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Correcting "Beyond the Cycle:" Accounting for Asset Prices in Structural Fiscal Balances

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Correcting "Beyond the Cycle:" Accounting for Asset Prices in Structural Fiscal Balances[1]

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Abstract

This paper outlines an operational approach for incorporating the impact of asset price cycles in the calculation of structural fiscal balances (SFBs). The global financial crisis demonstrated that movements in asset prices can have an important fiscal impact. Failing to account for the fiscal impact of asset price cycles can encourage a pro-cyclical policy stance if temporarily high revenues are passed through into expenditures. In addition, over-estimating the SFB may lead to inadequate fiscal buffers when cyclical revenues eventually dissipate. The paper proposes an empirical approach to correct for asset prices and provides illustrative country results for selected OECD countries. We find that asset price cycles are imperfectly synchronized with the business cycle and are quantitatively significant with an average pre-crisis fiscal impact ranging from about ½ to 2 percent of GDP in the sample. For a number of countries, the pre-crisis fiscal impact of high asset prices was larger at about 4 percent of GDP.

JEL Classification Numbers: G01, G12, H62

Keywords: structural fiscal balance, financial crisis, asset price, equity market, housing market, panel data econometrics.

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I. INTRODUCTION

The global financial crisis demonstrated that temporary asset price movements can exert a large fiscal impact. Asset prices can affect public finances through different channels, including the build-up of contingent fiscal risks in the financial sector and more directly through the impact on revenues. This paper focuses on the latter channel by outlining an approach to adjust structural fiscal balances (SFBs) for the cyclical revenue impact of asset prices. The conventional calculation of SFBs involves an adjustment of the fiscal balance to control for the cyclical impact of automatic stabilizers and large one-time transactions. Using a sample of OECD countries, this paper demonstrates that government revenues are also affected by asset price fluctuations both directly through taxes on capital transactions and indirectly through wealth effects.

The conventional cyclical adjustment of the fiscal balance for the business cycle can be inadequate to assess the actual underlying stance of fiscal policy. We find that both output and asset price cycles exert a statistically significant impact on revenues and that these cycles are not highly synchronized. Excluding non-synchronous asset price cycles from the calculation of SFBs can provide a misleading signal to policy makers about the actual underlying fiscal stance. The conventional SFB calculation can also reinforce an underlying pro-cyclical fiscal stance as temporarily higher fiscal revenues are passed through to higher recurring expenditures. This may also lead to inadequate guidance on the need to build fiscal buffers to cushion the future impact of lower revenues when asset prices eventually decline.

This paper uses an operationally tractable methodology to correct for asset price cycles in calculating SFBs and assesses their impact on the pre-crisis fiscal stance. The paper begins by dating asset price cycles and proposing a framework for measuring the degree of their synchronization with the business cycle. It subsequently outlines an approach to estimate the responsiveness of government revenues and the overall fiscal balance to business and asset price cycles based on elasticity and semi-elasticity estimation approaches. The specific asset classes considered in this paper include equities and residential housing. These assets represent large shares of private wealth and have been linked to boom and bust cycles that resulted in large fiscal costs (e.g., the 2001 and 2009 recessions).[2]

A key finding is that OECD business and asset price cycles are not fully synchronized, suggesting that beyond-the-business cycle adjustments are needed to assess the underlying fiscal stance properly. The calculation of SFBs excluding asset price cycles results in a significant overestimation of the underlying fiscal balance by about 2 percentage points of GDP based on the average impact in 20 OECD countries before the crisis. The average overestimation consists of ¾ percentage point of GDP owing to the impact of house price cycles and 1¼ percentage points of GDP owing to the impact of equity price cycles.

[2] IMF (2015) listed transmission channels from house price swings to aggregate demand. House price booms and busts could alter consumption via wealth effects and impact on liquidity constrains for households, changes in residential and small business investment funded by loans collaterized by real estate assets, bank profitability and consequently lending conditions in the economy, and labor mobility due to changes in underwater mortgages.

The fiscal impact was larger in some economies where the extent and persistence of rising asset prices generated a larger fiscal impact, including Ireland and Spain.

II. Literature Review

An increasing number of studies have examined the underlying fiscal stance adjusted for asset prices. Most papers focus on the OECD and other advanced economies (AEs) since financial and real assets are a relatively more important source of wealth compared to developing countries. Also, financial data for AEs tend to have wider availability and cover longer periods, which are important to obtain robust estimation results when calculating SFBs. In addition, a number of recent studies have been motivated by the large increase in asset prices before the global financial crisis (e.g., Kanda, 2010). Housing prices in particular rose sharply in several AEs before the crisis, raising concerns that conventional cyclical adjustments for the business cycle overstated the underlying fiscal balance.

Controlling for the impact of asset prices in the calculation of SFB is generally analogous to the methodology for undertaking cyclical adjustments to account for the business cycle (Bornhorst and others, 2011). The responsiveness of government revenues or the fiscal balance to changes in asset prices relative to trend can be estimated using an elasticity or semi-elasticity approach, respectively (Table 1). The empirical approach generally entails commonly used estimation techniques, such as the fixed-effects OLS regression to capture the contemporaneous relationship in Eschenbach and Schuknecht (2004) and Farrington and others (2008), and an error-correction mechanism to capture both short- and long-run relationships as in Price and Dang (2011). These studies generally find a significant impact of asset prices on the fiscal balance and aggregated revenue (i.e., top-down approach) as well as disaggregated revenue categories (i.e., bottom-up approach). Property prices tend to have a larger elasticity than changes in stock prices. Most studies focus mainly on equity and house prices as measures for asset prices.

A number of studies estimate the cyclical components of asset prices to calculate SFBs. Using equity and house prices as measures of asset prices, cycles are typically measured using the Hodrick-Prescott (HP) Filter consistent with the estimation of the output gap (Morris and Schuknecht, 2007; Kanda, 2010; and Price and Dang, 2011). Other papers de-trend asset prices relative to estimates of equilibrium. For example, Farrington et al. (2008) use the median ratio of real house prices to real disposable per capita income and the ratio of share prices to nominal GDP. In addition to the HP filter, Price and Dang (2011) estimate the intrinsic value of equity prices using the Gordon model, which anchors equilibrium prices as the present value of expected future dividends. Similar to the Gordon growth model, Price and Dang (2011) also consider a model proposed by Poterba (1984) and applied by André (2010) to estimate the fundamental value of a housing index. Consistent with this framework, long-term equilibrium house prices are determined by the intersection of the user cost of housing and the price-to-rent ratio. However, neither of these studies assesses the impact of not accounting for asset price cycles on the pre-crisis fiscal stance in OECD countries.

Table 1. Literature Summary: Adjusting beyond the Business Cycle

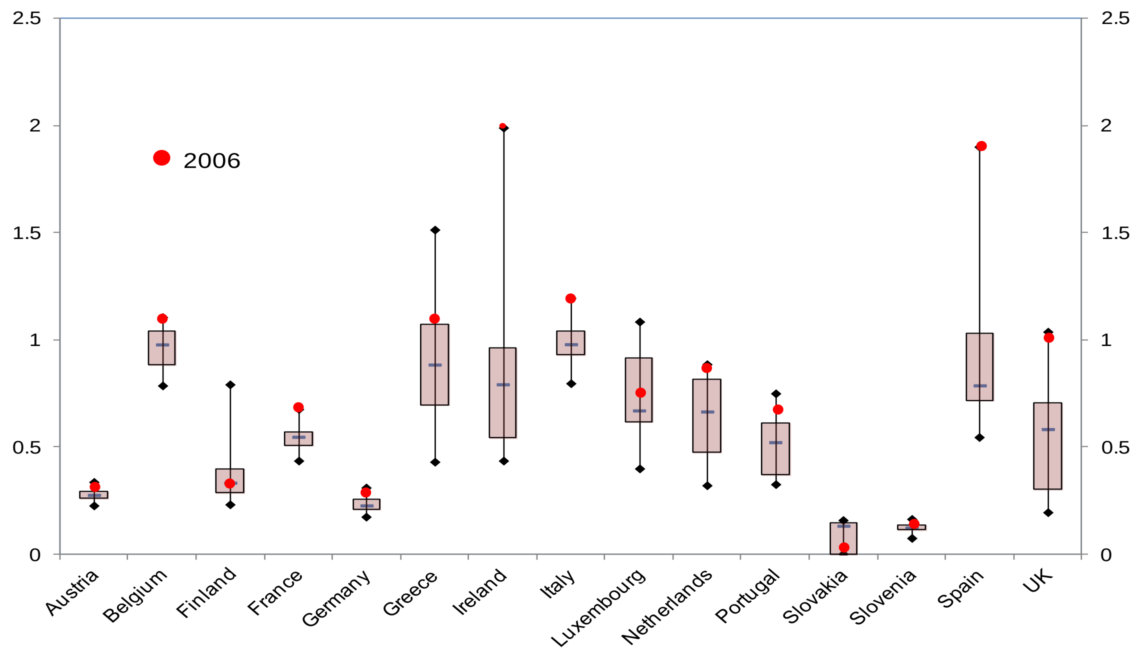
Details	Studies	E &S 1/ (2002)	E &S (2004)	Morris and Schuknecht (2007)	Jaeger and Schuknecht (2007)	Tujula and Wolswijk (2007)	Farrington et al. (2008)	Kanda (2010)	Agnello and Sousa (2011)	Price and Dang (2011)	Tagkalakis (2011a)	Tagkalakis (2011b)	Benetrix and Lane (2011)
Country Coverage		17 OECDs	20 AEs	16 OECDs	20 AEs	22 OECDs	UK	Ireland	10 AEs	OECD	19 OECDs	17 OECDs	52 countries, both AMs and EMs
Beyond the Cycle Adjustment		Housing and equity prices	Housing and equity prices	Housing and equity prices	Housing and equity prices	Housing and equity prices	Housing price/real disposable per capita income; share prices/nominal GDP	Housing and equity prices	Housing and equity prices	Price to rent; price to earnings	Housing and equity prices	Housing and equity prices	Net capital flows and domestic credit growth
Dependent Variables under Different Estimation Framework	Elasticity	Disaggregate tax revenues		Disaggregate tax revenues			Tax receipts, aggregate & disaggregate	Disaggregate tax revenues	Spending & aggregate revenues	Disaggregate and aggregate tax revenues			
	Semi-elasticity		Fiscal deficit		Fiscal deficit	Fiscal deficit			Primary surplus			Primary balance	Overall balance
	Others										Fiscal consolidation dummy		
Estimation Techniques	Time series	OLS		OLS, ECM	OLS		OLS	Log-linear regressions		ECM			
	Panel		Panel, fixed effect			Panel, fixed effect			PVAR		Probit model, Panel	Panel	Panel, fixed effect
Equilibrium assessment		None	None	HP filter	None	None	Fundamental valuation	Detrending: HP filter	Detrending: HP filter	HP filter, intrinsic valuation	None	None	None

1/ E&S: Eschenbach and Schuknecht

III. Empirical Methodology

This section outlines an operational approach to correct for asset prices in the calculation of SFBs. Asset prices impact fiscal revenues directly through transactional receipts, although the impact differs substantially across OECD countries owing to differences in the treatment of capital gains, mortgage interest and other factors (Price and Dang, 2011). As an illustration, Figure 1 outlines the range of receipts from taxes on financial and capital transactions based on OECD data. The pre-crisis outcome in 2006 is also marked in Figure 1. The chart underscores that capital and financial market-related revenues peaked just before the crisis in most countries. In addition to the direct impact of asset price fluctuations on revenues, rising asset prices can also increase expected wealth and stimulate additional expenditures consistent with the permanent income hypothesis, raising both output and fiscal revenues. Unlike the direct impact of asset prices on revenues, the indirect impact of wealth effects on fiscal variables from higher asset prices cannot be observed. This requires estimating the impact using econometric techniques as elaborated below.

Figure 1. Taxes on Financial and Capital Transactions, 1990–2012 1/
(in percent of GDP)



Sources: OECD and IMF staff estimates.

1/ For each country, the inter-quartile range is illustrated by the bar and the full range is plotted by the vertical line. The outcome in 2006 before the onset of the global financial crisis is marked by the red dot.

The empirical approach to control for the cyclical impact of asset prices on the fiscal balance entails two key steps. The first step involves identifying an appropriate measure of asset price cycles and estimating the extent that asset price cycles are synchronized with the business cycle. A high degree of synchronization suggests that conventional adjustments for the output cycle could be sufficient to capture the impact of asset price cycles. In a second step, coefficients are estimated on the sensitivity of fiscal variables to asset prices, allowing for an adjustment in calculating SFBs beyond the business cycle.

Below we present the results of applying the structural adjustment for a panel of selected OECD countries. The empirical sample is based on 20 OECD countries reflecting the relative importance of asset markets in these countries and the availability of quarterly data, including for fiscal variables, during 1980Q1–2012Q4.[3] Data on fiscal variables (government revenues and expenditures) and real variables (seasonally adjusted nominal GDP and the GDP deflator) are taken from the OECD analytical database. Data on real house prices are taken from an IMF database incorporating Bank for International Settlements (BIS) and national sources. MSCI data on national stock price indices are extracted from DataStream.

A. Measuring the Synchronization of Business and Asset Price Cycles

Dating economic and financial cycles

In order to identify economic and asset price cycles, we use the cycle dating algorithm introduced by Harding and Pagan (2002a).[4] The algorithm identifies turning points in economic and asset price series by searching for local maxima and minima over a given period and selecting pairs of adjacent (locally absolute) maxima and minima that meet the following censoring rules: (i) the duration of a complete cycle to be at least five quarters; and (ii) the duration of each phase to be at least two quarters. More specifically, for a series x_t:

- a cyclical *peak* occurs at quarter *t* if:

  $$\{[(x_t - x_{t-2})>0, (x_t - x_{t-1})>0] \text{ and } [(x_{t+2} - x_t)<0, (x_{t+1} - x_t)<0]\}$$

- a cyclical *trough* occurs at time *t* if:

  $$\{[(x_t - x_{t-2})<0, (x_t - x_{t-1})<0] \text{ and } [(x_{t+2} - x_t)>0, (x_{t+1} - x_t)>0]\}$$

- Most recently, this algorithm was used for dating economic and asset price cycles in log levels by Claessens and others (2011a, 2011b). For our purposes, we use detrended real asset prices and output to eliminate the common price factors for these cycles.

[3] The sample includes Australia (AUS), Belgium (BEL), Canada (CAN), Denmark (DNK), Finland (FIN), France (FRA), Germany (DEU), Greece (GRC), Ireland (IRL), Italy (ITA), Japan (JPN), Korea (KOR), the Netherlands (NLD), Norway (NOR), New Zealand (NZL), Spain (ESP), Sweden (SWE), Switzerland (CHE), the United Kingdom (GBR), and the United States (USA).

[4] This algorithm extends the so-called ‘‘BB’’ algorithm developed by Bry and Boschan (1971).

Measuring synchronization

To examine the extent of synchronization across cycles, we use the concordance index developed by Harding and Pagan (2002b). The concordance index for variables *x* and *y*, CI_{xy}, over period $t=1,\dots T$, is defined as:

$$CI_{xy} = \frac{1}{T}\sum_{t=1}^{T}\left[C_t^x C_t^y + (1 - C_t^x)(1 - C_t^y)\right]$$

where:

$$C_t^i = \begin{cases} 0, & \text{if variable } i \text{ is in downturn phase at time } t \\ 1, & \text{if variable } i \text{ is in expansion phase at time } t \end{cases}$$

In other words, the concordance index provides a measure of the fraction of time two series are in the same phase of their respective cycles. The series are perfectly procyclical (countercyclical) if the index is equal to unity (zero). We further supplement the concordance index with simple correlation statistics.[5]

Historical output and asset prices are not fully synchronized in the data. This finding underscores the potential value-added in correcting beyond the business cycle to the extent that the additional cycles affect fiscal variables. Based on the approach described above, Appendix II Table 1 illustrates peaks and troughs of the cycles in real GDP, stock prices and housing price for the 20 countries in the sample from 2000Q1 to 2012Q4. The influence of global cycles can be readily observed. For instance, stock prices troughed in late 1998 and early 2009 and peaked in late 2000 and 2007 in most countries. Similarly, housing prices peaked in many countries during late 2007 and early 2008. Figure 2 illustrates the resulting concordance index, highlighting that the cycles are synchronized roughly 45 to 70 percent of the time depending on the country and type of cycle. By way of comparison, the median correlation between cycles is about 0.45 to 0.5 with significant variation by country (Figure 3).[6]

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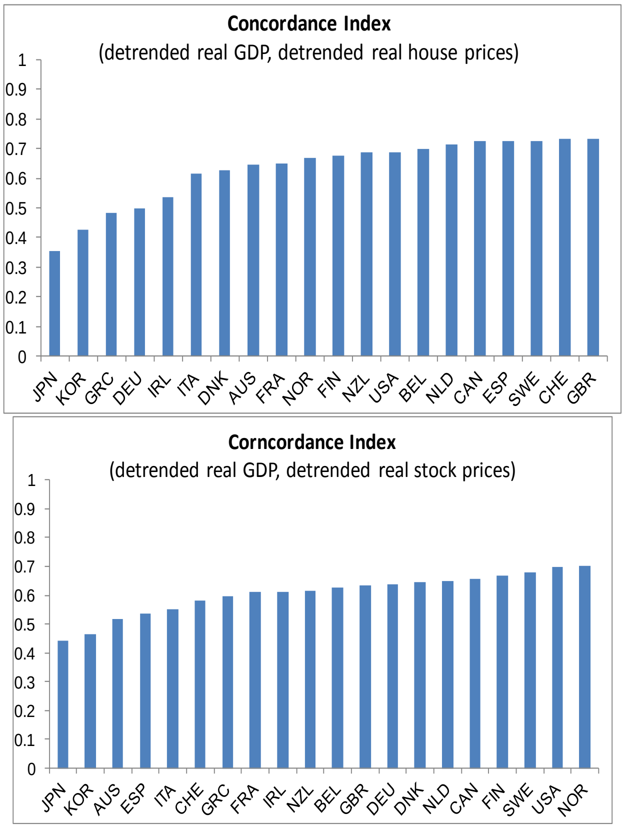
[5] Bivariate correlations are less accurate than the concordance index because they are based on covariance, which is affected by amplitude changes (shifts in the levels of two series). In particular, it is possible for a one-time shift in the level of two series (e.g., driven by a common shock) to induce significant correlation in two otherwise unrelated series. In contrast, such a shock will only be important under a concordance test to the extent that the co-movement lasts for a lengthy period of time (Cashin, 2000).

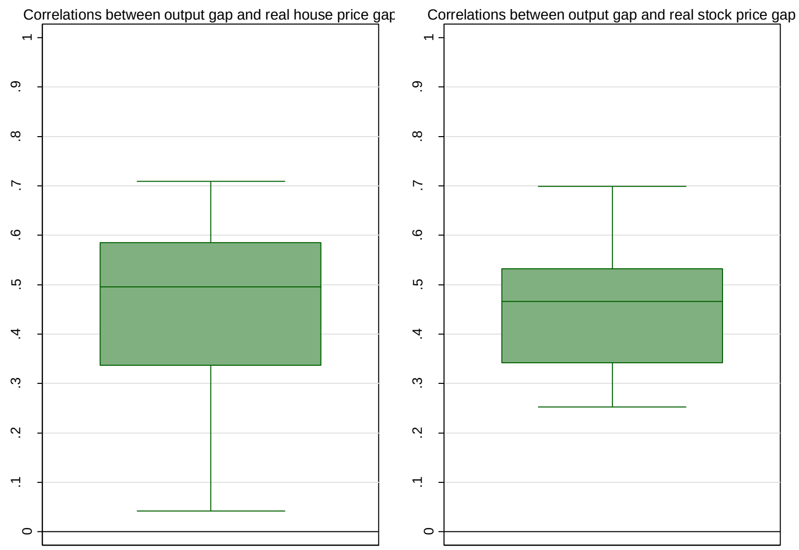
[6] The concordance index between de-trended equity and house prices ranged between 0.4 and 0.7 with a median of 0.59. The results suggest the asset cycles are imperfectly synchronized.

Figure 2. Concordance Indices
(concordance between de-trended output, equity, and house prices)



Source: IMF staff estimates based on Harding and Pagan (2002b).

Figure 3. Correlation of Detrended Output, Housing, and Equity 1/



Source: IMF staff estimates.
1/ The "whiskers" of the plot denote the minimum and maximum values. The edges of the box denote the 25th and 75th percentiles. The line splitting the box denotes the median.

B. Measuring Asset Price Cycles

As the equilibrium value of an asset is unobservable, proxies of the asset price cycle are needed. Measures of asset price cycles are conceptually similar to estimates of the output gap in this way since potential output is also unobservable. A potential concern with the notion of an asset price gap stems from the efficient markets hypothesis (EMH), which implies that asset prices continuously reflect all publicly available information suggesting an equilibrium relationship. While the EMH spawned an extensive empirical and theoretical literature, we do not need to take a position regarding the validity of the EMH to develop an operationally useful measure of asset price cycles. Specifically, the volatility of asset prices is consistent with time-varying discount rates or risk premiums (Cochrane, 2011). Moreover, fundamental asset valuations are typically mean-reverting over the medium term. In this context, we consider three broad approaches to identify asset price cycles:

Hodrick-Prescott (HP) filter. A proxy for the output gap is often estimated by applying the HP filter to real GDP. In this manner, the stochastic trend is interpreted as a proxy for potential output and the cyclical component is interpreted as business cycle fluctuations.[7] The HP filter can be analogously applied to a time series of an asset price to identify trend and cyclical components.[8] This approach is operationally attractive since it is simple to apply for practitioners and it generates a symmetric expansion and contraction phase of the cycle. However, the HP filter is vulnerable to understating mis-valuations compared to fundamental measures because of the end-point bias problem. This bias was particularly acute during the 'tech bubble' (i.e., see the relative understatement of the equity price gap based on the HP filter in Figure 4 compared to other valuation metrics). For this reason, the HP filter is our least preferred empirical proxy of the asset price gap as it understates the mis-valuations during periods of the most extreme mis-valuations when a correction is the most likely to be important.

Intrinsic valuation (IV) models. Intrinsic pricing models typically relate fundamental asset values to the expected present value of expected future cash flows. For example, the Gordon growth model (Gordon, 1959) determines equilibrium equity values as the discounted present value of expected dividends. In this way, the Gordon model relates the price-to-earnings ratio to the long-run growth rate of earnings, the real risk-free interest rate, and a risk premium:

$$\left(\frac{\mathrm{P}}{\mathrm{E}}\right)^* = \frac{1+\mathrm{g}}{\mathrm{r}+\sigma-\mathrm{g}} \,,$$

[7] This approach to calculating the output gap is also followed in the empirical section of this paper.

[8] When applying the HP filter to calculate underlying real GDP, equity and housing prices, we use 1600, 74300, and 36573 as smoothing parameters, respectively. The smoothing parameters for underlying equity and housing cycles are calibrated at a level exceeding the standard 1600 value to account for higher frequency cycles in asset prices relative to output cycles.

where g is the long-run growth rate of earnings, r represents the risk-free interest rate, and σ is the risk premium. Poterba (1984) developed a conceptually similar valuation model for real property, deriving an equilibrium relationship between the price-to-rent ratio and the user cost of capital:

$$\left(\frac{P}{R}\right)^* = \frac{1}{i^{\alpha}+\tau+f-\pi},$$

where i^{α} is the after-tax nominal mortgage interest rate; τ is the property tax rate; f refers to the recurring holding cost consisting of depreciation, maintenance and risk premium; and π is the expected capital gain on houses.[9] While IV models provide a theoretically robust framework to anchor fundamental asset values, the valuation results can be sensitive to the choice of input data, potentially generating counter-intuitive asset price gaps.[10]

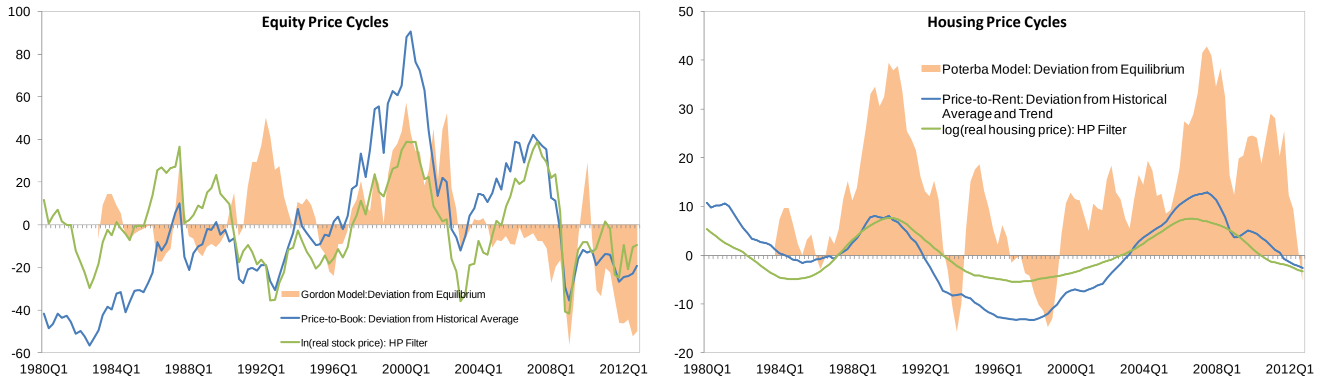
Fundamental valuation ratios. There is a long tradition, beginning from at least the classic work of Graham and Dodd (1934), of linking asset valuation to fundamental pricing ratios, such as the price-to-dividend ratio, price-to-book value ratio, price-to-earnings ratio and others. The cyclically-adjusted price-to-earnings (CAPE) ratio introduced by Shiller (2000) formalized the Graham and Dodd approach. These ratios tend to be volatile in line with market prices but are generally mean-reverting, providing a long-term anchor for fundamental asset valuation. In this manner, asset price gaps can be derived as the difference between the prevailing price ratio and its long-run mean.[11] This approach is also operationally attractive since the required financial time series are generally available for many countries.

[9] For the empirical exercise in this paper, we follow Price and Dang (2011) and use real GDP growth, nominal10-year government bond yield, and spread between the U.S. AAA corporate bond and the U.S. Treasury 10-year bond yields as inputs to the Gordon model. Similarly, we use 10-year government bond yields as the after-tax nominal mortgage rate, calculations from Girourd and the others (2006) as the property tax rate, and 4 percent as the recurring holding costs. The expected capital gain is approximated by a 5-year moving-average of the consumer inflation rate.

[10] For example, Price and Dang (2011) find that equity markets in most OECD countries were identified as under-valued prior to the global financial crisis based on the Gordon model.

[11] For the empirical work in this paper, the historical mean is calculated as the average between 1980 and 2012, subject to data availability.

Figure 4. Comparison of Asset Price Gaps, OECD Average 1/



Sources: DataStream and IMF staff estimates.

1/ The area chart depicts the asset price gap by comparing the price ratio to its intrinsic value as given by the Gordon and Poterba models, respectively. The blue line illustrates the asset price gap based on the deviation of the current price ratio from the long-term historical average. The green line depicts the asset price gap based on the HP filter method.

The baseline empirical analysis presented in the next section is based on the fundamental valuation ratios. As a robustness check, we also examine the sensitivity of the estimated results to alternative measures of the asset price gap. In general, the different measures of the equity price gaps are well aligned over time. The HP filter generates the least volatile and smallest equity price gaps. The other measures are more volatile, and generate larger gaps on average. This pattern highlights the importance of linking asset price gaps to fundamental trends rather than statistically generated stochastic trends. For the housing price cycles, the HP filter is substantially less volatile. The different housing gap measures are also less highly aligned compared to equities.

C. Estimation Framework

Structural balances can be estimated using either an elasticity or semi-elasticity approach. Each approach offers advantages and limitations that are discussed below.

Elasticity approach

This approach entails estimating elasticity coefficients between government revenues or the overall balance with respect to economic and asset price cycles. Define revenue (ε_R) and expenditure (ε_E) elasticity coefficients as:

$$R = (Y)^{\varepsilon_R} \qquad (1)$$

$$E = (Y)^{\varepsilon_E} \qquad (2)$$

where R is nominal government revenue, E is nominal government expenditure, and Y is nominal output. Expressions (1) and (2) suggest that a 1-percent change in nominal output leads to an ε_R (ε_E) percent change in nominal revenues (expenditures).[12] Expressions (1) and (2) also hold when the variables are at their potential level (denoted by R,* E,* and Y*).

$$R^* = (Y^*)^{\varepsilon_R} \tag{3}$$

$$E^* = (Y^*)^{\varepsilon_E} \tag{4}$$

The cyclically-adjusted balance (CAB) can be expressed as a function of revenue and expenditure ratios relative to potential output and the elasticity coefficients. Specifically, divide (1) over (3) and (2) over (4) to express revenue and spending relative to their potential levels:

$$\frac{R}{R^*} = \left(\frac{Y}{Y^*}\right)^{\varepsilon_R} \tag{5}$$

$$\frac{E}{E^*} = \left(\frac{Y}{Y^*}\right)^{\varepsilon_E} \tag{6}$$

where $\left(\frac{Y-Y^*}{Y^*}\right)$ is the output gap. Expressions (5) and (6) imply that a 1-percent change in nominal output relative to its potential level leads to ε_R (ε_E) percent change in nominal revenues (expenditures) relative to their potential level. The resulting CAB as a share of potential output can be expressed as:

$$cab = \frac{CAB}{Y^*} = \frac{R^* - E^*}{Y^*} = \frac{R}{Y}\frac{Y}{Y^*}\left(\frac{Y}{Y^*}\right)^{-\varepsilon_R} - \frac{E}{Y}\frac{Y}{Y^*}\left(\frac{Y}{Y^*}\right)^{-\varepsilon_E} = r\left(\frac{Y}{Y^*}\right)^{1-\varepsilon_R} - e\left(\frac{Y}{Y^*}\right)^{1-\varepsilon_E}$$

where cab = $\frac{CAB}{Y^*}$, r = $\frac{R}{Y}$, and e = $\frac{E}{Y}$.[13]

The elasticity coefficients can be estimated using time-series panel techniques. Equations (1) and (2) suggest that revenue (expenditure) elasticities with respect to output could be estimated by regressing the logarithm of revenue (expenditure) on the logarithm of output. However, given that revenue, expenditure, and output variables are non-stationary, a standard fixed effects regression would produce spurious coefficients. We estimate revenue elasticity coefficients (ε_R, ε_E) using the pooled mean-group estimator (PMG) for a panel of countries indexed by *i* (see also Appendix I):

$$\Delta \ln(R_{i,t}) = \gamma_i[\ln(R_{i,t-1}) - \varepsilon_R \ln(Y_{i,t-1})] + \beta_i \Delta \ln(Y_{i,t}) + v_{i,t} \tag{7}$$

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[12] Same reasoning can be applied to variables expressed in real terms.

[13] The choice of fiscal balance to correct differs in the literature with some studies focusing on the overall balance and others on the primary balance. The benefits of the overall balance include: (i) implicitly capturing the impact of asset price cycles on debt charges; and (ii) more direct link to public debt compared to primary balances. However, the methodology can be readily applied to corrections of the primary balance as well.

where γ is the speed of adjustment to the long-run equilibrium, ε_R is the long-run revenue elasticity and β is the short-run revenue elasticity.[14] The expenditure elasticity coefficient could be estimated similarly. The application of the PMG approach is appropriate given inherent trends in the levels of GDP and fiscal variables. In addition, the PMG approach is more flexible compared to the fixed effects regressions on changes of variables, as PMG allows estimating not only short-run elasticities, but also long-run elasticities and speed of adjustment to the long-run equilibrium.

An important advantage of the PMG approach is that a proxy of potential output is not required for estimation but it is also computationally burdensome. The PMG estimator is the panel equivalent of the error-correction model (ECM), in which long-run coefficients are assumed to be homogenous across panels, while speed of adjustment and short-run coefficients are allowed to vary across panels. The approach hinges on an equilibrium long-run relationship between observed real output and the fiscal variable (panel co integration). However, the PMG is more computationally intensive compared to the semi-elasticity approach outlined below since it is based on the maximum likelihood estimation approach.

Semi-elasticity approach

The semi-elasticity framework provides a relatively tractable and robust regression approach. We define the semi-elasticity η of the overall balance ratio relative to the output gap directly in the equation of "cab:"

$$cab = \frac{CAB}{Y^*} = b - \eta \frac{Y-Y^*}{Y^*} \tag{8}$$

where $b = \frac{B}{Y} = \frac{R-E}{Y}$ is the overall balance ratio and $\frac{Y-Y^*}{Y^*}$ is the output gap.[15] Expression (8) indicates that a 1-percent change in nominal output relative to its potential level leads to an η-percentage point change in the overall balance-to-output ratio. The impact of these automatic stabilization effects should be taken out from the overall balance ratio to estimate

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[14] See Bornhorst et al. (2011) for extension of formulas to financial cycles, which result in the following PMG specification that accounts for financial cycles:

- $$\Delta \ln(R_{i,t}) = \gamma_i[\ln(R_{i,t-1}) - \varepsilon_R \ln(Y_{i,t-1}) - \varepsilon_F \ln(F_{i,t-1})] + \beta_i \Delta \ln(Y_{i,t}) + \rho_i \Delta \ln(F_{i,t}) + v_{i,t}$$

where F is the financial variable (equity prices, house prices, or both), ε_F (ρ) are the long-run (short-run) elasticities with respect to the financial variable.

[15] A formal derivation of equation (8) is as follows:

$$\frac{B}{Y} - \eta \frac{Y-Y^*}{Y^*} = \frac{B}{Y} - \frac{d\left(\frac{B}{Y}\right)}{\frac{dY}{Y}} \frac{Y-Y^*}{Y^*} = \frac{B}{Y} - \frac{\frac{dB}{dY}Y - B}{\frac{Y^2}{Y}} \frac{Y-Y^*}{Y^*} = \frac{B}{Y} - \left(\frac{dB}{dY} - \frac{B}{Y}\right)\frac{Y-Y^*}{Y^*} =$$

$$= \left(1 + \frac{Y-Y^*}{Y^*}\right)\frac{B}{Y} - \frac{dB}{Y^*} = \frac{Y}{Y^*}\frac{B}{Y} - \frac{dB}{Y^*} = \frac{B-dB}{Y^*} = \frac{B^*}{Y^*} = cab$$

the cyclically-adjusted balance ratio. It can be shown that the semi-elasticity of the overall balance ratio can be expressed as a function of the revenue (ε_R) and expenditure (ε_E) elasticity coefficients:

$$\eta = (\varepsilon_R - 1)\frac{R}{Y} - (\varepsilon_E - 1)\frac{E}{Y} \tag{9}$$

Using specification (8), the semi-elasticity η can be directly estimated by running a panel regression of the overall balance-to-GDP ratio on the output gap. Equation (10) outlines the regression:

$$\frac{B_{i,t}}{Y_{i,t}} = \beta_0 + \eta\frac{Y_{i,t} - {Y^*}_{i,t}}{{Y^*}_{i,t}} + v_{i,t} \tag{10}$$

The advantage of the semi-elasticity approach is that all variables in the equation are generally stationary (even though the overall balance ratio could be trending in-sample for some countries). The main disadvantage of the semi-elasticity approach is that the precision of the coefficient estimate depends on the accuracy of the measured output gap. Adjustments beyond the output cycle are handled analogously so that equation (10) would be supplemented with an asset price F relative to its fundamental value, $\left(\frac{F-F^*}{F^*}\right)$ and include elasticity coefficients (${\varepsilon^F}_R$, ${\varepsilon^F}_E$), which would enter the calculations of *cab* as additional terms.

D. Empirical Results

Elasticity approach

The long-run revenue elasticity with respect to output is close to one and is highly significant (Table 2). The unitary long-run elasticity of revenues suggests that a 1-percent permanent increase in output leads to an approximately 1-percent permanent increase in total revenues in the long-run. This estimate is in line with previous empirical findings using an aggregated approach and the frequent "rule of thumb" applied by practitioners assuming elastic revenues (elasticity=1) and inelastic expenditures (elasticity=0) to adjust headline fiscal balances for the impact of output cycles (Bornhorst and others, 2011). The short-run revenue elasticity to changes in real GDP is about half of the long-run elasticity and is highly significant (Column 4). The lower short-run elasticity of revenues suggests that a 1-percent temporary increase in output leads to a 0.62 percent increase in total revenues (Column 4). Temporary deviations from the long-run equilibrium are adjusted with a speed of 2.5 percent per quarter, with half of the deviations being adjusted in 34 quarters.

Table 2. Estimation Results: Long-Run and Short-Run Revenue Elasticities, 1980:1–2012:4 1/

		1	2	3	4
Long-run elast.	ln (Real GDP)	0.978***	0.934***	1.007***	0.956***
		[0.008]	[0.008]	[0.017]	[0.007]
	ln (Real House Prices)		0.082***		0.166***
			[0.027]		[0.044]
	ln (Real Stock Prices)			0.069***	0.095***
				[0.018]	[0.017]
	Speed of adjustment	-0.033*	-0.034**	-0.026**	-0.025***
		[0.020]	[0.014]	[0.012]	[0.006]
Short-run elast.	Δ ln (Real GDP)	0.586***	0.703***	0.546***	0.617***
		[0.077]	[0.095]	[0.055]	[0.079]
	Δ ln (Real House Prices)		0.068		0.145**
			[0.072]		[0.066]
	Δ ln (Real Stock Prices)			0.008**	0.013***
				[0.004]	[0.005]
	Obs.	1719	1422	2083	1460
	Countries	20	20	20	20
	Log likelihood	5111.5	4264.5	6154.5	4419.5
	Half life (in quarters)	**22.8**	**22.8**	**26.3**	**34.3**

1/ Estimations are performed using the pooled mean group (PMG) estimator. The intercept is included in the long-run specification but not reported. All t-statistics are reported in parentheses. The *, **, and *** denote significance at the 10-, 5-, and 1-percent confidence levels, respectively. All variables are tested for the presence of unit roots.

The impact of asset price variables (beyond-the-cycle effects) is also highly significant when added individually or jointly to the specification (Table 2, Columns 2–4). This suggests that business and asset price cycles are not fully synchronous. The long-run elasticities of revenues to real house prices (0.166) and real stock prices (0.095) are much lower than that of real output (column 4). The short-run elasticities of revenues to real house prices (0.14) and real stock prices (0.01) are also highly significant, implying total revenues respond to temporary shocks to asset price variables. The speed of adjustment coefficient is relatively small (2.5 percent adjustment per quarter), suggesting convergence occurs almost twice slower the long-run equilibrium determined by both economic and financial determinants (half of the deviation adjusted in 34 quarters).

Semi-elasticity approach

The semi-elasticity estimates of the overall balance ratio with respect to both output and asset price cycles are highly significant (Table 3). The semi-elasticity with respect to the output gap declines from 0.83 (Column 1) to 0.58 (Column 4) when asset price cycles are included in the regression, suggesting that business and asset price cycles are not fully synchronous and that asset price variables capture part of the variation attributed to the output cycle in Column 1. Given equation (9), the semi-elasticity coefficient of 0.58 corresponds to an elasticity of about 1½.[16] Similar to the elasticity results, the semi-elasticity with respect to house prices (0.053) and stock prices (0.036) appears to be low compared to the output cycle (0.58).[17] However, as shown in the next section, the smaller semi-elasticity coefficients continue to imply a sizable impact on the overall balance ratio from asset price cycles given the high volatility of asset price cycles compared to output cycles.

The relationship between the overall balance ratio and cyclical variables is time-varying. The semi-elasticity of the overall balance ratio with respect to output cycles and house price cycles has gradually declined since 1995 before a reversal of the trend in recent years following the global financial crisis (Figure 5). The higher semi-elasticity coefficients during the crisis could be largely driven by the bailout program and large stimulus packages by multiple countries as part of governments' effort to safeguard the financial sector and prevent a more severe economic recession. The wide confidence interval however, might suggest a constant semi-elasticity with respect to output and house price cycles over the sample period. In contrast, the semi-elasticity of the overall balance ratio with respect to equity price cycles has increased over time, accompanied with financial deepening in sample countries, and does not seem to be affected during the recent crisis.[18]

[16] This result is based on a revenue- and expenditure-to-GDP ratio in the OECD sample of 42.5 and 45 percent of GDP, respectively.

[17] To address potential issue of cross-sectional dependence, we conduct estimation using Driscoll and Kraay (1995) robust standard errors. The main results remain qualitatively unchanged.

[18] Country-by-country regressions assess the variation of semi-elasticity coefficients across countries. For most countries, we found positive and significant semi-elasticity coefficients of the output gap (ranging between 0.2 and 0.83) and stock price gap (ranging between 0.05 and 0.32) variables. The house price gap semi-elasticity coefficients were positive and significant in only four countries (ranging between 0.1 and 0.24). The main reason for the mixed results in country-by-country regressions is the low power of the OLS estimator due to the small number observations for individual countries.

Table 3. Estimation Results: Semi-Elasticity Coefficients, 1980:1–2012:4 1/

	1	2	3	4
Output gap	0.833***	0.787***	0.694***	0.583***
	[0.096]	[0.077]	[0.107]	[0.090]
Housing price gap (%)		0.034**		0.053***
		[0.016]		[0.014]
Equity price gap (%)			0.034***	0.036***
			[0.006]	[0.006]
Intercept	-2.282***	-2.274***	-2.444***	-2.361***
	[0.000]	[0.004]	[0.008]	[0.012]
Obs.	2511	2451	2102	2082
Countries	20	20	18	18
Adjusted R-squared	0.110	0.125	0.258	0.292
Log likelihood	-6,800	-6,600	-5,500	-5,400

1/ The dependent variable is the overall balance-to-GDP ratio (in percent). The output gap is estimated using the HP filter (in percent); the housing price gap is estimated using the de-trended price-to-rent ratio; and the equity price gap is estimated using the demeaned price-to-book ratio. Estimations are performed using the fixed effects estimator. Robust t-statistics are in parentheses. *, **, and *** denote significance at 10-, 5-, and 1-percent confidence levels, respectively. All variables are tested for unit roots.

Figure 5. Time-Varying Semi-Elasticity Coefficients 1/

1/ Estimations are performed based on 60-quarter rolling regressions starting from 1980Q1. Solid lines denote coefficient estimates and dashed lines denote a 95-percent confidence interval.

Robustness checks

The robustness of the coefficient estimates are evaluated by extending the baseline model outlined in Table 3 in a number of ways. These include alternative measures of asset price cycles, different sample compositions and time periods, tests for omitted variables, simultaneity bias, non-linear specifications and additional robustness checks. As summarized below, the benchmark results appear to be robust. Table 4 summarizes the results of the main robustness checks, and the remaining results are presented in Appendix II (Table 2 and Table 3).

Alternative proxies of asset price cycles. The estimated coefficients vary with alternative measures of the asset price cycles. In particular, the coefficients on the housing and equity price gaps based on the intrinsic valuation methods take the incorrect sign (Appendix II, Table 3). In contrast, the coefficient on the housing and equity price gap remains statistically significant using the HP filter method. We interpret these findings as reflecting the methodological limitations of the intrinsic valuation methods (i.e., intrinsic valuation is highly sensitive to input variables). The coefficient on the output gap remains strongly significant when using alternative proxies for asset price gaps; although it changes in magnitude suggesting that the explanatory power attributed to asset price cycles in our benchmark specification has changed in the alternative specifications.

***Sample selection*.** The sensitivity of the results is also assessed for sample dependence. We re-estimate the benchmark model with different country samples and time periods, including the pre-crisis period. As shown in Figure 5, there is a step increase in the semi-elasticity of the overall fiscal balance with respect to the business cycle in the post-crisis period. The expansion in large bailout programs and discretionary fiscal stimulus since the crisis has resulted in a large increase in the fiscal deficit just as the output gap widened substantially, which may exaggerate the semi-elasticity of the overall fiscal balance to the business cycle. In recognizing that the estimates could be distorted by including the post-crisis period, we consider two approaches as a check on robustness—constraining the sample to the period before the global financial crisis (GFS) and excluding European countries that experienced financial market pressure (i.e., Greece, Ireland, Italy, and Spain or “GIIS”). In the sample before the GFS, Table 4 (Column 3) suggests that the semi-elasticity with respect to the output gap is lower than the benchmark result[19] and the housing coefficient is higher. For the sample of non-GIIS countries, Table 4 (Column 4) reports the reverse pattern with a larger semi-elasticity of the output gap than the benchmark result and a smaller coefficient on the housing price gap. These findings suggest that housing price cycles were more highly synchronized with the output gap in the GIIS countries. The semi-elasticity of equity cycles remains stable across the different samples.[20]

***Emerging market economies*.** The baseline findings are based on OECD countries. To test the sensitivity of our results to a broader set of economies with developing financial markets, we add emerging-market economies.[21] The elasticity of the fiscal balance to the output cycle for emerging market economies is lower at 0.36 compared to the baseline results for OECD countries (Table 4, Column 8). Based on Equation (9), this result suggests a revenue elasticity of about unity given the lower average expenditure-to-GDP ratio in the sample of emerging-market countries of about 0.35.

***Omitted variables*.** We enhance the benchmark model with three additional economic variables that could potentially impact the results. First, we study if the credit cycle—defined as the annual growth rate of banking credit to the private sector—represents another independent cycle affecting the dynamics of the overall fiscal balance. Specifically, higher consumption or investment financed from an increase in credit could generate higher tax revenue and a stronger fiscal balance. As another test, we include market capitalization as a

[19] The semi-elasticity coefficient remains broadly consistent with the result of the elasticity approach.

[20] We also conducted country-by-country tests, but refrain from presenting the results as they are unreliable owing to small sample sizes and noise in country-level data.

[21] These include Argentina, Brazil, Chile, China, Colombia, China, P.R.: Hong Kong SAR, Hungary, India, Indonesia, Malaysia, Mexico, Peru, Philippines, Poland, Singapore, South Africa, Taiwan, People’s Republic of Thailand, Venezuela, Vietnam, and 20 OECD countries in the sample.

proxy for both the level of financial development and the volume of financial transactions. The results presented in Table 4 (Column 5–6) do not suggest that the benchmark results are materially different.

***Non-linearity*.** To test for possible non-linearity in the relationship between asset prices and the fiscal balance, we include the square of the equity price and housing price gaps (Column 7, Table 4). We also examine how the coefficients differ in periods of economic boom and bust (Appendix II, Table 2). There is modest evidence of non-linearity in the equity price gap although the magnitude of the impact on fiscal revenue is low. In addition, the pattern of results for the semi-elasticity on equity and housing price gaps remains broadly unchanged compared to the benchmark findings. [22]

Simultaneity and autocorrelation issues. We consider dynamic specifications and instrumental variable techniques given that the overall balance, output gap and asset prices are endogenous and auto correlated macroeconomic variables. We estimate instrumental variable regressions using system generalized method of moments GMM (Column 2, Table 4).[23] We generally find a consistent pattern of empirical results compared to the benchmark specification, especially the impact of equity price cycles which we interpret as broadly supporting the robustness of the benchmark findings.

***Additional tests*.** Other robustness checks are also considered, including the duration of the asset price cycle based on the notion that persistent mis-valuations affect indirect wealth effects more strongly than short-term fluctuations. We also assess the robustness of the benchmark results by (i) using four quarter lagged asset price gaps instead of contemporary ones to account for possible delayed impact of asset price cycles on fiscal revenues; (ii) adding dummy variables for banking crisis episodes; (iii) asset market expansions; (iv) the cyclically-adjusted price-to-earning ratio popularized by Shiller (2000); and (v) replacing explanatory variables with four quarter smoothed values. The details are presented in Table 2, Appendix II. Overall, there is little significant variation relative to the benchmark results. In particular, the semi-elasticity of the overall fiscal balance with respect equity cycles remains highly stable among different specifications, ranging between 0.035 and 0.045. The impact of the four quarter lagged housing price gap is not significant, suggesting a stronger contemporary impact of housing cycles on fiscal balance.

[22] Additional tests for non-linearity were also conducted. We examined the semi-elasticity of the overall balance ratio with respect to business and asset price cycles during economic expansions and contractions, and during asset price booms and busts, including how the relationship reacts to the duration of the asset price boom and bust. The results presented in Appendix II, Table 2 do not provide clear evidence of non-linearity.

[23] Exogenous instrument is the sample average output gap. The coefficient on the equity price gap remains unchanged, the housing coefficient declines, while the output gap coefficient increases marginally.

Table 4. Robustness Checks

			Different Sample		Omitted Variables		Non-linearity	
	Benchmark	Dynamic Model	pre-GFC	Non-GIIS countries	with credit cycle	wt. mkt cap.	wt. square terms	wt. Emerging market
	1	2	3	4	5	6	7	8
4-qtr lag fiscal balance (% of GDP)		0.461**						
		[0.141]						
Output gap	**0.583*** **	0.471*	0.448***	0.637***	0.565***	0.561***	0.566***	0.356***
	[0.090]	[0.171]	[0.091]	[0.076]	[0.093]	[0.100]	[0.086]	[0.088]
Price to Rent gap (%)	**0.053*** **	0.013	0.061***	0.047**	0.050***	0.061***	0.052***	0.049***
	[0.014]	[0.019]	[0.014]	[0.020]	[0.011]	[0.019]	[0.016]	[0.011]
Price to Book gap (%)	**0.036*** **	0.028***	0.036***	0.032***	0.033***	0.046***	0.042***	0.035***
	[0.006]	[0.010]	[0.006]	[0.007]	[0.006]	[0.008]	[0.006]	[0.005]
Price to Rent gap^2 (%)							0	
							[0.001]	
Price to book gap^2 (%)							-0.000**	
							[0.000]	
Price to Book gap * Market cap (% of GDP)						-0.304**		
						[0.107]		
Credit growth (yoy %)					3.021			
					[2.785]			
Intercept	**-2.361*** **	-1.071	-1.867***	-1.592***	-2.578***	-2.281***	-2.307***	-1.976***
	[0.012]	[3.532]	[0.041]	[0.018]	[0.150]	[0.025]	[0.124]	[0.021]
Obs.	**2082**	2030	1739	1664	1931	2004	2082	2559
Countries	**18**	18	18	14	18	18	18	27
Adjusted R-squared	**0.292**		0.338	0.286	0.309	0.312	0.304	0.198
Log likelihood	**-5,400**		-4,300	-4,200	-5,000	-5200	-5400	-7000

Fiscal impact of asset price cycles

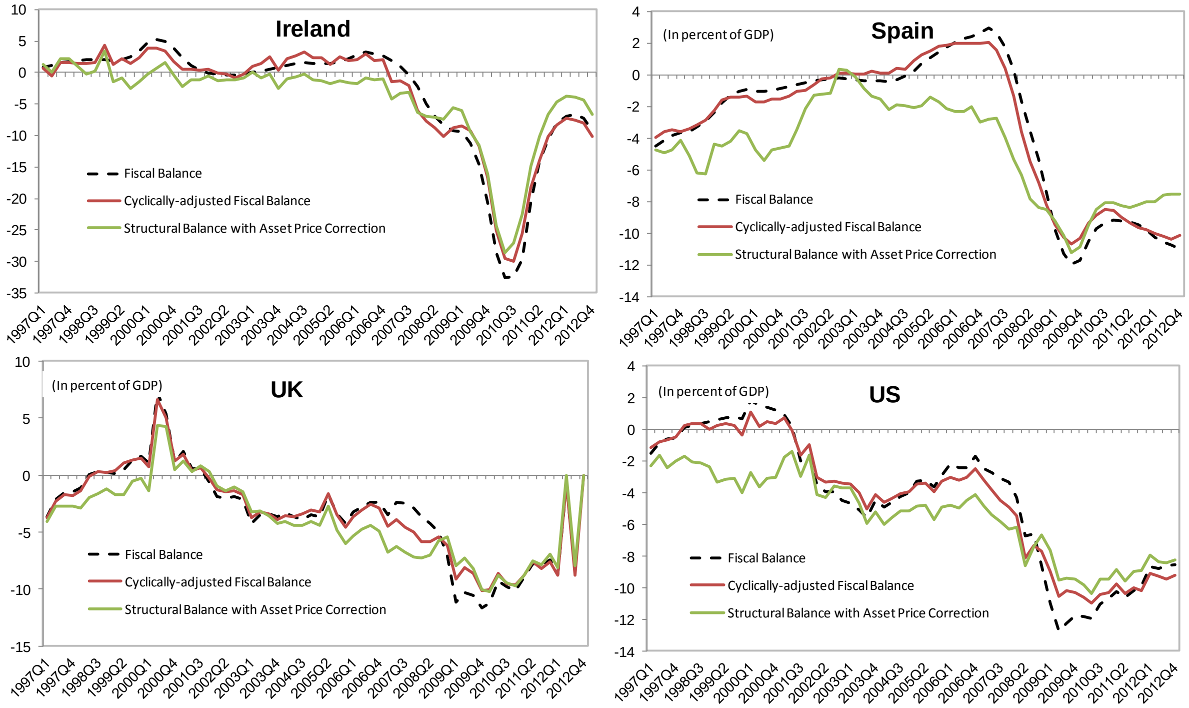
Illustrative results are presented in Figure 6 comparing the headline fiscal balance with the SFBs adjusted for both business and asset price cycles. Specifically, Figure 6 is based on the benchmark specification for Ireland, Spain, the United Kingdom, and the United States. Adjusting for asset price cycles suggests that the SFBs are over-estimated in the years preceding the global financial crisis by about 3 percentage points of GDP on average compared to the conventional cyclically-adjusted fiscal balance. The fiscal impact of asset prices is also pronounced during the dot-com equity bubble in the late 1990s, especially in Spain and the United States with an estimated impact of about 4 percent of GDP. Similar country-level results for other OECD countries in the sample are presented in Appendix II, Figure 1. For the overall sample of OECD countries, Figure 7 summarizes the fiscal impact of the asset price correction before the global financial crisis based on different estimation approaches and measures of the asset price gap.[24]

The estimated fiscal impact of asset prices is larger based on the semi-elasticity approach using fundamental valuation ratios compared to the elasticity approach. To calculate fiscal impact using the elasticity approach, we apply HP filters to asset prices to calculate asset price gaps, as the estimation framework is based on real asset prices rather than any fundamental ratios. Our benchmark model is based on the semi-elasticity specification with equity and housing price cycles calculated using fundamental valuation ratios. In this framework, the average fiscal impact in the OECD of housing and equity price cycles is about 1 and 1¼ percent of GDP, respectively. The fiscal impact of house price cycles in Ireland, the United Kingdom, and the United States before the crisis was higher at about 3, 1, and 1¼ percent of GDP, respectively. The overall pre-crisis fiscal impact of asset prices was particularly high in Spain at above 4 percent of GDP, but the impact is mainly from equity price misalignment.[25] In contrast, the estimated pre-crisis fiscal impacts based on the elasticity method are smaller. Although there is no need to identify business and asset cycles during estimation based on the elasticity method, the adjustment to the fiscal balance will still be based on the deviation of output and asset prices from their equilibrium levels. Since HP filter is applied to calculate business and asset cycles in the elasticity approach, the magnitude of adjustment is much lower.

[24] To calculate pre-crisis fiscal impact of asset price corrections, we select four-quarter periods when the housing and equity cycles are at their peaks in each country.

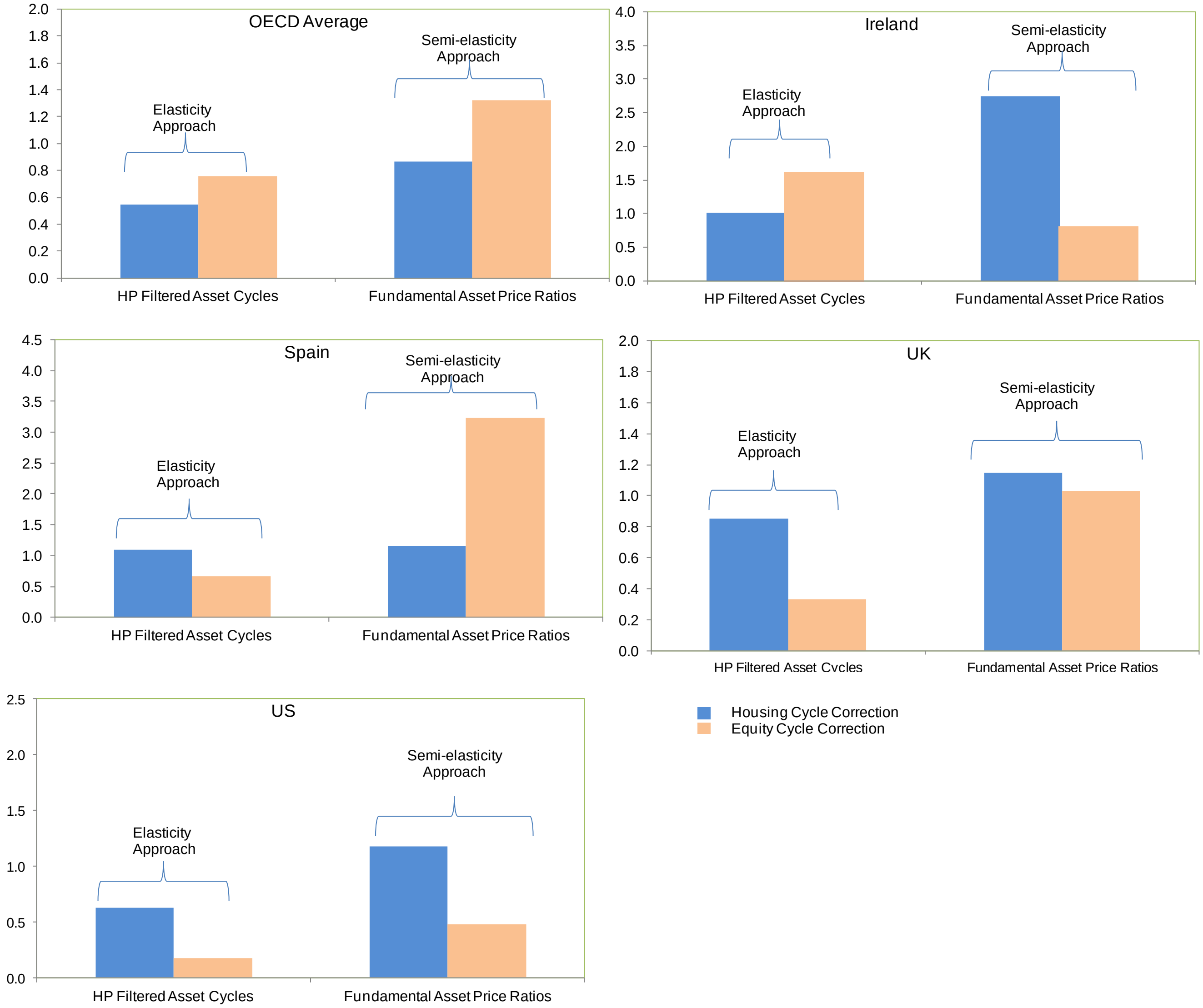
[25] In the case of Spain, there was a drastic build-up in property prices before the financial crisis, which is expected to have had a large impact on fiscal revenues. However, the existence of tax incentives for house ownership, high synchronization of housing and output cycles in the 2000s, and the decoupling of labor cost movements from higher house prices dampened both the direct and indirect impact of housing bubbles on fiscal revenues. At the same time, equity prices rose sharply to almost the same level during the dot-com bubbles, resulting in much larger adjustment to fiscal balance compared with the adjustment due to housing price bubbles.

Figure 6. Comparison of Selected SFB Estimates 1/
(in percent of GDP)



1/ IMF staff estimates. Fiscal balance refers to overall fiscal balance for general government. Cyclically-adjusted fiscal balance is the overall balance adjusted for output cycles. Structural balance with asset price correction is the overall balance adjusted for output, housing, and equity price cycles.

Figure 7. Average Fiscal Impact of Asset Price Corrections in Structural Fiscal Balances, before the Global Financial Crisis 1/ 2/
(in percent of GDP)



1/ The blue and yellow columns indicate how much the structural fiscal balance was over estimated before the financial crisis when housing and equity price cycles were ignored, respectively. Adjustments suggested by the elasticity approach and semi-elasticity approach are both presented in the charts. For the semi-elasticity approach, we adopt the results using the fundamental valuation approach to estimate asset price gaps.
2/ To calculate pre-crisis fiscal impact of asset price corrections, we select four-quarter periods when the housing and equity cycles are at their peaks in each country.

IV. CONCLUSIONS

This paper provides an operationally tractable methodology to adjust fiscal balances for the impact of asset-price cycles. Unlike previous studies, we use alternative methodologies to date asset price cycles (HP filter, intrinsic valuation, and fundamental valuation), assess their synchronization, and evaluate the impact of not correcting for pre-crisis asset price booms on the fiscal stance. Each approach to date asset price cycles its pros and cons. Practitioners should apply additional judgment in applying these methodologies for dating asset price cycles in their country of interest and assessing the impact on SFBs. In addition, more disaggregated data, if available, could be used to identify revenue components that are more closely dependent to cyclical fluctuations in asset prices.

The analysis highlights the need to adjust fiscal variables for beyond-the-business cycle effects such as asset prices. We find that economic and asset price cycles are not fully synchronized, suggesting that corrections for asset prices are needed to avoid a potentially pro-cyclical bias in SFB calculations. The degree of synchronization differs across countries, but remains far short of full synchronization. Second, asset price cycles are quantitatively important factors influencing fiscal balances and revenues. Based on the semi-elasticity approach, we find that the average fiscal impact of asset price cycles in a sample of OECD countries is about 2 percent of GDP pre-crisis and significantly higher in countries with large asset price movements, reaching at least 4 percentage points of GDP during episodes of large mis-valuation. In this context, correcting fiscal balances for the impact of asset price cycles is important to ensure that cyclical revenues are not passed through into recurrent expenditures, resulting in a pro-cyclical fiscal stance and inadequate fiscal buffers to accommodate lower future revenues.

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APPENDIX I. Dynamic Adjustment using Long-Run and Short-Run Elasticity Coefficients from the Error-Correction Model

The example below applies to government revenues, but a similar approach could be adapted to government expenditures.

Expanding specification (1) to allow for beyond the cycle (equity and house price gap) effects and expressing all variables in logarithms (and real terms) yields:

$$r_t = \alpha_1 y_t + \alpha_2 s_t + \alpha_3 h_t \tag{A.1}$$

where lower case letters denote logarithms and *t* denotes time, *r* is the real government revenue, *y* is the real output, *s* is the real stock price index, and *h* is the real house price index. Expression (A.1) suggests that a 1-percent change in real output/equity/house prices leads to a α_1/ α_2/ α_3 percent change in real revenue.

Allowing for dynamic effects, expression (A.1) could be rewritten in ARDL(1,1) form:

$$r_t = \alpha_0 r_{t-1} + \alpha_1 y_t + \alpha_2 s_t + \alpha_3 h_t + \alpha_4 y_{t-1} + \alpha_5 s_{t-1} + \alpha_6 h_{t-1} \tag{A.2}$$

A particular case of expression (A.2) holds when all variables are at their potential levels (denoted by stars). Taking the difference between (A.2) and its steady state version yields:

$$\begin{aligned} r_t - r_t^* = {} & \alpha_0 (r_{t-1} - r_{t-1}^*) + \alpha_1 (y_t - y_t^*) + \alpha_2 (s_t - s_t^*) + \alpha_3 (h_t - h_t^*) + \\ & + \ \alpha_4 (y_{t-1} - y_{t-1}^*) + \alpha_5 (s_{t-1} - s_{t-1}^*) + \alpha_6 (h_{t-1} - h_{t-1}^*) \end{aligned} \tag{A.3}$$

Exponentiation of both sides yields expanded version of specification (5) that accounts for dynamic effects and beyond the cycle effects:

$$\frac{R_t}{R_t^*} = \left(\frac{R_{t-1}}{R_{t-1}^*}\right)^{\alpha_0} \left(\frac{Y_t}{Y_t^*}\right)^{\alpha_1} \left(\frac{S_t}{S_t^*}\right)^{\alpha_2} \left(\frac{H_t}{H_t^*}\right)^{\alpha_3} \left(\frac{Y_{t-1}}{Y_{t-1}^*}\right)^{\alpha_4} \left(\frac{S_{t-1}}{S_{t-1}^*}\right)^{\alpha_5} \left(\frac{H_{t-1}}{H_{t-1}^*}\right)^{\alpha_6} \tag{A.4}$$

where uppercase letter denotes levels of respective variables. Intuitively, specification (A.4) suggests that the deviation of government revenues from their potential level depends on its deviation from potential level in the previous period, and output/equity/house price gaps in current and previous periods. Elasticities α_0-α_6 needed to do cyclical adjustment can be obtained from the error-correction specification.

Transforming expression (A.2) to an expanded version of the error-correction (7) that accounts for beyond the cycle effects can be achieved using the following steps:

- Subtract r_{t-1} from both sides of the equation:

$$\Delta r_t = (\alpha_0 - 1) r_{t-1} + \alpha_1 y_t + \alpha_2 s_t + \alpha_3 h_t + \alpha_4 y_{t-1} + \alpha_5 s_{t-1} + \alpha_6 h_{t-1}$$

- Add and subtract $\alpha_1 y_{t-1}$, $\alpha_2 s_{t-1}$, and $\alpha_3 h_{t-1}$ on the right hand side the equation:

$$\Delta r_t = (\alpha_0 - 1)r_{t-1} + \alpha_1 y_t + \alpha_2 s_t + \alpha_3 h_t + \alpha_4 y_{t-1} + \alpha_5 s_{t-1} + \alpha_6 h_{t-1} +$$
$$+ \alpha_1 y_{t-1} + \alpha_2 s_{t-1} + \alpha_3 h_{t-1} - \alpha_1 y_{t-1} - \alpha_2 s_{t-1} - \alpha_3 h_{t-1} =$$
$$= (\alpha_0 - 1)r_{t-1} + \alpha_1 \Delta y_t + \alpha_2 \Delta s_t + \alpha_3 \Delta h_t + (\alpha_1 + \alpha_4)y_{t-1} + (\alpha_2 + \alpha_5)s_{t-1} + (\alpha_3 + \alpha_6)h_{t-1}$$

- Make rearrangements to generate the error-correction term:

$$\Delta r_t = \alpha_1 \Delta y_t + \alpha_2 \Delta s_t + \alpha_3 \Delta h_t + (\alpha_0 - 1)\left[r_{t-1} + \frac{(\alpha_1+\alpha_4)}{(\alpha_0-1)} y_{t-1} + \frac{(\alpha_2+\alpha_5)}{(\alpha_0-1)} s_{t-1} + \frac{(\alpha_3+\alpha_6)}{(\alpha_0-1)} h_{t-1}\right]$$

The latter expression could be estimated using the error-correction model:

$$\Delta r_t = \beta_1 \Delta y_t + \beta_2 \Delta s_t + \beta_3 \Delta h_t + \beta_4 \left[r_{t-1} + \beta_5 y_{t-1} + \beta_6 s_{t-1} + \beta_7 h_{t-1}\right] \quad \text{(A.6)}$$

where $\beta_1/\beta_2/\beta_3$ are short-run elasticities of revenue with respect to output/equity/house prices, $\beta_5/\beta_6/\beta_7$ are long-run elasticities of revenue with respect to output/equity/house prices, and β_4 is the speed of adjustment coefficient. After obtaining estimates of β_1-β_7, one could derive coefficients α_0-α_6 needed to do cyclical adjustment in (A.4) as follows:

$$\alpha_0 = \beta_4 + 1$$
$$\alpha_1 = \beta_1$$
$$\alpha_2 = \beta_2$$
$$\alpha_3 = \beta_3$$
$$\alpha 4 = \beta_5 \beta_4 - \beta_1$$
$$\alpha_5 = \beta_6 \beta_4 - \beta_2$$
$$\alpha_6 = \beta_7 \beta_4 - \beta_3$$

APPENDIX II. Table 1. Dating Economic and Asset Price Cycles

		AUS			BEL			CAN			CHE			DEU		
		GDP	HP	SP	GDP	HP	SP	GDP	HP	SP	GDP	HP	SP	GDP	HP	SP
2000	1					P	T					T				P
2000	2															
2000	3					T	P			P						
2000	4				P								P			
2001	1															
2001	2			P										P		
2001	3															
2001	4				T											
2002	1										P			T		
2002	2															
2002	3													P		
2002	4									T						
2003	1			T			T				T		T			T
2003	2													T		
2003	3															
2003	4															
2004	1		P							P			P			P
2004	2													P		
2004	3									T			T			T
2004	4											P				
2005	1													T		
2005	2											T				
2005	3		T													
2005	4															
2006	1			P						P						P
2006	2															
2006	3			T						T						T
2006	4															
2007	1											P				
2007	2						P						P			
2007	3			P						P						
2007	4															P
2008	1		P									T		P		
2008	2				P											
2008	3							P	P		P				T	
2008	4					P										
2009	1		T	T	T		T			T			T	T		T
2009	2					T		T	T		T					
2009	3														P	
2009	4			P												
2010	1												P		T	
2010	2		P	T												
2010	3															
2010	4					P										
2011	1			P			P			P						
2011	2															P
2011	3			T									T			
2011	4						T									T
2012	1				P											
2012	2									T						

		DNK			ESP			FIN			FRA			GBR		
		GDP	HP	SP	GDP	HP	SP	GDP	HP	SP	GDP	HP	SP	GDP	HP	SP
2000	1						P									
2000	2									P						
2000	3			P									P			P
2000	4															
2001	1															
2001	2															
2001	3	P					T			T						
2001	4								T							
2002	1	T					P			P						
2002	2															
2002	3															
2002	4															
2003	1			T			T			T			T			T
2003	2															
2003	3															
2003	4															
2004	1						P			P						P
2004	2															
2004	3						T			T						T
2004	4															
2005	1															
2005	2															
2005	3															
2005	4															
2006	1			P												
2006	2															
2006	3			T												
2006	4															
2007	1		P													
2007	2												P			P
2007	3			P		P			P							
2007	4						P	P		P		P			P	
2008	1				P						P			P		
2008	2	P														
2008	3															
2008	4															
2009	1			T			T		T	T			T			T
2009	2	T						T			T			T	T	
2009	3		T									T				
2009	4				T		P									
2010	1															
2010	2		P				T								P	
2010	3								P							
2010	4															
2011	1			P			P			P			P			P
2011	2	P			P											
2011	3											P		P		
2011	4			T					T				T			T
2012	1							P								
2012	2	T					T			T				T		

		GRC			IRL			ITA			JPN			KOR		
		GDP	HP	SP	GDP	HP	SP	GDP	HP	SP	GDP	HP	SP	GDP	HP	SP
2000	1												P			
2000	2															
2000	3									P						
2000	4															
2001	1							P			P				T	
2001	2															
2001	3						P	T								T
2001	4															
2002	1										T					
2002	2															P
2002	3							P								
2002	4		P													
2003	1			T			T			T						T
2003	2							T					T			
2003	3														P	
2003	4															
2004	1			P												P
2004	2		T										P			
2004	3			T							P					T
2004	4												T			
2005	1														T	
2005	2															
2005	3															
2005	4															
2006	1			P						P			P			
2006	2															
2006	3			T						T		T	T			
2006	4															
2007	1					P						P			P	
2007	2						P			P			P			
2007	3		P					P			T					
2007	4			P	P											P
2008	1	P							P		P					
2008	2															
2008	3															
2008	4															T
2009	1			T			T			T	T		T			
2009	2	T						T							T	
2009	3			P												
2009	4	P			T					P						
2010	1														P	
2010	2						P									
2010	3									T	P					
2010	4														T	
2011	1									P			P			
2011	2							P			T					P
2011	3						T									
2011	4												T			T
2012	1										P				P	
2012	2			T	P					T						

		NLD			NOR			NZL			SWE			USA		
		GDP	HP	SP	GDP	HP	SP	GDP	HP	SP	GDP	HP	SP	GDP	HP	SP
2000	1												P			
2000	2															
2000	3			P			P									
2000	4								T							
2001	1															
2001	2															
2001	3															
2001	4						T									
2002	1															
2002	2				P	P	P									
2002	3															
2002	4															
2003	1			T		T	T						T			T
2003	2				T											
2003	3															
2003	4															
2004	1			P												P
2004	2															
2004	3			T												T
2004	4															
2005	1															
2005	2															
2005	3															
2005	4															
2006	1															
2006	2															
2006	3															
2006	4														P	
2007	1															
2007	2			P						P			P			
2007	3					P	P		P							P
2007	4				P			P			P	P		P		
2008	1	P														
2008	2															
2008	3															
2008	4		P			T	T									
2009	1			T				T	T	T	T	T	T			T
2009	2	T			T									T		
2009	3															
2009	4								P	P						
2010	1				P											
2010	2															
2010	3				T					T						
2010	4															
2011	1	P		P			P		T			P				
2011	2									P			P			
2011	3						T									
2011	4	T		T						T			T		T	
2012	1															
2012	2	P			P							T				

Source: IMF staff estimates based on Harding and Pagan (2002a).

1/ Estimations are performed for detrended real GDP (GDP), detrended real house price (HP), and detrended real stock price (SP) variables. Detrending was done using the HP filter with smoothing parameter 1600. "P" indicates the quarter in which the series reached its *peak*, while "T" denotes the quarter in which the series reached its *trough*.

APPENDIX II. TABLE 2. ADDITIONAL ROBUSTNESS CHECKS 5/

	Benchmark	With 4-qtr lagged asset price gaps	With banking crisis dummy 1/	with Shiller cyclically adjusted price-to-earning gaps (CAPE) 2/	with 4-qtr smoothed gaps	With dummy for expansion in output and assets 3/	With 4-qtr lagged output gap
Output gap	**0.583*****	0.680***	0.541***	0.651***	0.630***	0.611**	
	[0.090]	[0.107]	[0.078]	[0.126]	[0.113]	[0.232]	
Price to Rent gap (%)	**0.053*****	0.009	0.043***	0.032	0.039**	0.043	0.064***
	[0.014]	[0.013]	[0.014]	[0.020]	[0.014]	[0.046]	[0.016]
Price to Book gap (%)	**0.036*****	0.032***	0.034***		0.040***	0.042**	0.041***
	[0.006]	[0.005]	[0.007]		[0.006]	[0.016]	[0.006]
Output gap*crisis			0.069				
			[0.416]				
Price to rent gap* crisis			0.065				
			[0.047]				
Price-to-book*crisis			0.014				
			[0.032]				
CAPE gap				0.021***			
				[0.006]			
output gap*output expansion						-0.076	
						[0.418]	
Price-to-rent gap*housing expansion						0.02	
						[0.070]	
Price-to-book gap*equity expansion						-0.01	
						[0.022]	
Price-to-rent gap* duration							
Price-to-book gap*duration							
Intercept	**-2.361*****	-2.381***	-2.317***	-1.806***	-2.400***	-2.273***	-2.383***
	[0.012]	[0.015]	[0.096]	[0.076]	[0.017]	[0.488]	[0.022]
Obs.	2082	2014	2082	1757	2031	2082	2034
Countries	18	18	18	18	18	18	18
Adjusted R-squared	0.292	0.253	0.300	0.242	0.295	0.295	
Log likelihood	-5,400	-5,300	-5,400	-4,600	-5,300	-5,400	-5,300

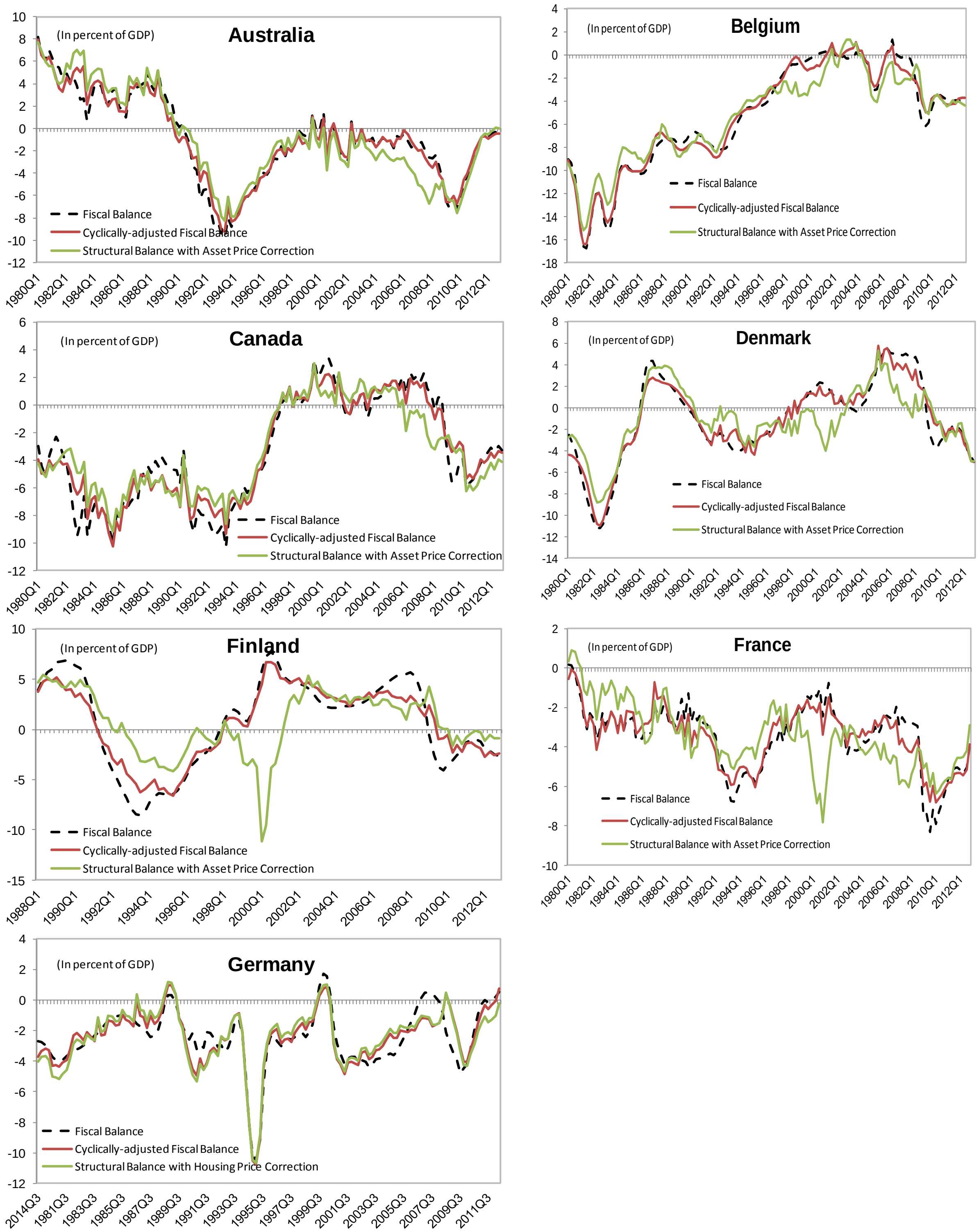
1/Banking crises dummies come from Laeven and Valencia (2012).
2/ The equity cycles are calculated following techniques introduced in Shiller (2000).
3/ Periods are defined as output (asset) expansion if the output (asset price) gaps are positive.
4/ The duration dummy indicates the persistence of the expansion/contraction periods for business and asset cycles.
5/ We also checked if concordance indices help to generate country-varied coefficients on asset price gaps, but results are not significant and not presented here.

APPENDIX II. TABLE 3. ROBUSTNESS CHECKS TO DIFFERENT ASSET PRICE MEASURES

Asset price gaps	Valuation Ratio	HP Filter	Intrinsic Valuation
Output gap	0.583***	0.471***	0.989***
	[0.090]	[0.056]	[0.114]
Housing price gap (%)	0.053***	0.067**	-0.013**
	[0.014]	[0.028]	[0.005]
Equity price gap (%)	0.036***	0.043***	0
	[0.006]	[0.007]	[0.000]
Intercept	-2.361***	-2.231***	-2.198***
	[0.012]	[0.010]	[0.081]
Obs.	2082	2427	1707
Countries	18	20	18
Adjusted R-squared	0.292	0.196	0.162
Log likelihood	-5400	-6,400	-4,500

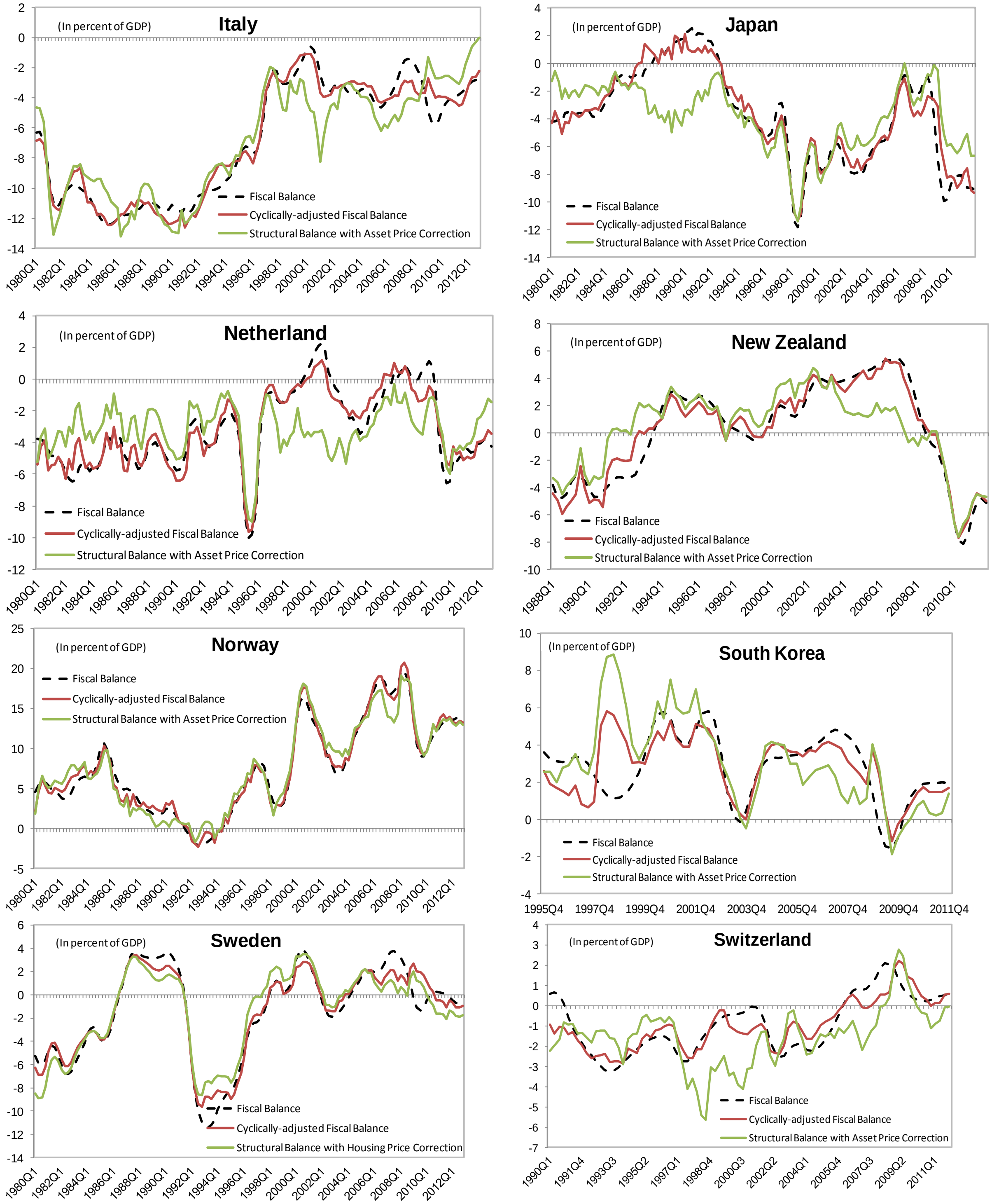
Note: The dependent variable is the overall balance/GDP ratio (in percent). Output gap is estimated using the HP filter (in percent). Estimations are performed using the fixed effects estimator. Robust t-statistics are in parentheses. *, **, and *** denote significance at 10, 5, and 1 percent confidence levels, respectively. All variables are tested for unit root.

APPENDIX II. FIGURE 1. COMPARISON OF SFB ESTIMATES 1/
(in percent of GDP)



APPENDIX II. FIGURE 1. COMPARISON OF SFB ESTIMATES 1/ (CONCL'D)

(in percent of GDP)



1/ IMF staff estimates. Fiscal balance refers to overall fiscal balance for general government. Cyclically-adjusted fiscal balance is the overall balance adjusted for output cycles. Structural balance with asset price correction is the overall balance adjusted for output, housing and equity price cycles. The estimates do not account for one-off items.