BANK OF GREECE
EUROSYSTEM

Working Paper

Asset price volatility and government revenue

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JUNE 2011

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Printed in Athens, Greece
at the Bank of Greece Printing Works.

ISSN 1109-6691

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ABSTRACT

This paper investigates the effect of commercial, residential property and equity price volatility on the variability of cyclically adjusted government revenue. We find significant evidence that asset price volatility increases the variability of government revenue. A 1 percent increase in equity price volatility increases government revenue variability by 0.37-0.44 percent. An increase in residential property price volatility increases revenue volatility by about 0.15-0.22 percent, whereas this effect diminishes to 0.11 percent in case of commercial property price. This evidence reflects the automatic increase of government revenue variability due to asset price movements and supports arguments in favour of adjusting fiscal variables for both business cycle and asset price changes. However, we also find evidence that equity price variability increases revenue variability even when government revenue is adjusted for both economic and asset price cycles, indicating the presence of more complicated dynamics between fiscal variables and asset price changes.

Keywords: Asset prices, government revenue, volatility, cyclical adjustment.

JEL classification: E61, E62, H61, H62, E32

Acknowledgements: I would like to thank Mike Artis, Anindya Banerjee, Heather Gibson, Stephen Hall, George Hondroyiannis, Panagiotis Konstantinou, Eric Maskin and Joel Slemrod for comments received in various stages of the paper. I would also like to thank the Bank for International Settlements for kindly providing the asset price data. The views of the paper are my own and do not necessarily reflect those of the Bank of Greece.

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1. Introduction

The 2008-2009 economic and financial market crises has been accompanied by a significant fall in asset prices, following several years of asset price boom (e.g., house price developments in Ireland, the UK, Spain and the US; IMF, 2009).[1] These developments had significant implications for fiscal balances, due to automatic and discretionary fiscal policy responses. As economic conditions improve the policy focus shifts to correcting fiscal imbalances. In anticipation of the gradual economic recovery asset prices have started to improve (see Bank for International Settlements (BIS), 2009; International Monetary Fund (IMF), 2010a), boosting government revenue and improving fiscal balances. However, given that uncertainty remains high and that the recovery might be more gradual than expected this could have significant effects, in terms of volatility, on asset markets and asset prices, which have a negative feedback effect on government revenue and fiscal balances.[2]

In view of these developments and the events that preceded the 2008-2009 financial crisis several international institutions are assigning a more prominent role on the surveillance asset market developments given their inter-linkages with real economic activity, fiscal developments and financial stability. According to European Commission (2010) it is particularly important to detect asset price booms (e.g., housing bubbles) and excessive credit growth at an early stage to avert costly corrections of fiscal and external imbalances at a later stage. As noted by IMF (2009) early alleviation of tax distortions could have contributed to reducing the impact of factors that have facilitated excessive leveraging and led to high debt levels, paving, thus, the way for the recent financial crisis.

[1] According to IMF (2009) continued favourable treatment of housing in many countries, in pre-crisis years, supported high housing prices, while mortgage interest relief encouraged heavy household leverage, paving the way for the subsequent financial market crisis.

[2] As is pointed out in the 2010 Global Risk report of the World Economic Forum "the risk of an asset price collapse remains the strongest risk which illustrates the continuing uncertainty about the resilience of the global economy and the effectiveness of fiscal and monetary responses, governance and regulation". Moreover, as stated by the G20 Finance Ministers at the June 2010 meeting in the Republic of Korea "the global economy continues to recover faster than anticipated", however, "the recent volatility in financial markets reminds us that significant challenges remain" and that "the recent events highlight the importance of sustainable public finances and the need for countries to put in place credible, growth-friendly measures, to deliver fiscal sustainability".

Similarly, Wolswijk (2010) notes that fiscal instruments may be useful either for preventing or for correcting some housing market disequilibrium. [3]

Despite this recently increased policy interest on the interactions between fiscal policy and asset price movements, there is only limited empirical evidence on the linkages between government finances and asset prices and on whether fiscal policy has been affected by asset prices changes.

A series of earlier contributions investigate the effects that financial market movements and in particular asset price changes have on fiscal balances (e.g., Eschenbanch and Schuknecht, 2002; Jaeger and Schuknecht, 2004; Tujula and Wolswijk, 2004; Morris and Schucknecht, 2007). These were motivated by the asset price booms of the late 1980s and 1990s/2000s and the revenue windfall they generated, which were then deemed by policy makers to be of a structural nature leading to permanent improvement in fiscal positions. However, the subsequent burst of the asset price bubble led to a significant deterioration of fiscal balances, hindering the sustainability of fiscal positions and limiting the budgetary room for maneuver during the downturn of the early 2000s. Therefore, most contributions focus on whether fiscal revenues should be adjusted both for the economic and the asset price cycle. More recently, Tagkalakis (2011a) investigates the links between financial and real estate market movements and fiscal policy outcomes, and finds that asset prices have been a significant determinant of fiscal balances.

Taking on board this increased policy focus on the interactions between asset price developments and fiscal policy outcomes, this paper goes beyond the previous literature by examining whether asset price volatility amplifies the volatility of cyclically adjusted government revenue.[4] Increased revenue volatility could amplify the variability of the

[3] Ireland has recently used tax measures to bolster house prices (removed tax duty on first time buyers and extended mortgage interest relief), the 2003 cuts in dividend taxation and capitals gains tax in the US is estimated to have increased share prices by about 6 percent (IMF, 2009), whereas Korea took measures to curb house price increases in 2005 (national level progressive property tax) and 2007 (progressive capital gains tax).

[4] Ardagna (2009) and Arin et al. (2009) examine the opposite question, i.e., they examine whether large fiscal adjustments and tax policy changes have an effect on financial markets, respectively.

(discretionary) fiscal policy stance, which according to Fatas and Mihov (2003) increases output volatility and harms economic growth.[5]

We find significant evidence that both asset price and output growth volatility increase the variability of government revenue. A 1 percent increase in equity price volatility increases government revenue variability by 0.37-0.44 percent. An increase in residential property price volatility increases revenue volatility by about 0.15-0.22 percent, whereas this effect diminishes to 0.11 percent in case of commercial property prices. This evidence reflects the automatic increase of government revenue variability due to asset price movements and supports arguments in favour of adjusting fiscal variables for both business cycle and asset price changes. However, we also report evidence that equity price variability increases revenue variability even when government revenue is adjusted for both economic and asset price cycles, indicating the presence of more complicated dynamics between fiscal variables and asset price changes. This could reflect discretionary fiscal policy actions to stabilize asset prices and/or economic activity, as well as political economy motives, i.e., in case of asset price booms revenue windfalls might be passed on to consumers and businesses in the form of tax cuts.

Section 2 summarizes the finding of previous studies and discusses the potential channels of interaction between asset prices and fiscal policy. Section 3 presents the methodology and the baseline empirical findings. In Section 4, we investigate the effect of asset price volatility of government revenue, when cyclically adjusted revenues are adjusted for the asset price movements. The last section summarizes the main findings and concludes. Appendix 1 provides some information on property and capital income taxes which are affected directly by asset price (house price and equity) changes. Appendix 2 presents information on the variables and data definitions used.

[5] According to Fatas and Mihov (2003) the volatility of output caused by discretionary fiscal policy lowers economic growth by more than 0.8 percentage points for every percentage point increase in volatility

2. Literature review and potential channels of interaction between asset prices and fiscal policy

As has been discussed by relevant literature (e.g., European Commission, 2009), asset prices (house prices and stock prices) can affect the budget via a series of channels. Directly, they affect specific revenue categories, e.g., capital gains and losses related to direct taxes on households and businesses. [6] Indirectly, they affect revenue via a feedback loop from higher asset prices to real economic activity (higher asset prices raise consumer confidence and consumption, via the wealth effect,) which increases the collection of indirect taxes.

However, the above channels of interaction describe the relationship between the level of asset prices and government revenue. There additional links between asset price and tax revenue volatility. As volatility of asset prices increases so does the variability of the specific revenue base (e.g., stamp duty receipts, capital income taxes) which is directly affected by the specific asset price change (house prices or equity price changes). An increase in revenue volatility increases uncertainty on the achievement of revenue targets, which puts at risk the achievement of the planned fiscal policy stance and pre-specified policy goals such as debt sustainability and demand stabilization.

Uncertainty about the achievement of pre-specified policy goals is likely to bring additional revenue enhancing or expenditure saving measures which can be harmful to economic activity, generating a negative feedback effect on fiscal balances.

In addition, increased asset price volatility and its immediate repercussions on revenue variability could induce governments to act discretionarily and adjust spending and revenue accordingly. If revenues are well above targets, due to revenue windfalls on the back of surging asset prices, then spending could be increased or taxes could be cut if the government believes that the improvement in fiscal balance is well beyond the already set goals. This will have further implications for the volatility of the fiscal policy stance, which, as has been shown by Fatas and Mihov (2003), raises output growth volatility and lowers economic growth.

[6] It is primarily property and capital income taxes that are directly affected by asset price movements (financial and real estate variables). See Appendix 1 for more information on property and capital income taxes in OECD countries.

The aforementioned channels of interaction between revenue and asset price volatility characterize typical non-crisis periods. However, as the recent crisis has shown, in crisis situations, on top of these direct links between asset prices and fiscal policy changes, there are some additional indirect channels of interaction. In case asset price busts lead to defaults of financial institutions, the state will be asked to intervene to preserve the stability of the financial system. The government's intervention to bailout financial institutions affects public finances via several channels. (e.g., as was the case in Ireland)[7]. In case they take the form of budgetary subsidies or expenditures they directly affect the budget deficit. However, if they take the form of financial transactions, e.g., purchase of assets or equity injections they will affect only the debt ratio. In case of guarantees extended to the private sector, the government will be burdened only at the time that the guarantees on loans are called up.

here is an additional indirect channel, i.e., if the asset price bust leads to financial instability and induces a negative feedback loop on economic activity the government might have to undertake expansionary fiscal measures to avert the danger of a full blown economic recession, leading to the deterioration of its budgetary position (European Commission, 2009).

As noted beforehand, some previous studies have focused on the impact of asset price changes on fiscal balances and on whether fiscal balances should be adjusted both for the economic and the asset price cycles. However, none of them examined the effect of asset price volatility on government revenue.

Eschenbanch and Schuknecht (2002) find that a 10% change in stock and real estate prices affects the fiscal balance by on average 0.4% of GDP in most industrialized OECD countries with values ranging from 0.1% to 0.8% of GDP depending on the country. Schuknecht and Eschenbanch (2004), focusing on specific countries (UK and Sweden), conclude that financial instability increases the variability of fiscal balances. Sweden and the UK experienced in the late 1980s-early 1990s a dramatic deterioration in fiscal balances by 9% and 16%, respectively. According to Schuknect and Eschenbanch (2004) 40-50% of this deterioration was due to asset price and financial instability related effects

[7] See IMF (2010b).

on revenues and financial sector bail-out costs. Moreover, the authors report that financial instability led to significant debt ratio increases in six industrialized countries (Sweden, Finland, Japan, France, UK, Switzerland) ranging from 11 to 50% of GDP.[8]

Jaeger and Schuknecht (2004), find that (i) expansions and contractions in economic activity during such boom-bust phases in asset prices tend to be highly persistent, (ii) conventional estimates of tax elasticities are not accurate, leading to a biased assessment of the fiscal stance and the underlying fiscal position in boom-bust phases, (iii) boom-bust phases exacerbate existing pro-cyclical policy biases, and political economy biases toward higher spending and public debt ratios. According to Morris and Schucknecht (2007) asset prices changes are found to be a major factor behind unexplained changes in cyclically adjusted balances. Tujula and Wolswijk (2004) show that asset prices (housing and equity prices) affect budgetary outcomes, but their effect is limited in normal times.

More recently, Tagkalakis (2011a) by estimating fiscal policy reaction functions investigates the links between financial and real estate market movements and fiscal policy outcomes. Tagkalakis (2011a) finds that an increase in asset prices affects in a positive and significant manner primary balances, with the response reflecting both an increase in government revenues and a fall in government spending. The most important impact on fiscal balances is due to changes in residential property prices. Changes in equity and commercial property prices are also important determinants of fiscal balances.[9]

[8] Another class of studies e.g., Honohan and Kliengebiel (2003), Schuknect and Eschenbanch (2004), Reinhart and Rogoff (2008, 2009) and European Commission (2009) discuss in detail the fiscal implications of past financial and banking crises.

[9] Tagkalakis (2011b) investigates the effects of asset price changes on fiscal adjustments. He finds evidence that revenue windfalls due to higher residential, commercial property and equity prices can be sustained, thus, improving revenue and primary balances. Moreover, the same study reports a positive association between residential and commercial property price changes and expenditure based fiscal adjustments

3. Asset price volatility and government revenue

Policy makers and international institutions in the process of fiscal policy making and fiscal surveillance exercises typically cyclically adjust fiscal variables in order to investigate the conduct of the non-automatic or discretionary fiscal policy stance. This exercise is meant to remove the automatic effects of business cycle movements. The remaining part reflects solely discretionary fiscal policy decisions, i.e., changes in the policy instruments at hand in order to achieve certain policy goals (e.g., debt sustainability and demand stabilization).

However, similar automatic effects on fiscal variables arise from asset price movements, which are not a priori captured by the business cycle correction. For example, economic activity might be below trend and GDP growth might even be negative, but at the same time asset prices could be booming reflecting an improved future economic outlook. This will certainly impact on revenue performance and on overall fiscal balances. Cyclically adjusted revenues and cyclically adjusted primary balances (corrected for business cycle movements) will paint a much rosier picture compared to reality. This automatic boost in revenues and the improvement in primary balances driven by asset price movements will be classified as being of a structural nature (a permanent improvement), which however is not the case. Consequently, fiscal policy makers will not have a clear grasp of their fiscal policy tools and will not be able to effectively use their policy instrument to achieve their goals (e.g., debt sustainability and/or demand stabilization).

Therefore, the findings of the paper will show that unaccounted automatic asset price effects will induce greater volatility on government revenues impairing the conduct of fiscal policy making. This implies that government revenues should be adjusted both for the business cycle and asset price movements.

3.1 Methodology

Using annual data for 17 OECD countries for the period 1970 to 2005, we examine whether higher asset price volatility leads to higher volatility of government revenues. Following previous studies, (see, Jaeger and Schuknecht; 2004) our asset price data are

taken from the Bank for International Settlements (see Appendix 2). Given that our analysis involves only 17 countries, we split the sample into seven parts, 1970-74, 1975-79, 1980-84, 1985-89, 1990-94, 1995-1999, 2000-05 and construct volatility (standard deviations) measures and average values for the respective variables and sub-samples. Therefore, our unbalanced panel involves at the maximum 119 observations.[10] The volatility of government revenues is measured by the standard deviation of the change in the log of the cyclically adjusted real government revenues excluding interest receipts. The volatility of the asset price variables is measured as the standard deviation of the change in the log of the cyclically adjusted real asset price series.

In the spirit of Fatas and Mihov (2003) our specification is equation (1) where:

$$Log(\sigma^{fiscal}_{it}) = a*log(\sigma^{fiscal}_{it-1}) + b*log(\sigma^{y}_{it}) + c*log(\sigma^{ap}_{it}) + d*X_{it} + v_i + \lambda_t + \varepsilon_{it} \quad (1)$$

σ^{fiscal}_{it} is the standard deviation of the change in the log of the cyclically adjusted real total government revenue excluding interest receipts. The key explanatory variables are the standard deviation (volatility) of the change in the log of the real aggregate asset prices (σ^{ap}_{it}), we also consider the disaggregated asset price series, i.e., commercial property, residential property and equity prices. We control for the standard deviation of the real GDP growth rate (σ^{y}_{it}), and additional control variables (X_{it}) i.e., the log of trade openness, the log of initial budgetary conditions (debt ratio), the size of the public sector (total expenditure and total revenue to GDP) and monetary conditions (the real short term interest rate), the log of GDP per capita in PPP terms, the log of the GDP deflator based inflation rate. v_i and λ_t stand for unobserved country and time effects, respectively, ε_{it} is the error term. Time effects are used in order to reduce the omitted variable bias from the simple specification used.

If government revenues are not adjusted both for the economic and the asset price cycle, then cyclically adjusted revenues (and cyclically adjusted primary balances) will be affected by asset price movements (Jaeger and Schuknecht, 2004; Morris and

[10] Our modelling choices (the use of annual data and the use of the standard deviations as a proxy of volatility) are dictated by the following reasons. First, because only a few OECD countries publish quarterly (non-interpolated) fiscal policy data. Second, because the Bank for international Settlement (BIS) asset price data are available only for a few countries. Finally, we use standard deviations as proxy of volatility in line with Fatas and Mihov (2003).

Schucknecht, 2007). Hence, asset price volatility should be taken on board when investigating the determinants of the volatility of government revenue. Note that due to the automatic effect that asset price changes have on government revenues the sign of the coefficient of the asset price volatility variable is expected to be positive.

Alternatively, a fiscal policy maker might be asked to respond or take on board asset price movements. For example, this can happen when a fiscal policy maker has to act proactively in order to curb asset price booms, possibly by raising taxes (see IMF, 2009; European Commission, 2010; Wolswijk, 2010).

The literature on fiscal policy rules (Gali and Perotti, 2003; Davig and Leeper, 2010; Tagkalakis, 2011b) implies that cyclically adjusted government revenue, will react to output deviations from trend (or alternatively to GDP growth).[11] Hence, the fiscal policy maker can respond in a counter-cyclical or pro-cyclical manner to output growth movements. This means that the volatility of real GDP growth should be taken on board when examining the determinants of the volatility of cyclically adjusted government revenue.

Turning to the additional control variables used, real GDP per capita is added because as Fatas and Mihov (2003) point out it is possible that poor countries have more volatile business cycles due to less developed financial markets and at the same time resort more often to discretionary policy. The GDP deflator based inflation rate is added in order to ensure that our results are not driven by high inflation episodes in which the co-movement between real government revenue and output might be due to monetary instability rather than fiscal policy actions. In addition, an unexpected increase in inflation rate lowers real government revenues. We control for the average value of the debt ratio in order to take into account initial budgetary conditions. At the same time we control for total revenue and total expenditure to GDP ratios in order to take into account both initial budgetary conditions and the size of the public sector. According to Gali (1994) and Fatas and Mihov (2003) a more sizeable government exerts a stabilizing effect on the economy. Moreover, we include the ratio of imports and exports as a percent to

[11] See Golinelli and Momigliano (2009) for an extensive discussion of the literature on fiscal policy rules and the modelling choices in previous studies.

GDP (trade openness) to control for the fact that the tax revenue base of an open economy is more exposed to international economic conditions, which could affect revenue variability. Alternatively, as Rodrick (1998) and Fatas and Mihov (2003) have shown a higher degree of openness might induce governments to use more actively fiscal policy in order to stabilize their economies. Finally, we include the real short term interest rate (RIRS) to control for monetary conditions.[12]

Several studies examining fiscal policy reaction function, assume that there is persistence in the reaction of fiscal policy instruments, i.e., they typically include in the reaction function a lagged dependent variable, say, the lagged value of the ratio of cyclically adjusted primary balance to GDP or the lagged value of the cyclically adjusted government revenue to GDP (see Candelon et al., 2010; Tagkalakis, 2011a; Golinelli and Momigliano, 2009; Gali and Perotti, 2003). Persistence in the reaction of the policy instrument probably reflects the lengthy parliamentary processes and related sunk decisions, which make the fiscal instrument, react gradually to its target (Claeys, 2006). Hence, in order to take into account that there might be some inherent persistence in the volatility measure of our fiscal policy variable, we included a lagged dependent variable.

The presence of a lagged dependent variable implies that estimating equation (1) with fixed effect OLS and IV estimators render the coefficient estimates inconsistent. We must also take into account the possibility of endogeneity of the volatility of real GDP growth rate and the volatility of asset price variables and the likely endogeneity of GDP per capital and the inflation rate (even if we use five year averages). To this end, the most appropriate estimation technique is to employ a dynamic panel data one-step system GMM estimator (see Blundell and Bond, 1998; Roodman, 2009b), which is also appropriate because of the small time dimension (7) relative to the number of countries (17). In line with Celasun et al. (2006), Gollinelli and Momigliano (2009) and Tagkalakis (2011a) we use a subset of the available instrument matrix, i.e., we use the t-2 to t-3 lags of the volatility of the fiscal policy variable, the volatility of real GDP growth rate, the GDP per capita, the inflation rate, the revenue and expenditure to GDP ratios, the debt

[12] See data appendix for additional information on the variables and data used.

ratio, trade openness, and the real short term interest rate.[13][14] The specific decision on the subset of instruments to be used in each case that will be presented below, takes into account the performance of the Sargan test of overidentifying restrictions and the absence of second order autocorrelation in first difference errors (i.e., that moment conditions are valid).[15]

3.2 Findings

In Tables 1 and 2 we present the findings for the determinants of the volatility of cyclically adjusted government revenue.[16] Columns 1-4 of Table 1 report the findings for aggregate asset prices; columns 5-8 and 9-12 of Table 1 present the finding for commercial and residential property prices, respectively. Columns 1-4 of Table 2 present the findings for equity prices, whereas in columns 5-8 of Table 2 we report the joint effect of the disaggregated asset price series.[17]

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[13] The system GMM estimator is less affected by the weak instrument problem compared to the differenced GMM (Arellano and Bond 1991). See discussion in Celasun and Kang (2006), Hayakawa (2007) and Gollineli and Momigliano (2009). Omitting the more distant lags might not lead to significant loss of information, see Bond (2002) and Roodman (2009a) on the implication of using too many instruments.

[14] When we specify that lagged levels of the left and right hand side variables dated t-a to t-b are used as instruments in the difference equation, then in the level equation we use as instruments the first difference dated at t-a+1 of the left and right hand side variables.

[15] In all specifications, the test on overidentifying restrictions indicates that the hypothesis that instruments are valid cannot be rejected and that there is no higher-order autocorrelation.

[16] In Tables 1 and 2 the dependent variable is the log volatility of the change in the cyclically adjusted real total revenues excluding interest receipts (log volatility of government revenues). Turning to the right-hand-side variables we use the volatility of real GDP growth rate, the log volatility of aggregate asset prices (which is the log volatility of the change in aggregate asset prices), the log volatility of commercial property prices (which is the log volatility of the change in commercial property prices), the log volatility of residential property prices (which is the log volatility of the change in residential property prices), the log volatility of equity prices (which is the log volatility of the change in equity prices), the log of inflation rate (which is the log of GDP Deflator based inflation rate), the log of real GDP per capita, the log of total revenue as a percent of GDP, the log of total expenditure as a percent of GDP, the log of the debt ratio (the debt to GDP ratio), the log of trade openness, and the real short term interest rate (see Appendix 2 for more details on definitions).

[17] In all specifications we control for the volatility of the real GDP growth rate, the inflation rate, the GDP per capita in PPP terms, trade openness and the real short term interest rate. In columns 1, 5, 9 in Tables 1 and 2 we control for total revenue and total expenditure to GDP ratios. In columns 2, 6 and 10 of Table 1 and in columns 2, 6 of Table 2 we control for the total revenue to GDP ratio and the debt ratio. In columns 3, 7 and 11 of Table 1 and columns 3, 7 of Table 2 we control for the total expenditure to GDP ratio and the debt ratio. Finally, in columns 4, 8 and 12 of Table 1 and columns 4, 8 of Table 2 we control for all three fiscal variables (total revenue, total spending and debt to GDP ratios).

The results indicate that higher asset price volatility can lead to higher volatility of the cyclically adjusted revenue. Given that the variables are in logs the coefficient report the elasticity of revenue volatility with respect to the volatility of asset prices. A 1 percent increase aggregate asset price volatility leads to between 0.35 percent to 0.40 percent increase in the volatility of cyclically adjusted government revenue (columns 1-4; Table 1). Interestingly, this effect is more sizeable that the one of output volatility (about 0.30-0.33 percent; see columns 1-4, Table 1).

[Table 1 around here]

This is primarily due to equity price changes and to a lesser extent to residential property prices (see columns 1-4 of Table 2 and columns 9-12 of Table 1), whereas the effect of commercial property prices is much smaller and in most cases insignificant (columns 5-8, Table 1). A 1 percent increase in the volatility of equity prices increases government revenue volatility by about 0.37-0.44 percent (see Columns 1-4; Table 2). An increase in residential property price volatility increases revenue volatility by about 0.15-0.22 percent (columns 9 and 11, Table 1), whereas this effect diminishes to about 0.11 percent in case of commercial property prices (column 5, Table 1).

[Table 2 around here]

As a robustness check we control simultaneously for all asset price variables (columns 5-8; Table 2). The results obtained are qualitatively similar, i.e., equity prices and to a lesser extent residential property prices increase revenue volatility. The fact that equity price and revenue volatility are more closely related could merely reflect that the impact of stock price movements on tax revenues and in particular on corporate and personal income taxation is characterized by more frequent pattern and has more immediate effects compared to house price changes. House prices have more medium term trend and in most cases have no immediate impact on tax revenues. This is due to the fact that, in most countries, their relevance for taxes is limited to incidences of house sales and not to frequent revaluations on balance sheets.[18]

[18] I would like to thank one of the referees for making this point.

Output volatility has a dominant effect on the volatility of cyclically adjusted real government revenue excluding interest receipts compared to asset price volatility when one examines commercial and residential property prices (the effect reaches around 0.37-0.44; see columns 5-12, Table 1). However, when considering equity price volatility, the impact effect of output variability diminishes in size and is weaker than the effect of equity price variability (its coefficient reaches about 0.32-0.33 percent; see columns 1-4, Table 2).[19]

Turning next to the other control variables, we see that higher inflation is associated with more volatile cyclically adjusted government revenues, but the effect is not particularly significant. GDP per capita is not associated in any way with government revenue volatility. In the case of trade openness we get a very significant and positive coefficient estimate. A possible interpretation is that the tax revenue base of an open economy is more exposed to international economic conditions, which could amplify revenue variability.

The coefficient of real short term interest is in most cases insignificant, but when examining equity price changes it is highly significant. Tighter monetary conditions contain demand pressures and lower output, impacting negatively on government revenue. This increases revenue variability if at the same time the fiscal policy maker engages in more activist policy, either by raising taxes to counteract the negative effect of monetary policy or by lowering them in a way to stimulate demand. Hence, tighter monetary conditions can be linked with an activist fiscal policy which involves frequent changes in government revenue.[20] Alternatively, tighter monetary conditions to contain

[19] The lagged dependent variable has a positive effect on revenue variability, but its coefficient estimate is significant only when considering commercial and residential property prices.

[20] Clayes (2006) finds that in some EMU countries (e.g., Austria, the Netherlands) fiscal policy was set as a substitute to monetary policy, i.e., an interest rate hike of 1% lowers primary surpluses by about 0.3% of GDP. Mèlitz, (1997) and Wyplosz (1999) support the view that fiscal and monetary policies are strategic substitutes. On the other hand, Von Hagen et al. (2001) find that the interdependence between the fiscal and monetary policymakers is asymmetric, i.e., looser fiscal stances match monetary contractions, whereas monetary policies broadly accommodate fiscal expansions. Muscatelli et al. (2004) finds that the nature of the interaction between fiscal and monetary policy should depend on the nature of the shocks hitting the system. As Muscatelli et al (2004) point out in "the case of output shocks fiscal and monetary policies tend to act in harmony, whereas they are used as substitutes following inflation shocks or shocks to one policy instrument. Furthermore, the apparent shift to policy complementarity observed in the 1990s is mainly due to the specific configuration of shocks observed in that period."

abrupt asset price movements could increase the variability of cyclically (but not asset price) adjusted revenues.

Turning to the fiscal control variables (debt, revenue and expenditure ratios) the picture that we get is very mixed, with the exception of the government expenditure variable. A high expenditure to GDP ratio is associated with lower revenue variability.[21]

4. Asset price adjusted government revenue

As a next step we correct (even by means of a crude way) for the automatic effect of asset price changes on cyclically adjusted revenues, i.e., we correct for the automatic effect of asset price volatility on the volatility of cyclically adjusted revenues. Hence, any remaining effect from asset price changes on business cycle and asset price adjusted revenues will imply the presence of a "discretionary" or non-automatic effect from asset price volatility on revenue volatility. This will verify the very important role that asset price changes play on revenue performance and consequently on the achievement of fiscal policy goals. Implying that their movements ought to be properly accounted for in order for the fiscal policy maker to improve control on government revenues. This contributes to better fiscal planning, which in turn translates to the achievement of previously set goals (e.g., in terms of debt sustainability and or demand stabilization).

[21] The total revenue to GDP ratio, at times, is associated with lower revenue variability when the expenditure to GDP ratio is not included in the regression (columns 2 and 10 in Table 1 and columns 2 and 6 in Table 2). However, when it is included its effect is positive and, at times, highly significant (see columns 1, 4, 5, 8, 9, and 12 in Table 1 and columns 1, 4, 5, and 8 in Table 2). The total expenditure to GDP ratio has a negative and at times significant coefficient estimate (columns 1, 3, 4, 5, 7, 8, 9, 11 and 12 in Table 1 and columns 1, 3, 4,5 7, 8 in Table 2). A high expenditure to GDP ratio implies the need for secured funding (financing of expenditure), in order to avoid building up fiscal imbalances; this might to contribute to reducing revenue variability. Alternatively, large governments might not engage frequently in activist fiscal policy (changes in cyclically adjusted revenues) because their automatic stabilizers are larger.

The debt ratio has a negative coefficient estimate when either total revenue or total spending to GDP ratios are not included in the regression (columns 2,3, 6, 7, 10, 11 in Table 1 and columns 2,3, 6, and 7 in Table 2), with the effect being significant when expenditure is excluded (columns 2,6 and 10 in Table 1 and columns 2 and 6 in Table 2). When both revenue and expenditure ratios are controlled for, the debt ratio has a positive but highly insignificant effect on revenue variability (columns 4, 8, and 12 in Table 1 and columns 4 and 8 in Table 2).

Therefore, we regress our revenue variable (the change in the log of the cyclically adjusted real government revenue excluding interest receipts) to the contemporaneous and first lagged value of each asset price variable (the change in the log of each asset price variable). The residuals from these regressions are used to construct the new volatility measures (log of standard deviations of each series). These asset price adjusted revenue volatility variables are used as dependent variables in this section. We control both for the contemporaneous and the first lagged value of the asset price data because of timing lags in revenue collection. For example, a pick up in house prices raises the value of one person's wealth and the amount of wealth tax that he or she will have to pay in the following period.

The findings from this exercise are displayed in Tables 3 and 4. The dependent variable used is slightly different in each case. For example, in columns 1-4 of Table 1 we use the revenue variable which has been adjusted for the change in aggregate asset price series. In columns 5-8, 9-12 of Table 3 we use the revenue variable which has been adjusted for changes in commercial and residential property prices, respectively. In columns 1-4 of Table 4 we use the revenue variable which has been adjusted for equity price changes, and in columns 5-8 of Table 4 we use the revenue variable which has been adjusted for changes in commercial, residential property and equity prices (contemporaneous and first lags of each asset price variable).[22]

Interestingly, as is shown in Table 3 (columns 1-4) there is some evidence that aggregate asset price variability leads to higher (asset price adjusted) government revenue variability. This effect captures the so-called "discretionary" or non-automatic effect of asset price volatility on government revenue variability. A 1 percent increase in aggregate asset price volatility increases revenue variability by about 0.17-0.23 percent (columns 1 and 3, Table 3).

[Table 3 around here]

[22] Table 5 in the Data Appendix presents the cross-correlations between these asset prices adjusted revenue variables and the initial revenue variable used in section 3.2. Cross correlation are sizeable and highly significant.

This asset price effect is due to equity price volatility as we can see in Table 4 (columns 1-4 and 7). Commercial and residential property prices have no additional effect on revenue variability. This non-automatic effect of equity price variability on government revenue is highly significant and approaches 0.28-0.39 percent (columns 1-4, Table 2), but diminishes to 0.19-0.26 when all disaggregate asset price series are taken into account and is not particularly significant (see columns 5-8, Table 4; it is marginally significant in column 7).

[Table 4 around here]

This non-automatic or "discretionary" equity price volatility effect on revenue variability could merely reflect the limitations of our crude asset price adjustment exercise. Therefore, in this case it points to the need for adequately correcting government revenue and fiscal balances for both business cycle and asset price changes.

On the other hand, the fact that asset price volatility coincides with more volatile cyclically and asset price adjusted revenue possibly reflects discretionary fiscal policy actions to stabilize asset prices and/or the economic activity. Therefore, it might indicate that fiscal policy makers react or take into account developments in financial and real estate markets, thereby adjusting their policy decisions and instruments to asset price developments (see Tagkalakis, 2011a; Wolswijk, 2010). This would be manifested by a non-automatic or "discretionary" response to asset price movements which would then show up as increased revenue variability.

Alternatively, the fact that asset price volatility coincides with more volatile cyclically and asset price adjusted revenue it could also reflect political economy motives. In case of asset price booms the policy maker might pass on revenue windfalls in the form of tax cuts, whereas in case of asset price busts the policy maker might raise taxes to counterbalance falling revenues.

In addition, this non-automatic effect of equity price variability on government revenue might also highlight the more complicated dynamic effects between asset price movements and fiscal variables, in particular at times of crisis. For example, Engle (2002) has shown that changes in correlations have first order effect on asset price valuation in particular during financial crisis. This could further increase revenue and

fiscal balances variability, putting additional strain on the fiscal policy maker and his or her endeavour to achieve his or here policy goals (e.g., debt sustainability and demand stabilization).[23]

5. Summary and conclusions

This paper investigates the effect of commercial, residential property and equity price volatility on volatility of cyclically adjusted government revenues, controlling for output variability, initial budgetary conditions, government size, openness to trade and monetary conditions. We find significant evidence that aggregate asset price volatility amplifies the volatility of government revenue. It is primarily equity price volatility that increases the variability of government revenue. A 1 percent increase in equity price volatility increases the volatility of cyclically adjusted revenue by about 0.37-0.44 percent. An increase in residential property price volatility increases revenue volatility by about 0.14 percent, whereas this effect diminishes to about 0.11 percent in case of commercial property prices.

There is evidence that equity price variability increases revenue variability even when government revenue is adjusted for both the business cycle and asset price changes. This non-automatic or "discretionary" effect of equity price variability on government revenue is very significant and approaches 0.26-0.39 percent.

Our findings imply that there is need for adequately adjusting government revenue and fiscal balances for both business cycle and asset price movements, because of the automatic effect they exert on several revenue components (see, Jaeger and Schuknecht,2004; Morris and Schucknecht, 2007). This will enable the fiscal policy maker to improve control over his or her policy instrument (the fiscal policy stance or cyclically adjusted primary balances) and will contribute to achieving his or her policy goals (e.g., debt sustainability and or demand stabilization).

[23] The findings for the control variables are qualitatively the same with those reported in the previous section.

However, the fact that there is a significant non-automatic or "discretionary" effect of asset price variability on government revenue highlights the more complicated dynamics between asset price movements and fiscal variables. This could be a reflection either of our crude way for adjusting government revenue for asset price changes or it could imply that there is a possibility that the fiscal policy maker responds discretionary to asset price movements, e.g., as way of correcting some disequilibrium (Wolswijk, 2010). Hence, the fact that asset price volatility coincides with more volatile cyclically and asset price adjusted revenue possibly reflects discretionary fiscal policy actions to stabilize asset prices and/or the economic activity. Alternatively, it could also reflect political economy motives. In case of asset price booms the policy maker might pass on revenue windfalls in the form of tax cuts, whereas in case of asset price busts the policy maker might raise taxes to counterbalance falling revenues.

In any case the dynamics of asset price changes and fiscal balances is an issue that needs to be investigated further. Because, asset price movements amplify the volatility of the discretionary fiscal policy stance, which in turn amplifies business cycle fluctuations and harms economic growth (Fatas and Mihov, 2003).

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Appendix 1: Property and personal capital income taxes

This section draws heavily on information provided by two OECD studies, Johansson et al (2008) and Andre (2010), and summarizes the main features of property and personal capital income taxes in OECD countries. This information is relevant because property and personal capital income taxes are affected by asset price movements (financial and real estate variables).

As documented by Johansson et al. (2008) on average in the OECD the share of property taxes [they include recurrent taxes on immovable property (paid by both households and businesses), taxes on net wealth (paid by both households and corporations), taxes on gifts and inheritance and taxes on financial and capital transactions] as a percentage of GDP has remained approximately constant at around 1.7-1.8% in the period 1975-2005. However, there are some differences, i.e., in France, Ireland, Korea, Luxembourg and Spain the share has increased by more than 2.5 percentage points since 1980, whereas in New Zealand it decreased more than 3 percentage points. Moreover, although property taxes have a low revenue share, they do remain an important source of revenue in some OECD countries, with the United Kingdom, Korea, the United States and Canada obtaining at least 10% of tax revenue from this source in 2005 (Johansson et al., 2008).

OECD averages indicate that recurrent taxes on immovable property – mainly levied at the sub-national level - account for approximately half of total property taxes (about 0.9% of GDP), while taxes on financial and capital transactions account for about half of the rest (about 0.4% of GDP). Recurrent taxes on net wealth are on average a bit more than 0.2% of GDP, whereas estate, inheritance and gift taxes are about 0.1% of GDP. As reported in Johansson et al (2008) there are no strong trends in the revenues from any of these taxes as a share of GDP despite short-term variations) As a percentage of GDP, the recurrent taxes on immovable property have increased by 0.5 percentage points or more only in France, Italy, Portugal, Spain and Sweden and decreased by more than 0.5 percentage points in the United Kingdom. The taxes on financial and capital transactions, in percent of GDP, have increased by more than 0.4 percentage points in

Belgium, Greece, Ireland, the Netherlands, Spain and the United Kingdom while they decreased by more than 0.4 percentage points only in Japan.

A variety of taxes, tax reliefs and subsidies affect the housing sector. These fiscal provisions vary greatly across countries, but generally result in a system which is far from neutral, i.e., there is often a bias in favour of homeownership, which is widely assumed to bring positive externalities (see Andre, 2010).[24] Imputed rental income is not taxed under the income tax (except in Belgium, the Netherlands, Norway and Sweden), however most countries impose property taxes which have a similar effect (Johansson et al. 2008; ECB, 2009). At the same time, mortgage interest payments can be deducted from the personal income tax base in many countries, but not in Canada, Germany, France (they became partly deductible in 2007) and the United Kingdom (tax reliefs on mortgages were abolished in 2000 in the UK). However, some countries, like Belgium and Spain, even allow for a deduction of the principal repayments.

Realised capital gains on owner-occupied houses are often not subject to capital gains tax, though the value of the house is subject to inheritance tax in most countries, except Canada and Sweden. Moreover, some countries levy a high transaction tax on the purchase of houses. This refers to stamp duties, transfer and cadastral taxes, VAT taxes which are levied on housing transactions. These taxes vary widely across countries and usually account for a large share of the acquisition costs. In Ireland, stamp duties have been used to restrain housing demand, with mixed results (OECD, 2006).[25]

Scandinavian countries (Finland, Norway, Sweden and Denmark), have introduced a dual tax system which taxes personal capital income at low and proportional rate while labour income continues to be taxed at high and progressive rates. In practice, a majority

[24] According to Andre (2010) it is questionable whether tax advantages granted to homeowners are effective at achieving their social objectives, i.e., ensuring access to housing at a reasonable cost. "As tax advantages increase demand for housing, they tend to increase the level of house prices, offsetting part of the tax advantage. Moreover, housing-related tax advantages are usually regressive in terms of redistribution and costly for the government budget." Furthermore, advantageous tax treatment of housing may also lead to over-investment in real estate and misallocation of capital, with negative effects on long-term economic growth (see Andre, 2010; ECB, 2009).

[25] And in the present crisis, a number of countries have used tax measures to bolster house prices: Ireland, for example, removed stamp duty on first-time buyers (of relatively inexpensive properties) and extended mortgage interest relief (IMF, 2009).

of OECD countries may be characterized as having 'semi-dual' income tax systems, which are defined as tax systems that use different nominal tax rates on different types of income, typically by taxing some forms of capital income at low and often flat rates and remaining forms of income at higher and progressive rates (e.g., Netherlands introduced such a system in 2001).

The rate of taxation on dividends combines features of both the personal and corporate tax systems. Many European countries have moved away from full imputation systems to systems where dividends are taxed at a lower rate at the personal level. Germany introduced the so-called half-income system in 2002, whereby 50% of dividends are taxed as personal income (but it was abolished as part of the 2008 tax reform). Several other countries have introduced or are introducing similar partial inclusion systems where some proportion of dividends are taxed as personal income, e.g., Finland, France, Italy, and Portugal. On average, the top marginal tax rate on dividends in OECD countries was reduced by more than 7 percentage points between 2000 and 2007 to 43%. The largest part of this reduction is attributable to the reduction in the corporate income tax rate.[26] Since 2000, the top marginal tax rate on dividends has increased only in Finland and Norway (as a result of the introduction of the partial inclusion system in Finland and the allowance for shareholder equity tax system in Norway) and in Korea.

Appendix 2: Data information

We used a yearly unbalanced panel data set (1970-2005) of 17 Organization for Economic Cooperation and Development (OECD) economies: Australia, Belgium, Canada, Germany, Denmark, Spain, Finland, France, United Kingdom, Ireland, Italy, Japan, Netherlands, Norway, New Zealand, Sweden, and United States. Given that our

[26] The part of the tax that is paid as corporate income tax has decreased by more than 5 percentage points to 27.6% on average in the OECD. A smaller part of the reduction in the statutory tax burden on dividends is due to the decrease in personal income tax rates. The reduction of the effective tax rate was 10.8 percentage points in the United States, due to the recent introduction of a reduced tax rate on dividends at the personal level.

analysis involves only 17 countries, we split the sample into seven parts, 1970-74, 1975-79, 1980-84, 1985-89, 1990-94, 1995-1999, 2000-05 and construct volatility (standard deviations) measures and average values for the respective variables and sub-samples. Therefore, our unbalanced panel involves at the maximum 119 observations.

The macroeconomic variables used extend from 1970 to 2005. Fiscal and output variables are from the Organization for Economic Cooperation and Development (OECD) Economic Outlook (2008), the definitions used are: log of the volatility (standard deviation) of real GDP growth rate, the log of the GDP Deflator based inflation rate, log of the total revenue to GDP ratio, the log of the total expenditure to GDP ratio, the log of the debt to GDP ratio, the log of trade openness, with trade openness defined as export plus imports over GDP, the real short term interest (which is nominal short term interest date minus the change in the log of the GDP deflator), the log of the volatility (standard deviation) of the change in log of the cyclically adjusted real total government revenue excluding interest receipts (it has been deflated by using the GDP deflator). We use also the log of real GDP per capita. Real GDP per capita on purchasing power parity basis is taken from Penn World Tables 6.3 (Heston et al., 2009)

The main asset price indicator is the change in log of the annual aggregate real asset prices which covers 1970-2005 for 17 industrial countries and combines price indices for three asset classes - equities, residential property and commercial property – by weighting the components using shares of the asset classes in private sector wealth. The private consumption deflator is used to convert nominal to real asset prices. In addition, we considered also the change in log of the three disaggregate asset price indices, i.e., real commercial prices, real residential prices and real equity prices. Using these asset price data we construct their volatility measures (standard deviations) and then use in the analysis the logs of the volatilities.

As stated in section 4 we regress our revenue variable (the change in the log of the cyclically adjusted real total government revenue excluding interest receipts) to the contemporaneous and first lagged value of each asset price variable (the change in the log of each asset price variable). The residuals from these regressions are used to construct the new volatility measures (log of standard deviations of each series). These asset price

adjusted revenue volatility variables are used as dependent variables in section 4. These are: the log of the volatility of the change in the cyclically adjusted real government revenues excluding interest receipts adjusted for aggregate asset prices, the log of the volatility of the change in the cyclically adjusted real total revenues excluding interest receipts adjusted for commercial property prices, the log of the volatility of the change in the cyclically adjusted real total revenues excluding interest receipts adjusted for residential property prices, the log of the volatility of the change in the cyclically adjusted real total revenues excluding interest receipts adjusted for equity prices, the log of the volatility of the change in the cyclically adjusted real total revenues excluding interest receipts adjusted for all disaggregated asset prices. Table 5 presents cross-correlations between these cyclically and asset price adjusted real government revenues. Table 6 presents descriptive statistics of the variables used in the analysis.

[Tables 5 and 6 around here]

Table 1: Government revenue and asset price volatility

Dependent variable: Log volatility of government revenues	1	2	3	4	5	6	7	8	9	10	11	12
Log volatility of government revenues (t-1)	0.017 (0.18)	0.125 (1.39)	0.102 (1.32)	0.076 (0.94)	0.119 (1.10)	0.191 (1.79)*	0.184 (2.09)**	0.132 (1.58)	0.071 (0.77)	0.169 (1.81)*	0.157 (1.97)**	0.113 (1.42)
Log volatility of real GDP growth rate	0.302 (2.58)**	0.332 (3.00)***	0.315 (2.87)***	0.312 (2.87)***	0.372 (2.76)***	0.406 (2.81)***	0.419 (4.17)***	0.404 (4.07)***	0.440 (3.91)***	0.439 (3.74)***	0.439 (4.12)***	0.420 (4.12)***
Log volatility of aggregate asset prices	0.402 (3.91)***	0.364 (4.09)***	0.377 (4.46)***	0.347 (3.44)***								
Log volatility of commercial property prices					0.107 (1.67)*	0.075 (1.44)	0.016 (0.41)	-0.008 (-0.24)				
Log volatility of residential property prices									0.199 (1.97)**	0.144 (1.61)	0.148 (1.65)*	0.096 (1.11)
Log volatility of equity prices												
Log of inflation rate	0.118 (1.27)	0.060 (0.63)	0.064 (0.74)	0.069 (0.90)	0.105 (1.11)	0.018 (0.18)	0.086 (0.93)	0.100 (1.27)	0.120 (1.43)	0.048 (0.57)	0.046 (0.57)	0.069 (0.96)
Log of real GDP per capita	0.165 (0.69)	0.186 (0.73)	0.109 (0.51)	0.033 (0.23)	0.188 (0.91)	0.237 (0.96)	0.130 (0.46)	-0.011 (-0.08)	0.246 (0.87)	0.313 (0.98)	0.273 (0.87)	0.112 (0.57)
Log of total revenue as a percent of GDP	0.603 (1.26)	-0.626 (-2.28)**		1.121 (1.129)	1.333 (2.48)**	0.102 (0.47)		1.958 (2.42)**	0.707 (1.08)	-0.126 (-0.53)		1.667 (2.11)**

Table 1: continued

Dependent variable: Log volatility of government revenues	1	2	3	4	5	6	7	8	9	10	11	12
Log of total expenditure as a percent of GDP	-1.369 (-2.65)***		-0.924 (-3.04)***	-2.060 (-2.15)**	-1.367 (-2.32)**		-0.321 (-1.21)	-2.367 (-2.47)**	-0.981 (-1.45)		-0.378 (-1.46)	-2.118 (-2.29)**
Log of the debt ratio		-0.176 (-2.70)***	-0.087 (-1.11)	0.018 (0.14)		-0.227 (-2.64)***	-0.162 (-1.56)	0.023 (0.19)		-0.181 (-1.95)*	-0.147 (-1.45)	0.013 (0.11)
Log of trade openness	0.182 (1.68)*	0.218 (2.41)**	0.257 (3.19)***	0.235 (2.97)***	0.040 (0.40)	0.115 (1.13)	0.186 (1.96)*	0.161 (1.78)*	0.077 (0.79)	0.125 (1.33)	0.168 (1.84)*	0.152 (1.72)*
Real short term interest rate	1.436 (0.53)	0.259 (0.10)	1.450 (0.60)	2.489 (0.94)	2.426 (0.62)	-0.931 (-0.25)	1.532 (0.59)	3.082 (1.19)	-0.261 (-0.10)	-0.855 (-0.30)	-0.145 (-0.06)	2.097 (0.90)
No of Obs	85	76	76	76	78	73	73	73	85	76	76	76
Residual's 2nd order AR (p-values)	0.316	0.346	0.440	0.437	0.128	0.092	0.056	0.121	0.065	0.063	0.059	0.085
Sargan test of overidentifying restrictions (p-values)[a]	0.260	0.278	0.378	0.583	0.115	0.071	0.253	0.494	0.192	0.160	0.262	0.497
Wald (p-values)	Wald chi2(13): 141.26 (0.000)	Wald chi2(13): 321.44 (0.000)	Wald chi2(13): 245.50 (0.000)	Wald chi2(14): 647.19 (0.000)	Wald chi2(13): 753.68 (0.000)	Wald chi2(13): 1518.83 (0.000)	Wald chi2(13): 922.96 (0.000)	Wald chi2(14): 4914.07 (0.000)	Wald chi2(13): 633.27 (0.000)	Wald chi2(13): 1228.88 (0.000)	Wald chi2(13): 4377.15 (0.000)	Wald chi2(14): 4728.42 (0.000)

Notes: Dependent variable: log volatility of the change in the cyclically adjusted real total revenues excluding interest receipts, Estimator: One step system GMM, see Blundell and Bond (1998) and Roodman (2009b. In parenthesis t-statistics; . *,**, *** significant at the 10%, 5%, 1% level, respectively. Time dummy variables are included. Sargan test of overid. restrictions: [a] Not robust, but not weakened by many instruments (see Roodman, 2009a).). The instruments used in the first differences equation are the t-2 to t-3 lags of the right hand side variables used in each specification, i.e. the GDP growth rate, the asset price variables, the inflation rate, the GDP per capital, the revenue to GDP ratio, the expenditure to GDP ratio, the debt ratio, trade openness and the real short term interest rate. When we specify that lagged levels of the left and right hand side variables dated t-2 to t-3 are used as instruments in the difference equation then in the level equation we use as instruments the first difference dated at t-1 of the left and right hand side variables. In specifications 5 and 6 we have used as instruments the t-3 and t-4 lags in order to deal with autocorrelation problems. In specification 10 in order to deal with autocorrelation issues we use the t-3 and t-4 lags of the dependent variable and the GDP growth rate, for all other variables we use the t-2 and t-3 lags.

Table 2: Government revenue and asset price volatility

Dependent variable: Log volatility of government revenues	1	2	3	4	5	6	7	8
Log volatility of government revenues (t-1)	-0.034	0.105	0.061	0.020	-0.038	0.089	0.051	0.018
	(-0.28)	(0.93)	(0.63)	(0.21)	(-0.27)	(0.78)	(0.48)	(0.18)
Log volatility of real GDP growth rate	0.331	0.332	0.328	0.316	0.299	0.370	0.344	0.332
	(3.08)***	(2.86)***	(3.31)***	(3.28)***	(1.99)**	(3.16)***	(3.08)***	(3.19)***
Log volatility of aggregate asset prices								
Log volatility of commercial property prices					0.047	-0.038	-0.045	-0.061
					(0.84)	(-0.70)	(-0.85)	(-1.36)
Log volatility of residential property prices					0.113	0.144	0.132	0.083
					(1.36)	(1.86)*	(1.85)*	(1.05)
Log volatility of equity prices	0.437	0.366	0.419	0.397	0.445	0.366	0.432	0 .416
	(3.60)***	(3.12)***	(3.87)***	(3.43)***	(3.06)***	(2.68)***	(3.60)***	(3.23)***
Log of inflation rate	0.172	0.111	0.109	0.114	0.059	0.067	0.082	0.108
	(1.85)*	(1.20)	(1.31)	(1.65)*	(0.76)	(0.74)	(0.99)	(1.28)
Log of real GDP per capita	0.212	0.286	0.209	0.087	0.389	0.399	0.323	0.164
	(0.77)	(0.93)	(0.76)	(0.48)	(1.35)	(1.17)	(1.07)	(0.73)
Log of total revenue as a percent of GDP	0.805	-0.520		1.678	1.007	-0.589		1.565
	(1.51)	(-1.79)*		(2.18)**	(1.67)*	(-1.93)*		(1.94)*
Log of total expenditure as a percent of GDP	-1.582		-0.961	-2.697	-1.816		-0.998	-2.595
	(-2.77)***		(-3.11)***	(-3.00)***	(-2.99)***		(-3.38)***	(-2.95)***
Log of the debt ratio		-0.164	-0.076	0.085		-0.172	-0.075	0.065
		(-1.84)*	(-0.80)	(0.69)		(-1.90)*	(-0.77)	(0.55)
Log of trade openness	0.147	0.174	0.231	0.205	0.140	0.163	0.217	0.202
	(1.22)	(1.59)	(2.12)**	(2.00)**	(1.24)	(1.69)*	(2.14)**	(2.08)**
Real short term interest rate	4.506	2.964	4.717	6.062	3.521	0.783	2.730	4.548
	(1.68)*	(1.12)	(1.89)*	(2.42)**	(0.84)	(0.30)	(1.09)	(1.73)*
No of Obs	85	76	76	76	78	73	73	73
Residual's 2nd order AR (p-values)	0.067	0.073	0.068	0.105	0.075	0.063	0.114	0.167
Sargan test of overidentifying restrictions (p-values)[a]	0.248	0.114	0.223	0.497	0.179	0.261	0.313	0.525
Wald (p-values)	Wald chi2(13): 2753.97 (0.000)	Wald chi2(13): 431.14 (0.000)	Wald chi2(13): 607.29 (0.000)	Wald chi2(14): 12856.66 (0.000)	Wald chi2(15): 1799.15 (0.000)	Wald chi2(15): 18612.97 (0.000)	Wald chi2(15): 95085.41 (0.000)	Wald chi2(16): 2287.84 (0.000)

Notes: Dependent variable: log volatility of the change in the cyclically adjusted real total revenues excluding interest receipts, Estimator: One step system GMM, see Blundell and Bond (1998) and Roodman (2009b. In parenthesis t-statistics; . *,**, *** significant at the 10%, 5%, 1% level, respectively Time dummy variables are included. Sargan test of overid. restrictions: [a] Not robust, but not weakened by many instruments (see Roodman, 2009a).). The instruments used in the first differences equation are the t-2 to t-3 lags of the right hand side variables used in each specification, i.e. the GDP growth rate, the asset price variables, the inflation rate, the GDP per capita, the revenue to GDP ratio, the expenditure to GDP ratio, the debt ratio, trade openness and the real short term interest rate. When we specify that lagged levels of the left and right hand side variables dated t-2 to t-3 are used as instruments in the difference equation then in the level equation we use as instruments the first difference dated at t-1 of the left and right hand side variables. In specification 2 in order to deal with autocorrelation issues we use the t-3 and t-4 lags of the dependent variable and the GDP growth rate, for all other variables we use the t-2 and t-3 lags. In specification 5 we have used as instruments the t-3 and t-4 lags of the variables in order to deal with autocorrelation problems.

Table 3: Robustness –Government revenue and asset price volatility – asset price adjusted revenue

Dependent variable: Log volatility of government revenues adjusted for	1	2	3	4	5	6	7	8	9	10	11	12
	Aggregate asset prices				Commercial property prices				Residential property prices			
Log volatility of government revenues adjusted for asset prices (t-1)	0.009 (0.13)	0.098 (1.57)	0.080 (1.41)	0.047 (0.89)	0.032 (0.44)	0.139 (1.69)*	0.133 (1.84)*	0.063 (0.91)	0.031 (0.92)	0.052 (1.33)	0.045 (0.67)	0.008 (0.13)
Log volatility of real GDP growth rate	0.401 (2.73)***	0.456 (3.61)***	0.433 (3.40)***	0.427 (3.43)***	0.429 (3.21)***	0.485 (3.62)***	0.480 (3.65)***	0.448 (3.38)***	0.428 (3.40)***	0.464 (3.90)***	0.432 (3.55)***	0.407 (3.55)***
Log volatility of aggregate asset prices	0.232 (1.95)*	0.140 (1.32)	0.177 (1.91)*	0.120 (1.07)								
Log volatility of commercial property prices					0.007 (0.14)	-0.021 (-0.46)	-0.015 (-0.33)	-0.024 (-0.56)				
Log volatility of residential property prices									0.041 (0.26)	-0.021 (-0.15)	-0.054 (-0.38)	-0.119 (-0.82)
Log volatility of equity prices												
Log of inflation rate	0.135 (1.10)	0.065 (0.50)	0.064 (0.52)	0.069 (0.62)	0.155 (1.37)	0.124 (1.01)	0.128 (1.07)	0.115 (1.07)	0.183 (1.61)	0.099 (0.80)	0.100 (0.79)	0.124 (1.00)
Log of real GDP per capita	0.007 (0.03)	0.112 (0.37)	0.047 (0.16)	-0.099 (-0.74)	0.176 (0.67)	0.187 (0.73)	0.154 (0.59)	-0.032 (-0.21)	-0.098 (-0.30)	-0.022 (-0.06)	-0.027 (-0.07)	-0.234 (-0.91)
Log of total revenue as a percent of GDP	0.991 (1.41)	-0.169 (-0.57)		2.133 (2.20)**	1.663 (2.83)***	-0.069 (-0.30)		2.210 (2.79)***	0.706 (0.92)	-0.083 (-0.36)	-0.413 (-1.45)	2.050 (2.47)**

Table 3: continued

Log of total expenditure as a percent of GDP	-1.504 (-1.96)**		-0.569 (-1.94)*	-2.730 (-2.57)**	-1.846 (-2.85)***		-0.377 (-1.46)	-2.652 (2.95)***	-1.027 (-1.22)			-2.561 (-2.60)**
Log of the debt ratio		-0.204 (-1.95)*	-0.148 (-1.34)	0.052 (0.36)		-0.204 (-2.05)**	-0.166 (-1.48)	0.036 (0.29)		-0.216 (-2.13)**	-0.185 (-1.66)	0.013 (0.11)
Log of trade openness	0.148 (1.25)	0.159 (1.51)	0.226 (2.42)**	0.186 (2.02)**	0.033 (0.29)	0.097 (0.84)	0.146 (1.36)	0.122 (1.16)	0.102 (1.03)	0.151 (1.46)	0.227 (2.22)**	0.211 (2.10)**
Real short term interest rate	1.109 (0.48)	-0.164 (-0.06)	0.856 (0.37)	2.704 (1.17)	3.315 (1.16)	1.216 (0.49)	2.319 (1.00)	3.376 (1.29)	1.115 (0.43)	0.029 (0.01)	2.646 (0.80)	5.302 (1.83)*
No of Obs	85	76	76	76	73	70	70	70	85	76	76	76
Residual's 2nd order AR (p-values)	0.124	0.081	0.132	0.243	0.283	0.213	0.244	0.321	0.095	0.065	0.117	0.180
Sargan test of overidentifying restrictions (p-values)[a]	0.068	0.080	0.099	0.250	0.188	0.277	0.300	0.524	0.160	0.235	0.083	0.258
Wald (p-values)	Wald chi2(13): 406.86 (0.000)	Wald chi2(13): 157.16 (0.000)	Wald chi2(13): 79.58 (0.000)	Wald chi2(14): 730.14 (0.000)	Wald chi2(13): 1388.34 (0.000)	Wald chi2(13): 806.32 (0.000)	Wald chi2(13): 765.52 (0.000)	Wald chi2(14): 4827.20 (0.000)	Wald chi2(13): 2497.81 (0.000)	Wald chi2(13): 7766.45 (0.000)	Wald chi2(13): 669.40 (0.000)	Wald chi2(14): 7195.46 (0.000)

Notes: Estimator: One step system GMM, see Blundell and Bond (1998) and Roodman (2009b. In parenthesis t-statistics; . *,**, *** significant at the 10%, 5%, 1% level, respectively Time dummy variables are included. Sargan test of overid. restrictions: [a] Not robust, but not weakened by many instruments (see Roodman, 2009a).). The instruments used in the first differences equation are the t-2 to t-3 lags of the right hand side variables used in each specification, i.e. the GDP growth rate, the asset price variables, the inflation rate, the GDP per captita, the revenue to GDP ratio, the expenditure to GDP ratio, the debt ratio, trade openness and the real short term interest rate. When we specify that lagged levels of the left and right hand side variables dated t-2 to t-3 are used as instruments in the difference equation then in the level equation we use as instruments the first difference dated at t-1 of the left and right hand side variables. In specifications 9 and 10 we have used as instruments the t-1 to t-3 lags of the variables to ensure no autocorrelation and that the overidentifying restrictions are valid.

Table 4: Robustness –Government revenue and asset price volatility – asset price adjusted revenue

Dependent variable: Log volatility of government revenues adjusted for	1	2	3	4	5	6	7	8
	Equity prices				Commercial, residential property and equity prices			
Log volatility of government revenues adjusted for asset prices (t-1)	-0.011	0.070	0.035	-0.014	0.066	0.121	0.096	0.064
	(-0.13)	(0.86)	(0.48)	(-0.18)	(0.75)	(1.26)	(1.09)	(0.77)
Log volatility of real GDP growth rate	0.373	0.420	0.387	0.372	0.422	0.484	0.466	0.444
	(2.86)***	(3.39)***	(3.14)***	(3.08)***	(2.84)***	(3.41)***	(3.29)***	(3.31)***
Log volatility of aggregate asset prices								
Log volatility of commercial property prices					-0.065	-0.083	-0.088	-0.093
					(-0.88)	(-1.18)	(-1.21)	(-1.36)
Log volatility of residential property prices					0.005	-0.004	-0.007	-0.067
					(0.04)	(-0.03)	(-0.05)	(-0.53)
Log volatility of equity prices	0.394	0.285	0.362	0.335	0.244	0.191	0.258	0.225
	(2.69)***	(2.01)**	(2.82)***	(2.46)***	(1.50)	(1.12)	(1.65)*	(1.35)
Log of inflation rate	0.193	0.101	0.106	0.107	0.158	0.106	0.114	0.120
	(1.81)*	(1.00)	(1.13)	(1.31)	(1.06)	(0.71)	(0.75)	(0.78)
Log of real GDP per capita	0.157	0.215	0.143	-0.013	0.142	0.129	0.098	-0.116
	(0.55)	(0.68)	(0.48)	(-0.07)	(0.39)	(0.33)	(0.27)	(-0.41)
Log of total revenue as a percent of GDP	0.837	-0.418		2.052	1.231	-0.171		1.915
	(1.25)	(-1.25)		(2.40)**	(1.45)	(-0.50)		(1.94)*
Log of total expenditure as a percent of GDP	-1.559		-0.913	-3.035	-1.609		-0.551	-2.456
	(-2.14)**		(-2.93)***	(-3.12)***	(-1.78)*		(-1.46)	(-2.20)**
Log of the debt ratio		-0.207	-0.116	0.0805		-0.236	-0.179	-0.009
		(-2.25)**	(-1.16)	(0.59)		(-2.21)**	(-1.51)	(-0.06)
Log of trade openness	0.126	0.169	0.238	0.208	0.128	0.194	0.246	0.231
	(1.06)	(1.63)	(2.39)**	(2.19)**	(0.90)	(1.59)	(1.93)*	(1.89)*
Real short term interest rate	3.668	1.879	3.729	5.396	1.433	-1.138	0.569	2.132
	(1.38)	(0.71)	(1.42)	(1.91)*	(0.31)	(-0.25)	(0.13)	(0.44)
No of Obs	85	76	76	76	73	70	70	70
Residual's 2nd order AR (p-values)	0.295	0.163	0.262	0.369	0.780	0.932	0.981	0.891
Sargan test of overidentifying restrictions (p-values)[a]	0.171	0.155	0.217	0.515	0.154	0.244	0.269	0.450
Wald (p-values)	Wald chi2(13): 1228.46 (0.000)	Wald chi2(13): 278.98 (0.000)	Wald chi2(13): 423.01 (0.000)	Wald chi2(14): 2302.91 (0.000)	Wald chi2(15): 12359.69 (0.000)	Wald chi2(15): 4399.83 (0.000)	Wald chi2(15): 8442.80 (0.000)	Wald chi2(16): 1036.04 (0.000)

Notes: Estimator: One step system GMM, see Blundell and Bond (1998) and Roodman (2009b. In parenthesis t-statistics; . *,**, *** significant at the 10%, 5%, 1% level, respectively Time dummy variables are included. Sargan test of overid. restrictions: [a] Not robust, but not weakened by many instruments (see Roodman, 2009a).). The instruments used in the first differences equation are the t-2 to t-3 lags of the right hand side variables used in each specification, i.e. the GDP growth rate, the asset price variables, the inflation rate, the GDP per captita, the revenue to GDP ratio, the expenditure to GDP ratio, the debt ratio, trade openness and the real short term interest rate. When we specify that lagged levels of the left and right hand side variables dated t-2 to t-3 are used as instruments in the difference equation then in the level equation we use as instruments the first difference dated at t-1 of the left and right hand side variables.

Table 5: Cross correlations cyclically and asset price adjusted real revenues excluding interest receipts

		Change in the log of the cyclically adjusted real revenues excluding interest receipts	Change in the log of the cyclically adjusted real revenues excluding interest receipts adjusted for			
			Real aggregate asset prices	Real commercial property prices	Real residential property prices	Real equity prices
Change in the log of the cyclically adjusted real revenues excluding interest receipts adjusted for	Real aggregate asset prices	0.9446				
	Real commercial property prices	0.9968	0.9511			
	Real residential property prices	0.9318	0.9544	0.9409		
	Real equity prices	0.9897	0.9672	0.9885	0.9317	
	All disaggregated asset price series	0.8835	0.9291	0.8866	0.9434	0.9046

Table 6: Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
Volatility of the change in the cyclically adjusted real total revenues excluding interest receipts	0.0246885	0.0134682	0.0042621	0.0823782
Volatility of the change in the cyclically adjusted real total revenues excluding interest receipts –adjusted for aggregate asset prices	0.0256574	0.0177169	0.0005486	0.1358563
Volatility of the change in the cyclically adjusted real total revenues excluding interest receipts –adjusted for commercial property prices	0.0250238	0.0168437	0.0047681	0.1334938
Volatility of the change in the cyclically adjusted real total revenues excluding interest receipts –adjusted for residential property prices	0.0255893	0.0183597	0.00025	0.137397
Volatility of the change in the cyclically adjusted real total revenues excluding interest receipts –adjusted for equity prices	0.0253703	0.0168682	0.002745	0.1362708
Volatility of the change in the cyclically adjusted real total revenues excluding interest receipts –adjusted for all disaggregated asset prices	0.026387	0.0190707	0.0005076	0.1420707
Volatility of real GDP growth rate	0.0167624	0.0103455	0.0020652	0.072358
Volatility of the change in aggregate asset prices	0.0727446	0.0521317	0.0126539	0.4136274
Volatility of the change in commercial property prices	0.0893225	0.0636323	0.0090388	0.2749362
Volatility of the change in residential property prices	0.0515111	0.0341385	0.0058232	0.1781621
Volatility of the change in equity prices	0.1787429	0.0807626	0.0380551	0.4125231
GDP Deflator based inflation rate	0.056313	0.0402472	-.0143337	0.1723589
Log of real GDP per capita	9.984032	0.263525	9.300882	10.67124
Total revenue as a percent of GDP	43.14245	8.866496	23.52239	62.84491
Total expenditure as a percent of GDP	45.24316	8.82949	23.00287	67.56052
Debt to GDP ratio	58.47959	27.85701	10.84575	156.1297
Trade openness	61.57217	32.45733	12.87605	164.3953
Real short term interest rate	0.0317416	0.0299925	-0.03699	0.1106879

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