focused mainly on the industrial countries but more recently has addressed issues related to developing countries and countries in transition. It then discusses the approaches that country desk officers use for operational purposes, and presents estimates of potential output for the major industrial countries.

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SUMMARY

The concepts of potential output and the output gap are central to the IMF's analytical work in providing policy recommendations to member country governments. This key role has stimulated research at the IMF to develop and refine estimation techniques. Most of this research has concentrated on the production function approach, which has the advantage of helping to identify the factors contributing to changes in potential output over the last three decades. In addition, this research has supported efforts by IMF economists working on particular countries or in a multilateral context to estimate potential output for operational purposes. It is important to note, however, that country desk officers are not obliged to follow a standardized methodology. Rather, country-specific circumstances have tended to influence the methodology used in terms of the general approach, the specific details of the approach, and the extent to which judgment is brought to bear on the results.

I. Introduction

The concepts of potential output and the output gap are central to the International Monetary Fund's (IMF) analytical work in providing policy recommendations to member country governments. Representing the economy's supply side, potential output is the maximum output an economy can sustain without generating a rise in inflation. Over the medium term, the estimated trend in potential output helps determine the pace of sustainable growth. In the short term, estimates of the gap between actual and potential output provide a key benchmark against which to assess inflationary pressures. Potential output and the output gap are used in cyclically adjusting variables to reflect the levels that would exist if the economy were in neither a recession nor an inflationary expansion. For example, to gauge progress in fiscal consolidation, a cyclically adjusted budget balance provides a measure of the underlying or structural fiscal position, which is the actual budget balance corrected for the effects divergences of actual from potential output. Indicators of countries' real exchange rates based on cyclically adjusted unit labor costs are also useful for monitoring movements in international competitiveness.

The key role played by the concept of potential output in the surveillance work of the IMF has stimulated research to develop and refine estimation techniques. Most of this research has concentrated on the production function approach which helps to identify the factors contributing to changes in the growth rate of potential output over the last three decades. In addition, this research has supported efforts by IMF economists working on particular countries or in a multilateral context to estimate potential output for operational purposes. It is important to note, however, that country desk officers are not obliged to follow a standardized methodology. Rather, country specific circumstances have tended to influence the methodology used in terms of the general approach, the specific details of the approach, and the extent to which judgement is brought to bear on the results. The remainder of this paper summarizes the methodology and results of IMF research on potential output, which has mainly focussed on the industrial countries, but more recently has addressed issues related to developing countries and countries in transition. It then discusses the approaches country desk officers use for operational purposes, and presents current estimates of potential output for the major industrial countries, as regularly published in the IMF's *World Economic Outlook*.

II. IMF Research on Estimating Potential Output

A. Industrial Countries

Potential output and the output gap are unobserved variables and are difficult to estimate in a completely satisfactory manner. The widespread reliance on potential output as a means of assessing economic activity has resulted in the development of a broad range of techniques--none are free from difficulties--which all to some extent rely on judgment. IMF research on estimating potential output has mainly concentrated on developing and applying the production function approach for the industrial countries. This method explicitly models

output in terms of underlying factor inputs, and involves specifying and estimating production functions that link output to capital, labor, and total factor productivity. Potential output is then calculated as the level of output that results when the rates of capacity utilization are "normal," when labor input is consistent with the natural rate of unemployment, and when total factor productivity is at its trend level.

The production function methodology as implemented at the IMF represents the middle ground between a full-scale structural model to determine potential output, and the more mechanical univariate approaches such as the segmented-trend approach, or the Hodrick-Prescott filter.[2] Estimation relies on imposing a functional form on the production process, but does not require explicit modeling of the demand and supply of factors of production or the determinants of total factor productivity. This approach, however, implicitly assumes that: (1) in the short run, the potential inputs of capital and labor can be determined by the behavior of unemployment relative to its natural rate, and the deviation of output from its normal level; and (2) the growth of capital, labor, and total factor productivity embodied in projections of potential output can reasonably be based on judgments about trends in the macroeconomy.

This approach has a number of advantages over univariate techniques. It allows for an explicit accounting for growth in terms of the contributions of capital, labor, and total factor productivity. Therefore, it is possible to trace the impact of various past economic disturbances on potential output, as well as to estimate the impact of current or projected disturbances on future levels of potential output.

There are, however, a number of drawbacks. The data requirements are significant, with some variables such as the capital stock particularly difficult to measure and update. Another difficulty is that real output deviates systematically from the level given by factor inputs, and the difference is usually ascribed to total factor productivity growth. Since total factor productivity is not directly observable, estimating its trend poses many of the same challenges and uncertainties as estimating potential output.

Artus (1977) was the first IMF research study to adopt the production function method to estimate potential output.[3] A Cobb-Douglas production function with constant share parameters for labor and capital was used as a theoretical basis in estimating consistent potential output series in the manufacturing sector for 8 industrial countries for the period

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[2]A review of methods for estimating potential output can be found in Barrell and Sefton (1995).

[3]In Artus (1977) the production function approach was selected over two other techniques: (1) the survey of firms method in which manufacturing firms are regularly asked to indicate their actual operating rate and their preferred operating rate; and (2) the fitting of a linear trend-through peaks method.

1955-75, and projecting these series for the medium term (1976-78). Pooled time-series cross-section regression techniques were used to allow for a larger number of variables--such as the evolution of the mean age of the capital stock, the increase in the price of energy, and other factors specific to certain countries--to be taken into account in estimating potential output. Technical progress was treated as a residual in the production equation. An indirect method was used to measure the deviation of the intensity of use of labor and capital from their long-run normal levels. The natural rate of unemployment was estimated by fitting a log linear trend between successive peaks in labor force use.

The results of Artus (1977) established that the rate of growth of potential output in manufacturing was significantly lower in the 1970s than in the 1960s owing to lower rates of capital accumulation and a reduction in the length of the work week. This evidence dispelled the widely shared perception at that time that the productivity slowdown was directly attributable to the 1973 sharp increase in energy prices, but indicated instead that it was related to a broader set of factors. These results were, however, qualified because of a number of methodological shortcomings of the production function approach. The results were sensitive to how short-term variations in the intensity of use of labor and capital were specified over the business cycle. In addition, the lack of reliable capital stock data, and the treatment of technical progress as a residual, also limited the precision of these estimates.

Building on the methodology employed in Artus (1977), Adams, Fenton, and Larsen (1987) broadened the coverage from the manufacturing sector and provided economywide measures of potential output for the period 1960-83 and projections to 1995, based on econometric estimates for the business sector as a whole, with simple adjustments for production by the public sector. A significant innovation in this study was the enhanced technique used to estimate the natural rate of unemployment. A reduced form equation for the unemployment rate was used and included variables accounting for cyclical and structural factors, as well as other variables that contribute to rigid real wages--changes in relative import prices, social security contributions, and underlying trend productivity--and prevent the labor market from clearing. This equation was then solved for the natural rate of unemployment which is the rate that prevails when cyclical factors are eliminated.

Estimates of potential output derived in Adams, Fenton, and Larsen (1987) suggested that a number of factors had contributed to the widespread slowdown of growth in industrial countries after 1973. First, the evidence suggested that a decline in the growth of total factor productivity accounted for much of the slowdown in growth. Lower growth in total factor productivity reflected a slowdown in technological advancement, and in addition reduced scope for catch-up effects in countries other than the United States, and particularly in Europe, following the rapid convergence of the 1950s and 1960s. Other factors contributing to the slowdown in total factor productivity were identified, which included the impact of changes in the sectoral share of output, the rapid growth in public expenditures, reduced scope for scale economies, and changes in market share. Second, the slowdown in growth was also attributable to accelerated capital obsolescence following the 1973/74 and 1979/80 oil price shocks. Third, in most countries, and especially in Europe, reduced labor input was also

a factor in explaining the slowdown in growth, as natural rates of unemployment rose during the 1970s and early 1980s and average hours worked continued to decline.

Further research has extended this methodology.[4] Adams and Coe (1990) enhanced the production function approach by accounting explicitly for the relationship between wage and price inflation, potential output, and the natural rate of unemployment in the context of a consistent analytical framework. Using data for the United States, a system of equations that included a production function and unemployment rate equation together with wage and price equations was simultaneously estimated. This technique ensured that the estimates of potential output and the natural rate of unemployment were consistent with one another and fully utilized the information contained in wage and price developments. The results indicated that potential output growth in the United States had recovered somewhat during the early 1980s from the slowdown during the 1970s but remained below the rapid rates of increase of the late 1960s.

IMF research has also attempted to incorporate the role of structural variables and policy instruments in determining potential output. In terms of estimating the natural rate of unemployment--an important determinant of potential output--additional variables were introduced to take account of more of these factors which include, unemployment insurance replacement ratios, the degrees of unionization, payroll taxes, minimum wages, and various demographic characteristics, such as the age composition of the population. Enhanced estimates for total factor productivity--which initially were proxied by a time trend--have focussed on the role of research and development expenditures and how they affect technical progress, although additional variables such as demographic factors or measures of integration in the European Union have also been found to be important in some countries.

B. Developing Countries

Relatively few empirical studies have attempted to estimate potential output for developing countries, owing mainly to the lack of reliable data. In addition, the concept of potential output is less meaningful for countries in which a large proportion of output is accounted for by primary commodities whose production is supply-determined, or which are experiencing large inflows or outflow of labor.

Nevertheless, in recent years, rapid growth in the east Asian countries--including Hong Kong, Korea, Singapore, and Taiwan Province of China (all now classified as advanced economies in the *World Economic Outlook)* since the 1970s and Malaysia, Indonesia and Thailand more recently has sparked interest in identifying how much of the growth is attributable to increases in total factor productivity and how much to the growth of factor inputs. In general, growth accounting methodologies have been used to decompose the annual percent change in real GDP into a weighted average of the changes in physical and human

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[4]See also Coe and Krueger (1990), IMF (1991); and Coe and Moghadam (1993).

capital and labor input, with a residual interpreted as the growth rate of total factor productivity. A recent IMF review of five studies found that because of the variety of accounting methodologies and empirical techniques used, little consensus has emerged regarding the relative importance of total factor productivity growth versus factors inputs in explaining changes in output.[5] Some studies have found that a significant proportion of output growth is explained by increases in factor inputs. These studies draw pessimistic conclusions about the prospects for continued rapid growth since this would require continued high rates of resource mobilization. Other studies have suggested that increases in total factor productivity--by as much as 4 percent a year in some countries--provide the primary explanation and therefore are more optimistic about future growth prospects. As long as such productivity growth continues, high rates of output growth can be sustained with lower rates of resource utilization.

Another recent IMF study has focused on the question of whether the rapid growth seen in many emerging market countries could possibly result in overheating pressures, highlighting the need to develop estimates for potential output to assess the extent of underlying inflationary pressures. Using a novel univariate detrending technique based on a nonparametric regression method, Coe and McDermott (1996) estimated potential output for 13 Asian countries, and addressed the question of whether the output gap model of inflation is relevant.[6] A univariate detrending technique was chosen over the production function approach because considerably less data were required, and implementation was much simpler--a particularly appealing features given the limited availability of data in many of these countries. In addition, the focus of the study was to explore the relationship between the output gap and inflation, so that the major advantage of the production function approach--explicitly identifying the sources of output growth--was not particularly relevant. The results of the study indicated that the output gap was a significant determinant of the change in inflation in 11 of the 13 countries examined. In China and Thailand, however, no evidence was found that the estimate of the output gap explained changes in inflation.

In a subsequent study, IMF staff estimated potential output using the Hodrick-Prescott filter for a broad sample of 19 emerging market economies to determine the size of current output gaps, and thereby gauge the extent of overheating.[7] The results suggested that for most Asian countries, output gaps in recent years have been about plus or minus 3 percent of

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[5]For a review of the literature on measuring productivity gains and a comparison of estimates from five studies, see IMF (1997), Box 9, pp. 82-83.

[6]These include Australia, China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, New Zealand, the Philippines, Singapore, Taiwan Province of China, and Thailand.

[7]See IMF (1996 b), Box 3. The 19 countries are: Argentina, Brazil, Chile, China, Colombia, India, Indonesia, Jordan, Korea, Malaysia, Mexico, Pakistan, Peru, the Philippines, South Africa, Taiwan Province of China, Thailand, Turkey, and Venezuela.

potential output. Among the Latin American countries, output fluctuations have been larger, with the output gap fluctuating in the plus or minus 5 percent range. Estimates of the output gap were found to be relatively good indicators of future inflation for some Asian emerging market countries and also for Mexico.

C. Countries in Transition

For the countries in transition, the short period of time which has elapsed since the transition process began, combined with the lack of reliable data preclude using the standard production function approach, or even univariate detrending techniques to estimate the growth of potential output.[8] To avoid these problems, in a recent study, IMF staff constructed long term growth scenarios for the transition countries which were based on the long-term growth experiences in other parts of the world.[9] A key difficulty in this approach was to estimate the rate of growth of total factor productivity which as experience has demonstrated can vary substantially over time and across countries. An endogenous (or "new") growth model was chosen as an analytical framework.[10] In this model, the rate of technical change and therefore total factor productivity is assumed to be determined by the returns from research and development (R&D) and the application of new ideas. Other factors contributing to the growth of total factor productivity include the diffusion of R&D through trade and investment, and the role of the public sector in raising the marginal productivity of private capital through public investment, the provision of education, etc. The endogenous growth model approach also assumes that marginal returns to capital do not diminish with capital accumulation, partly because of the new technology associated with new capital. Under these assumptions, long-run growth rates are affected by the rates at which physical and human capital are accumulated. Empirical analyses of the relationship between economic growth and key determining variables in this model (such as human capital, population growth, investment, and government consumption) in other countries in different stages of development were then used to estimate the long-term growth rate of real GDP in the countries in transition.[11] Although this approach may overlook aspects of the growth process that are unique to the countries in transition, the existing data problems indicated that using evidence from other parts of the world was probably the best method for assessing long-term growth potential. Given the uncertainties associated with this type of analysis, several

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[8]See Gavrilenkov and Koen (1995) for a discussion of difficulties in measuring output during the transition to a market economy.

[9]See IMF (1996 b), Chapter V.

[10]For a comprehensive discussion of endogenous growth models, see Barro and Sala-i-Martin (1995).

[11]This approach follows that of Fischer, Sahay, and Végh (1996), and is based on empirical estimates in Barro (1991), and Levine and Renelt (1992).

scenarios were examined: the more optimistic scenario implied long term growth rates of real GDP in the range of 4 to 5 percent, while the somewhat less favorable scenario implied growth rates in the range of 2 to 2.5 percent.

III. Estimating Potential Output for the Industrial Countries in Practice

A. Methodology

Estimates of potential output and output gaps for individual industrial countries are published on a regular basis in IMF publications such as the *World Economic Outlook* and *IMF Staff Country Reports*. Given the uncertainties associated with any particular estimate of potential growth, current practices at the IMF do not require that a standardized methodology be used, but rather allow country specific factors to determine the methodology employed. This flexible approach allows desk officers to choose a method that best fits the economic factors and is consistent with the availability of data.

In many cases the published estimates and projections for potential output are closely linked to previous econometric studies, particularly if the studies are relatively recent, drawing on the previously discussed research.[12] In other cases, however, structural shifts such as those associated with German unification, or benchmark revisions of the national accounts, mean that previous econometrically-based estimates have to be supplemented to a greater or lesser extent with more simple estimates of trend output. In all cases, estimates of potential output incorporate a substantial amount of judgement and country-specific expertise of desk officers. Staff estimates of potential have usually been presented and discussed with the national authorities.

Recent estimates of potential output for the seven major industrial countries are presented together with actual real output in Figure 1.[13] For Canada, France, Germany, Italy, Japan and the United Kingdom, the production function approach was used in calculating these estimates, although considerable variation across countries exists regarding the specific details of the estimation technique. One example of this variation centers around how total factor productivity is specified in the production function. For the United Kingdom, total factor productivity is assumed to grow at a constant trend rate, whereas for France, Germany, Canada and Japan it is derived as a residual from the production function. For France and Germany, an iterative procedure is used in which the residual is regressed on a constant term, a time trend, and capacity utilization. For Canada, the residual is regressed on a constant term, the growth in the volume of tradables, and the change in capacity utilization to proxy

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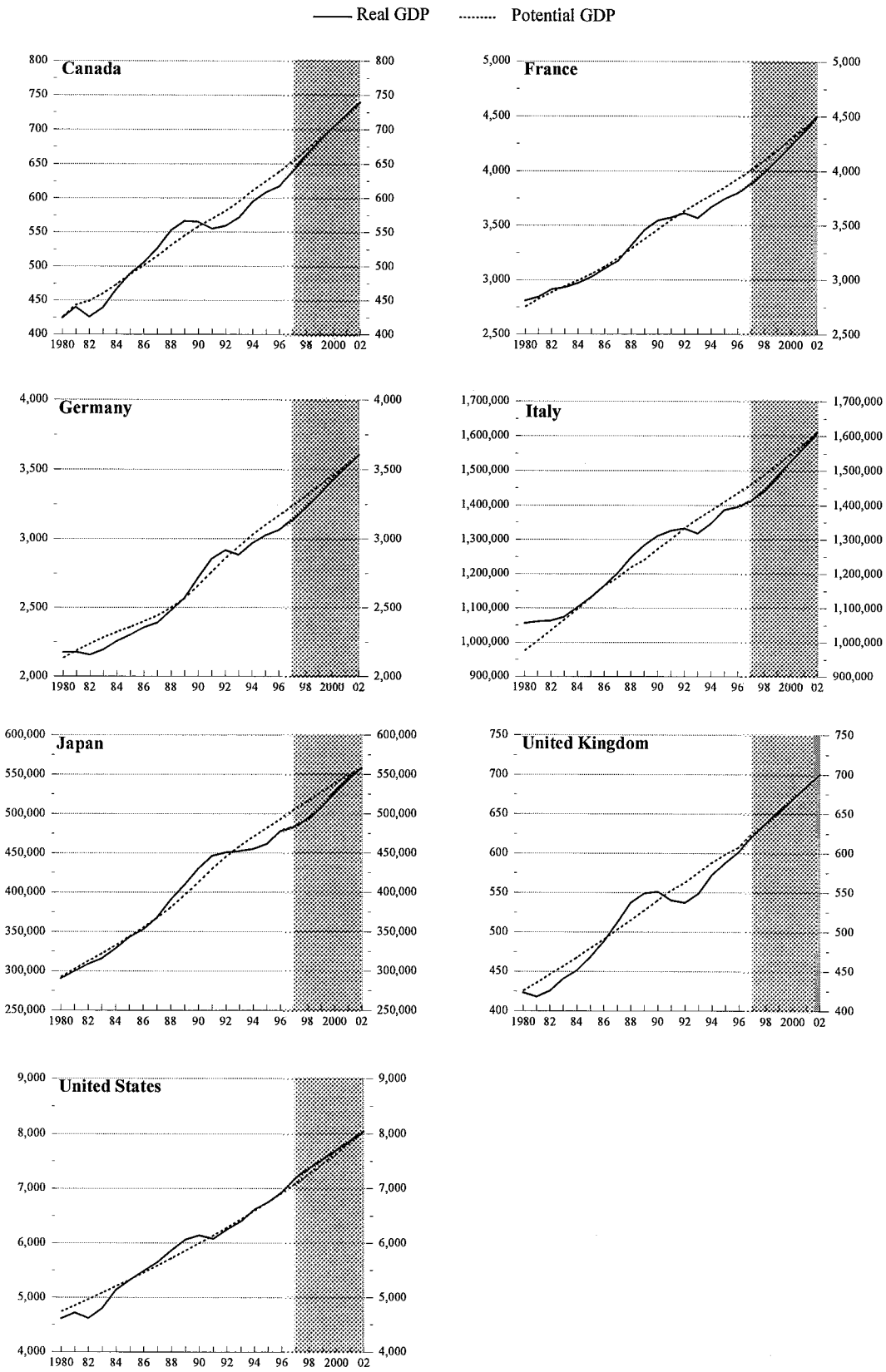
[12]See, for example, IMF (1995 a), IMF (1995 b), and IMF (1996 a).

[13]These estimates are published in IMF (1997 b)

Figure 1. Major Industrial Countries: Real GDP versus Potential GDP[1]

(Billions of national currency units)



Source: IMF, *World Economic Outlook*, October 1997.

[1]Shaded areas indicate IMF staff projections.

cyclical movements.[14] And, for Japan, the residuals from the production function are smoothed using the Hodrick-Prescott filter.

In contrast, for the United States, the segmented trend method is used to estimate potential output and assumes that the rate of growth of potential output changes at specific structural points, but is constant between these points.[15] Recursive residual tests are used to identify break points in quarterly GDP over the period 1959-95. These tests identify break points in the fourth quarter of 1973, and the fourth quarter of 1989. The first break point corresponds to the first oil price shock; and the second break point corresponds to the end of the upward trend in labor force participation.

B. Estimates of Potential Growth in the Medium Term[16]

Over the medium term, potential output growth for the seven major industrial countries is projected to be in the range of 2 to 2½ percent. For Germany and France potential output growth is projected to be 2¼ to 2½ percent, which is a decline particularly in Germany as compared to the late 1980s owing to the more recent slowdown in investment.[17] Potential output growth in Japan should slow to about 2 percent over the medium term, down from a rate of around 4 percent during the late 1980s and early 1990s. Recent work at the IMF reveals that about two thirds of this slowdown is attributable to movements in the business capital stock, reflecting the bubble-period boom in investment followed by the sharp decline after 1991; the remainder is due to declining growth in the working age population. The growth rate of potential is expected to pick up slightly to 2¼ to 2½ percent in the United Kingdom and Canada. In Italy, the growth rate of potential is expected to remain at about 2 percent, and in the United States to remain at about 2½ percent.

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[14]Since capacity utilization and total factor productivity are likely to be simultaneously determined, instrumental variables were used to correct for this bias.

[15]Two other methods for calculating potential output (the Hodrick-Prescott filter, and the production function approach) were also examined in a recent study, and were found to yield quite similar results to the segmented trend approach.

[16]As noted elsewhere, estimates of potential output are subject to a significant margin of uncertainty.

[17]See, for example, IMF (1995b).

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