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Appraising fiscal reaction functions

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Appraising fiscal reaction functions[*]

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Abstract: We estimate fiscal responses for an OECD panel, accounting for cross-country interactions, and also estimate the fiscal responses in a panel VAR. We find that governments have increased primary balances when facing higher government indebtedness, implying a Ricardian fiscal regime, while primary balances have improved to reduce government debt. These results hold for the single regression panel analysis and for the panel VAR.

JEL: C23, E62, H62
Keywords: fiscal regimes, Panel VAR, cross-sectional dependence

1. Introduction

In the aftermath of the 2008-2009 economic and financial crisis and in the context of important restrictions to the implementation of fiscal policies, notably in the European Union (EU), with the need for fiscal consolidation ever so present, the appraisal of how fiscal authorities adjust their reactions is quite important. For instance, it is useful to assess whether the track record as been on of more active (less Ricardian) or more passive fiscal developments in OECD economies, which can hint at the future expected reaction from the fiscal authorities.

The existing literature has estimated fiscal policy response functions notably in a cross-country analysis setup. In this context, where the underlying economic rationale is that governments care about fiscal sustainability issues, it is possible to envisage a simple fiscal reaction function with the primary balance improving to counteract past increases in government debt.

Several studies have addressed this question via single country analysis (Bohn, 2008) and panel analysis, although a VAR approach has also been used (see Canzoneri et al., 2001). For instance, Ballabriga and Martinez-Mongay (2005) mention that primary balances increase as

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response to higher government indebtedness in the EU. Afonso (2008), for an EU panel, reports evidence of a passive fiscal regime, and a counter-cyclical response of fiscal policy, with the primary balance improving with increases in the output gap.[1] On the other hand, the existence of possible cross-section dependences, notably given the economic and financial linkages in OECD countries, capital markets integration and spillover effects, common monetary policy for the Euro area countries, has been scarcely addressed in this framework.

Therefore, in our paper we estimate fiscal responses for the period 1970-2010, for OECD countries. Our contributions include: i) considering the cross-country interactions that occur inside the country panel, due to possible common factors; ii) estimating primary balances and a debt responses together in a panel VAR to provide additional robustness to the results.

In a nutshell, we find that governments have, on average, increased primary balances as a response to higher previous government indebtedness, implying that a Ricardian fiscal regime cannot be discarded. Moreover, results also show that better primary balances have been used to reduce the level of outstanding government debt in the subsequent periods. These results hold both for the single regression panel analysis and for the panel VAR.

The structure of the paper is as follows. Section 2 presents the methodology. Section 3 reports and discusses the empirical results. Section 4 concludes.

2. Methodology

2.1. Fiscal Reaction Functions

A common approach (see Canzoneri et al., 2001, and Afonso, 2008), for the empirical validation of the existence of Ricardian Fiscal regimes aims at assessing: i) if fiscal authorities are motivated by stabilization and sustainability motives, which then a implies positive response of the budget balance to the stock of debt; ii) and whether the primary budget balance negatively influences government liabilities. Therefore, we can estimate the following fiscal relationships, notably in the context of our panel dataset:

$$\Delta s_{it} = \delta \Delta s_{it-1} + \theta \Delta B_{it-1} + \alpha \Delta z_{it} + \Delta v_{it} \ , \tag{1}$$

$$\Delta B_{it} = \gamma \Delta s_{it-1} + \varphi \Delta B_{it-1} + \beta \Delta z_{it} + \Delta u_{it} \ . \tag{2}$$

In equation (1) the primary balance (s) is a function of government debt (B) and allows us to test whether $\theta = 0$, signalling a non-Ricardian fiscal regime or whether $\theta > 0$, translating a Ricardian fiscal regime. This is essentially a fiscal reaction function along the lines of Bohn

[1] Golinelli and Momigliano (2008) review alternative specifications of fiscal policy reaction functions on the basis of different measures for the primary balance.

(2008). On the other hand, equation (2) is compatible with the standard budget deficit and debt dynamics formulation (see Afonso, 2008 for details). The hypothesis of a Ricardian fiscal regime is not rejected when $\gamma < 0$, as most likely the government is then using budget surpluses to reduce outstanding government debt. On the other hand, with $\gamma \geq 0$ there may be a case for a non-Ricardian regime, i.e., a regime of fiscal dominance. In addition, the output gap (*z*), is also added to control for the reaction of fiscal variables to the business cycle.

Such first-differenced equation should take care of stationarity issues, however it introduces a correlation between the differenced lagged dependent variable and the differenced error term, hence, the use of instruments is required. Consistent estimates can be obtained with two-stage least squares (TSLS) with instrumental variables correlated with Δs_{it-1} (ΔB_{it-1}) and orthogonal to Δv_{it} (Δu_{it}). Indeed, lagged values Δs_{it-2} and B_{it-2} satisfy these assumptions and can be used as IV for the first-differenced equations (1) and (2). For completeness we also computed the pooled OLS version, and we also provide some robustness by presenting both the pooled and panel versions of an IV-GLS estimator as well as Arellano-Bover's (1995) System-GMM estimator.[2]

2.2. Econometric Issues: Robustness

One concern when working with time-series data is the possibility of spurious correlation between the variables of interest (Granger and Newbold, 1974). This situation arises when series are not stationary, that is, they contain stochastic trends as it is largely the case with GDP series. The advantage of panel data integration is threefold: firstly, enables to by-pass the difficulty related to short spanned time series; secondly, the tests are more powerful than the conventional ones; thirdly, cross-section information reduces the probability of a spurious regression (Barnerjee, 1999).[3]

Therefore, the time-series properties of the data play an important role, suggesting that the bias in our models is the result of nonstationary errors, which are introduced into the fixed-effects and GMM equations by the imposition of parameter homogeneity. Hence, careful modelling of short-run dynamics requires a slightly different econometric approach. We assume that (1), or (2), represent the equilibrium which holds in the long-run, but that the dependent variable may deviate from its path in the short-run (due, e.g., to fiscal or macroeconomic shocks that may be persistent). There are often good reasons to expect the

[2] Which jointly estimates the equations in first differences, using as instruments lagged levels of the dependent and independent variables, and in levels, using as instruments the first differences of the regressors.
[3] Recall, additionally, that t-ratios are invalid for the estimations if error terms are nonstationary.

long-run equilibrium relationships between variables to be similar across groups of countries, via e.g. budget constraints or common technologies (unobserved TFP), capital markets integration and spillover effects, or common monetary policy for the countries within the Euro area influencing them in a similar way. In fact, in line with discussions in the empirical growth literature for modelling the “measure of our ignorance” we shall assume that the long-run relationship is composed of a country-specific level and a set of common factors with country-specific factor loadings.

The parameters of (1) and (2) can be obtained via recent panel data methods. Indeed, based on the mean of the estimates (but not taking into account that certain parameters may be the same across groups), we can use the Mean Group (MG)[4] estimator (Pesaran and Smith, 1995). This estimator is appropriate for the analysis of dynamic panels with both large time and cross-section dimensions, and has the advantage of accommodating both the long-run equilibrium and the possibly heterogeneous dynamic adjustment process.

Therefore, a second step in our analysis is to make use of the Common Correlated Effects Pooled (CCEP) estimator that accounts for the presence of unobserved common factors by including cross-section averages of the dependent and independent variables in the regression equation, and where the averages are interacted with country-dummies to allow for country-specific parameters.[5] In the heterogeneous version, the Common Correlated Effects Mean Group (CCEMG), the presence of unobserved common factors is achieved by construction and the estimates are obtained as averages of the individual estimates (Pesaran, 2006). A related and recently developed approach due to Eberhardt and Teal (2010), termed Augmented Mean Group (AMG) estimator, accounts for cross-sectional dependence by inclusion of a “common dynamic process”.[6]

Finally, the previous set of estimators is complemented with a new fixed-effects estimation, with Driscoll-Kraay (1998) robust standard errors, which is a non-parametric technique assuming the error structure to be heteroskedastic, autocorrelated up to some lag, and possibly correlated between the groups.

[4] The MG approach consists of estimating separate regressions for each country and computing averages of the country-specific coefficients (Evans, 1997; Lee et al., 1997). This allows for heterogeneity of all the parameters.
[5] For reasons of parsimony we abstract from presenting these results but they are available on request.
[6] We thank Markus Eberhardt for making his code available.

3. Empirical Analysis

We use annual data for the period 1970-2010.[7] Results of first (Im-Pesaran-Shin, 1997; Maddala-Wu, 1999) and second generation (Pesaran CIPS, 2007) panel integration tests are presented in the Appendix A.[8] Essentially we can accept most conservatively that non-stationarity cannot be ruled out in our dataset.

Our results for the estimations of (1) and (2), first without the output gap, presented in Table 1 show, irrespectively of the estimation method (see also Table 2), statistically significant positive coefficient estimates for the lagged first-differenced debt-ratio for the fiscal reaction function (1), implying that governments have, on average increased, the primary balance as a response to higher previous government indebtedness. Therefore, a Ricardian fiscal regime cannot be discarded. On the other hand, the results for the estimation of (2) also show that better primary balances have been used to reduce the level of outstanding government debt in the subsequent periods.

[Table 1]

[Table 2]

As an additional exercise, accounting for the effects of the business cycle by adding the output gap (computed as the difference between actual GDP and potential GDP, the latter obtained via HP filter) does not alter our main findings (plus its coefficient comes out statistically insignificant). Such results are reported in Tables 3 and 4. In addition, there is evidence of counter-cyclical fiscal policies as seen by the positive estimated effect of the output gap on the primary balance, while past above trend growth also implies a reduction in government indebtedness (see Tables 3-4).

[Table 3-4]

In order to provide a further robustness check, we report additional results from the so-called “forward looking” approach, following the VAR set used by Canzoneri et al. (2001). Specifically, we present the impulse-response functions of the (first-differenced) debt-to-GDP ratio to innovations in the (first-differenced) primary balance-to-GDP ratio, from an estimated VAR in these two variables. The VAR for each country with the first-differenced primary balance, debt ratio and the output gap was estimated with one lag and a constant; and the optimal lag order was selected using the BIC. The results on a country-by-country basis are shown in Figure 1, together with standard errors over a 10-year horizon.

[7] The data set is essentially from the AMECO European Commission database, as follows: General government gross debt, from Abbas et al. (2010); Primary Balance (% GDP at market prices) code 1.0.319.0.UBLGI for EU countries; OECD database for Australia, Canada, Japan, and US. The output gap is also sourced from the OECD.
[8] For further details on these tests, the interested reader should refer to the original sources.

[Figure 1]

As can be seen, a general pattern appears: the debt-to-GDP ratio always exhibits a negative response following an innovation in the primary balance ratio (except in the case of Australia, but the response is not statistically different from zero), which is increasing for a number of years, to become stable later on.[9] Therefore, again a fiscal Ricardian behaviour can be detected with the authorities using budgetary primary balances in the vein of the fiscal function specified in (2), to reduce the outstanding amount of government debt.

A panel VAR version (P-VAR) was also computed and the impulse response functions are depicted in Figure 2a (over a 6-year horizon).[10] The same conclusion emerges with respect to the response of the (first-differenced) debt ratio to innovations in the (first-differenced) primary balance, i.e., a negative response which is always statistically different from zero at the entire time horizon. Looking at the responses of (first-differenced) debt ratio to innovations in the (first-differenced) output gap we observe a negative impact (statistically insignificant until horizon 3). The country-by-country profile is available the Appendix B, Figure B.1.

[Figure 2]

Additionally, from Figure 2b it is possible to confirm the statistically significant reduction of the debt ratio as response to increases in the output gap, confirming the results already reported for the single regression panel analysis.

Figure 3 reports the impulse response function of the (first-differenced) primary balance to innovations in the (first-differenced) debt ratio. In this case, for five countries a Ricardian behaviour is also present, with the primary budget balance improving (increasing) as a response to past increase in the debt ratio (statistically significant impulse responses). In the context of the P-VAR analysis, and still for the fiscal reaction function (1), the overall Ricardian fiscal behaviour is also uncovered as we can see in Figure 2c. We also get a positive response of the (first-differenced) primary balance to innovations in the (first-differenced) output gap. The country-by-country profile is available the Appendix B, Figure B.2.

[Figure 3]

[9] The precision of the estimation of the impulse responses can be gauged by looking at the confidence bands. Two standard error bands are the impulse responses are based in Lutkepohl (1990).

[10] We thank Inessa Love for providing the P-VAR code, which we adapted to our own purposes.

Regarding the cyclicality of fiscal policy, Figure 2d shows an overall counter-cyclical behaviour whereupon the primary balance improves following higher above trend real economic growth developments.

4. Conclusion

We have made a reappraisal of fiscal responses in the OECD countries, essentially covering notably the relevance of cross-country interactions in the panel analysis, and estimating also fiscal responses in the context of a panel VAR. Our main results show that the fiscal authorities have increased primary balances to deal with higher government debt levels, and that primary budgetary balances increase in order to counteract the level government debt.

Our chief results are robust both for the single regression panel analysis and also for the panel VAR estimated impulse reaction functions. Therefore, this evidence is supportive of the existence of Ricardian fiscal regimes. In other words, the past track record for the longer 1970-2010 period indicates that fiscal authorities do seem to care about the sustainability of public finances.

Interestingly, in the country specific VAR, the debt-to-GDP ratio always exhibits a negative response following an innovation in the primary balance ratio (except Australia, where there is no response). On the other hand, the responses of primary balance ratio to the debt ratio are most positive for the countries in the panel, which would, in this case, go along with not rejecting some longer term fiscal sustainability view.

In addition, we also find a counter-cyclical behaviour of fiscal policies as seen by the positive estimated effect of the output gap on the primary balance,

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Table 1: Estimations of Debt Ratios and Primary Balances: 1970-2010

	Dependent Variable: Δ Debt				Dependent Variable: Δ Primary balance			
Method	**Pooled OLS**	**Pooled IV-FE**	**Panel IV-FE**	**SYS-GMM**	**Pooled OLS**	**Pooled IV-FE**	**Panel IV-FE**	**SYS-GMM**
ΔDebt (-1)	0.54***	0.55***	0.51***	0.51***	0.06**	0.06**	0.06**	0.00
	(0.053)	(0.054)	(0.055)	(0.138)	(0.024)	(0.024)	(0.026)	(0.077)
ΔPrimary balance (-1)	-0.28***	-0.28***	-0.30***	-0.20	0.15**	0.15**	0.15**	0.14
	(0.106)	(0.107)	(0.108)	(0.279)	(0.067)	(0.068)	(0.068)	(0.172)
Obs.	596	567	567	596	625	596	596	625
R2	0.31	0.31	0.27		0.03	0.03	0.03	
Hansen (p-value)				1.00				1.00
AR(1)				0.01				0.01
AR(2)				0.33				0.29

Note: The models are estimated by either Pooled OLS, Pooled IV-FE, Panel IV-FE or Two-Step robust System GMM (SYS-GMM). For the latter method lagged regressors are used as suitable instruments. The dependent variable is Δ Debt or Δ Primary Balance. Robust heteroskedastic-consistent standard errors are reported in parenthesis below each coefficient estimate. The Hansen test evaluates the validity of the instrument set, i.e., tests for over-identifying restrictions. AR(1) and AR(2) are the Arellano-Bond autocorrelation tests of first and second order (the null is no autocorrelation), respectively. A constant term has been estimated but it is not reported for reasons of parsimony. *, **, *** denote significance at 10, 5 and 1% levels.

Table 2: Robustness: Estimations of Debt Ratios and Primary Balances: 1970-2010

	Dependent Variable: Δ Debt				Dependent Variable: Δ Primary balance			
Method	**Driscoll-Kraay**	**CCEMG**	**MG**	**AMG**	**Driscoll-Kraay**	**CCEMG**	**MG**	**AMG**
ΔDebt (-1)	0.50***	0.43***	0.34***	0.16***	0.06	0.08***	0.10***	0.08***
	(0.084)	(0.048)	(0.052)	(0.042)	(0.039)	(0.023)	(0.024)	(0.020)
ΔPrimary balance (-1)	-0.30*	-0.22**	-0.12	-0.21**	0.15	0.17**	-0.05	0.12**
	(0.143)	(0.109)	(0.091)	(0.090)	(0.106)	(0.075)	(0.056)	(0.048)
Obs.	596	596	596	596	625	625	625	625

Note: The models are estimated by either Fixed Effects Driscoll-Kraay robust S.E., Common Correlated Effects Mean Group, Mean Group, or Augmented Mean Group. Standard errors are reported in parenthesis below each coefficient estimate. A constant term has been estimated but it is not reported for reasons of parsimony. *, **, *** denote significance at 10, 5 and 1% levels.

Table 3: Estimations of Debt Ratios and Primary Balances, controlling for the Business Cycle: 1970-2010

	Dependent Variable: Δ Debt				Dependent Variable: Δ Primary balance			
Method	**Pooled OLS**	**Pooled IV-FE**	**Panel IV-FE**	**SYS-GMM**	**Pooled OLS**	**Pooled IV-FE**	**Panel IV-FE**	**SYS-GMM**
ΔDebt (-1)	0.54***	0.54***	0.49***	0.63**	0.08***	0.08***	0.09***	0.02
	(0.054)	(0.055)	(0.055)	(0.240)	(0.025)	(0.025)	(0.027)	(0.152)
ΔPrimary balance (-1)	-0.19*	-0.21*	-0.21*	-0.01	0.06	0.06	0.05	0.01
	(0.115)	(0.116)	(0.118)	(0.323)	(0.072)	(0.073)	(0.074)	(0.392)
ΔOutput Gap (-1)	-0.20*	-0.17	-0.20*	-0.06	0.29***	0.27***	0.28***	0.10
	(0.114)	(0.118)	(0.120)	(0.433)	(0.054)	(0.055)	(0.056)	(0.502)
Obs.	562	535	535	562	589	562	562	
R2	0.32	0.33	0.28		0.08	0.07	0.07	
Hansen (p-value)				1.00				1.00
AR(1)				0.01				0.14
AR(2)				0.23				0.68

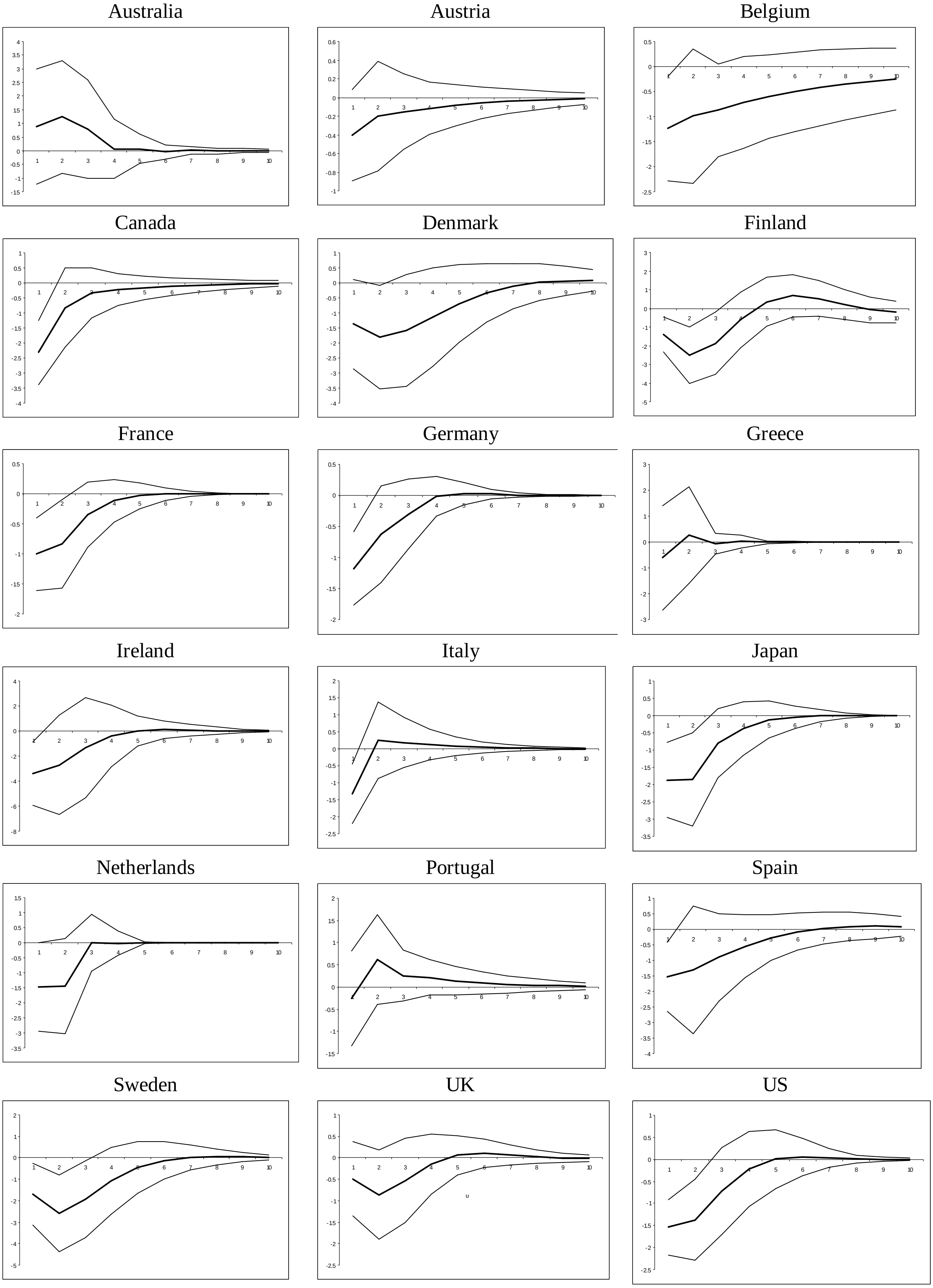
Note: The models are estimated by either Pooled OLS, Pooled IV-FE, Panel IV-FE or Two-Step robust System GMM (SYS-GMM). For the latter method lagged regressors are used as suitable instruments. The dependent variable is Δ Debt or Δ Primary Balance.Robust heteroskedastic-consistent standard errors are reported in parenthesis below each coefficient estimate. The Hansen test evaluates the validity of the instrument set, i.e., tests for over-identifying restrictions. AR(1) and AR(2) are the Arellano-Bond autocorrelation tests of first and second order (the null is no autocorrelation), respectively. A constant term has been estimated but it is not reported for reasons of parsimony. *, **, *** denote significance at 10, 5 and 1% levels.

Table 4: Robustness: Estimations of Debt Ratios and Primary Balances, controlling for the Business Cycle: 1970-2010

	Dependent Variable: Δ Debt				Dependent Variable: Δ Primary balance			
Method	**Driscoll-Kraay**	**CCEMG**	**MG**	**AMG**	**Driscoll-Kraay**	**CCEMG**	**MG**	**AMG**
ΔDebt (-1)	0.49***	0.37***	0.31***	0.17***	0.09**	0.10***	0.09***	0.08***
	(0.088)	(0.058)	(0.060)	(0.043)	(0.037)	(0.025)	(0.028)	(0.022)
ΔPrimary balance (-1)	-0.20	-0.15	-0.04	-0.13*	0.06	0.05	-0.11**	-0.18***
	(0.153)	(0.112)	(0.060)	(0.070)	(0.099)	(0.075)	(0.058)	(0.051)
ΔOutput Gap (-1)	-0.23	-0.15	-0.29	-0.02	0.29***	0.27***	0.18**	0.12**
	(0.144)	(0.173)	(0.187)	(0.144)	(0.061)	(0.062)	(0.085)	(0.055)
Obs.	562	562	562	562	589	589	589	589

Note: The models are estimated by either Fixed Effects Driscoll-Kraay robust S.E., Common Correlated Effects Mean Group, Mean Group, or Augmented Mean Group. Standard errors are reported in parenthesis below each coefficient estimate. A constant term has been estimated but it is not reported for reasons of parsimony. *, **, *** denote significance at 10, 5 and 1% levels.

Figure 1. Responses of debt ratio to the primary balance ratio from an estimated country-by-country VAR

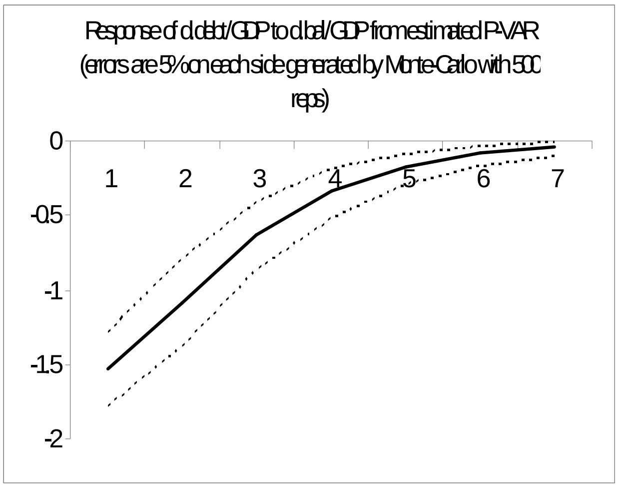


Source: authors' calculations.

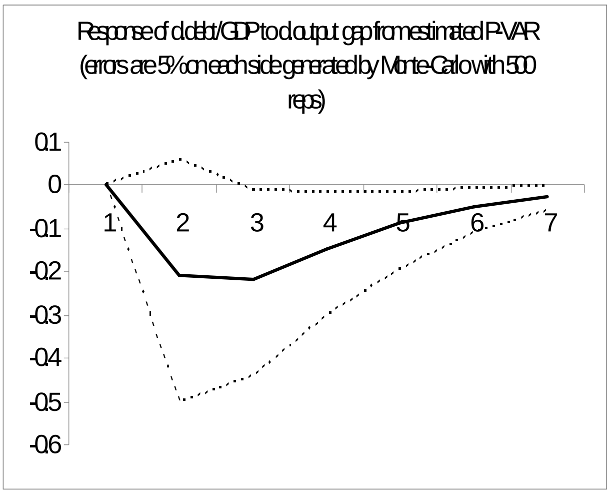
Note: responses of debt ratios to one S.D. innovation in the primary surplus with two standard error bands. Variables in first differences.

Figure 2. Response of debt and primary balance ratios from an estimated P-VAR

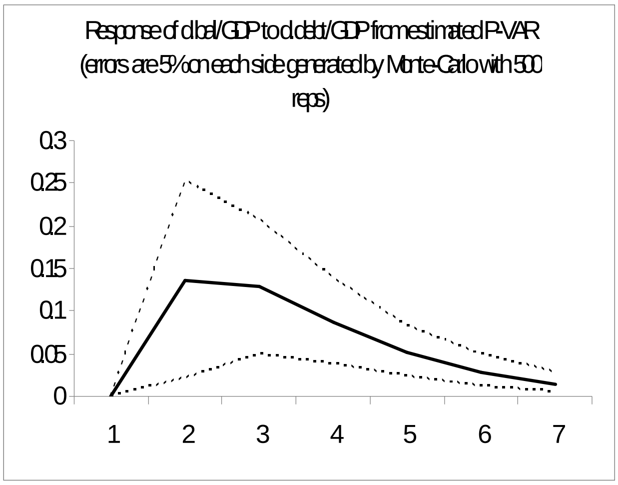
2a



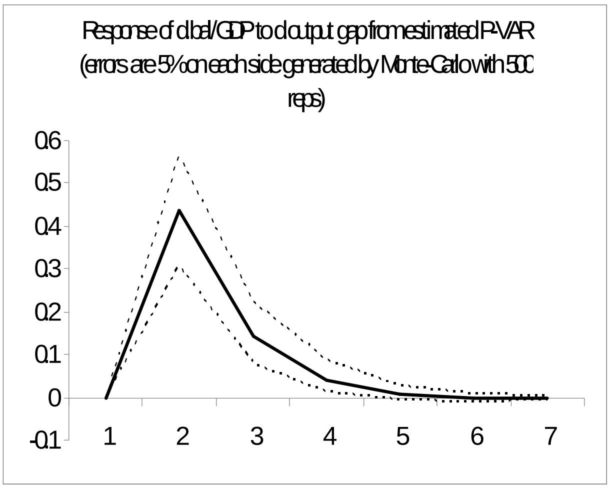
2b



2c

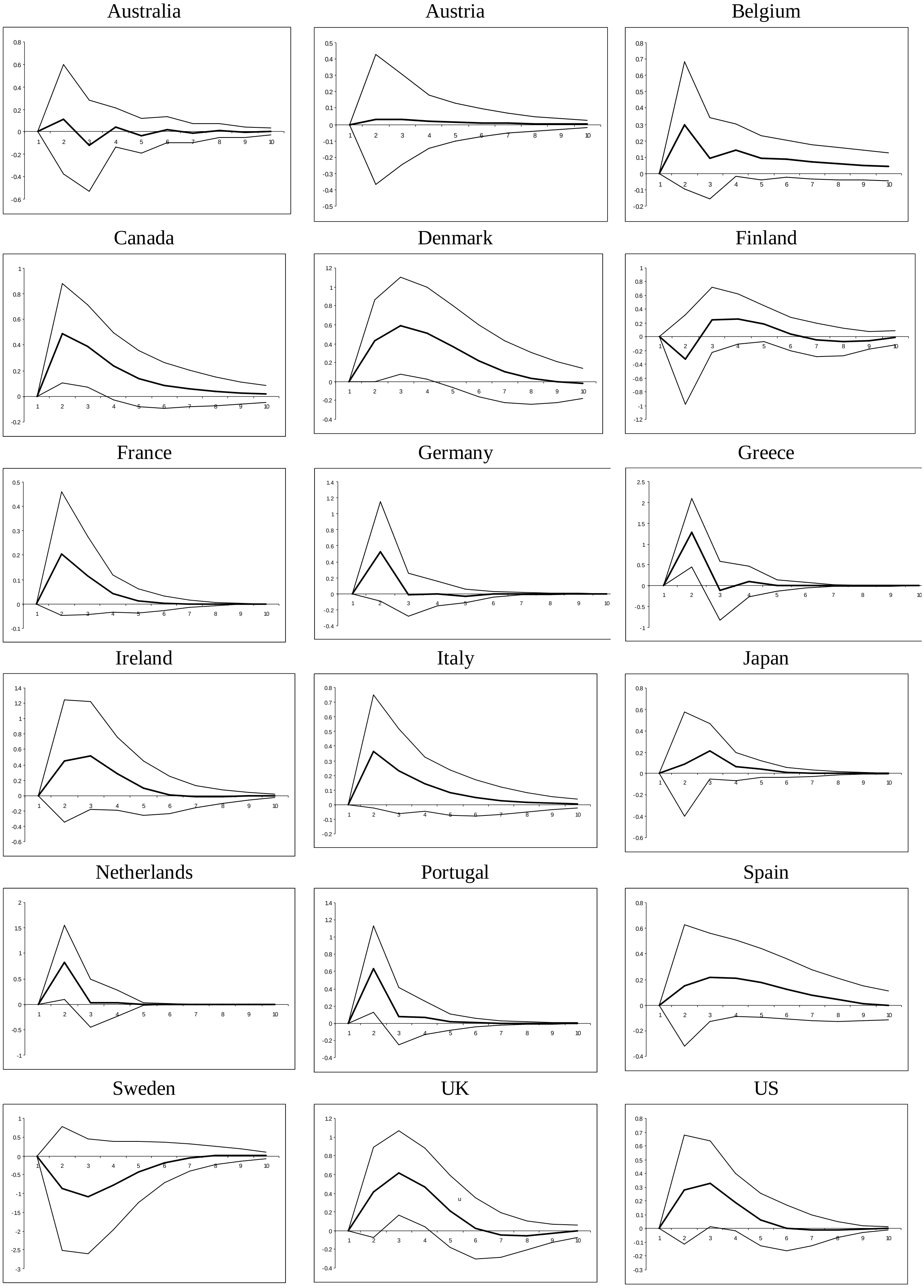


2d



Source: authors' calculations. Variables in first differences.

Figure 3. Responses of primary balance ratio to debt ratio from an estimated country-by-country VAR



Source: authors' calculations.

Note: responses primary surplus of to one S.D. innovation in the debt ratios with two standard error bands. Variables in first differences.

Appendix A

Table A1: First Generation Panel Unit Root Tests

Im, Pesaran and Shin (2003) Panel Unit Root Test (IPS) (a)

Full	**debt**		**primary balance**		**Output gap**
in levels					
lags	*[t-bar]*	*lags*	*[t-bar]*	*lags*	*[t-bar]*
1.78	-0.63	0.78	-4.95**	2.39	-18.43***

Maddala and Wu (1999) Panel Unit Root Test (MW) (b)

Full	**debt**		**primary balance**		**Output gap**	
lags	p_λ	*(p)*	p_λ	*(p)*	p_λ	*(p)*
in levels						
0	8.06	1.00	26.44	0.87	323.70	0.00
1	26.27	0.88	54.40	0.03	501.24	0.00
2	23.20	0.95	45.73	0.13	365.00	0.00
in first differences						
0	98.35	0.00	0.18	0.57	686.75	0.00
1	54.39	0.02	-0.47	0.32	621.05	0.00
2	34.08	0.56	0.45	0.67	466.23	0.00

Notes: (a) We report the average of the country-specific "ideal" lag-augmentation (via AIC). We report the t-bar statistic, constructed as $t-bar=(1/N)\sum_i t_i$ (t_i are country ADF t-statistics). Under the null of all country series containing a nonstationary process this statistic has a non-standard distribution: the critical values are -1.73 for 5%, -1.69 for 10% significance level – distribution is approximately *t*. We indicate the cases where the null is rejected with **. (b) We report the MW statistic constructed as $p_\lambda=-2\sum_i \log(p_i)$ (p_i are country ADF statistic p-values) for different lag-augmentations. Under the null of all country series containing a nonstationary process this statistic is distributed $\chi^2(2N)$. We further report the p-values for each of the MW tests.

Table A2: Second Generation Panel Unit Root Tests

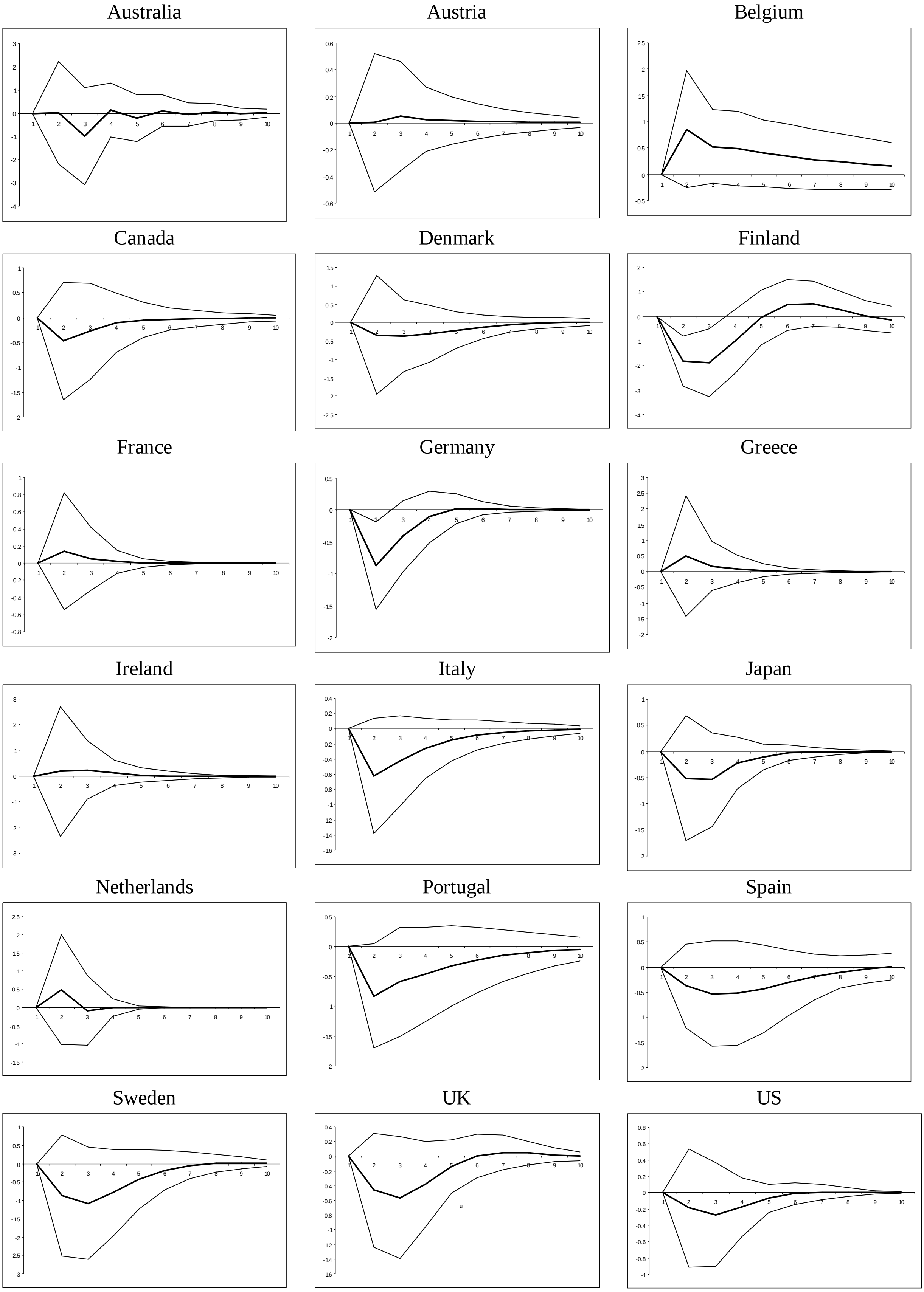
Pesaran (2007) Panel Unit Root Test (CIPS)

Full	**debt**		**primary balance**		**Output gap**	
lags	p_λ	*(p)*	p_λ	*(p)*	p_λ	*(p)*
in levels						
0	4.22	1.00	405.13	0.00	-14.14	0.00
1	2.29	0.98	208.96	0.00	-14.16	0.00
2	3.52	1.00	134.98	0.00	-11.52	0.00
in first differences						
0	-5.63	0.00	-15.97	0.00	-18.75	0.00
1	-2.53	0.00	-11.07	0.00	-17.44	0.00
2	0.57	0.71	-7.47	0.00	-14.41	0.00

` Notes: Null hypothesis of non-stationarity. We further report the p-values for each of the CIPS tests.

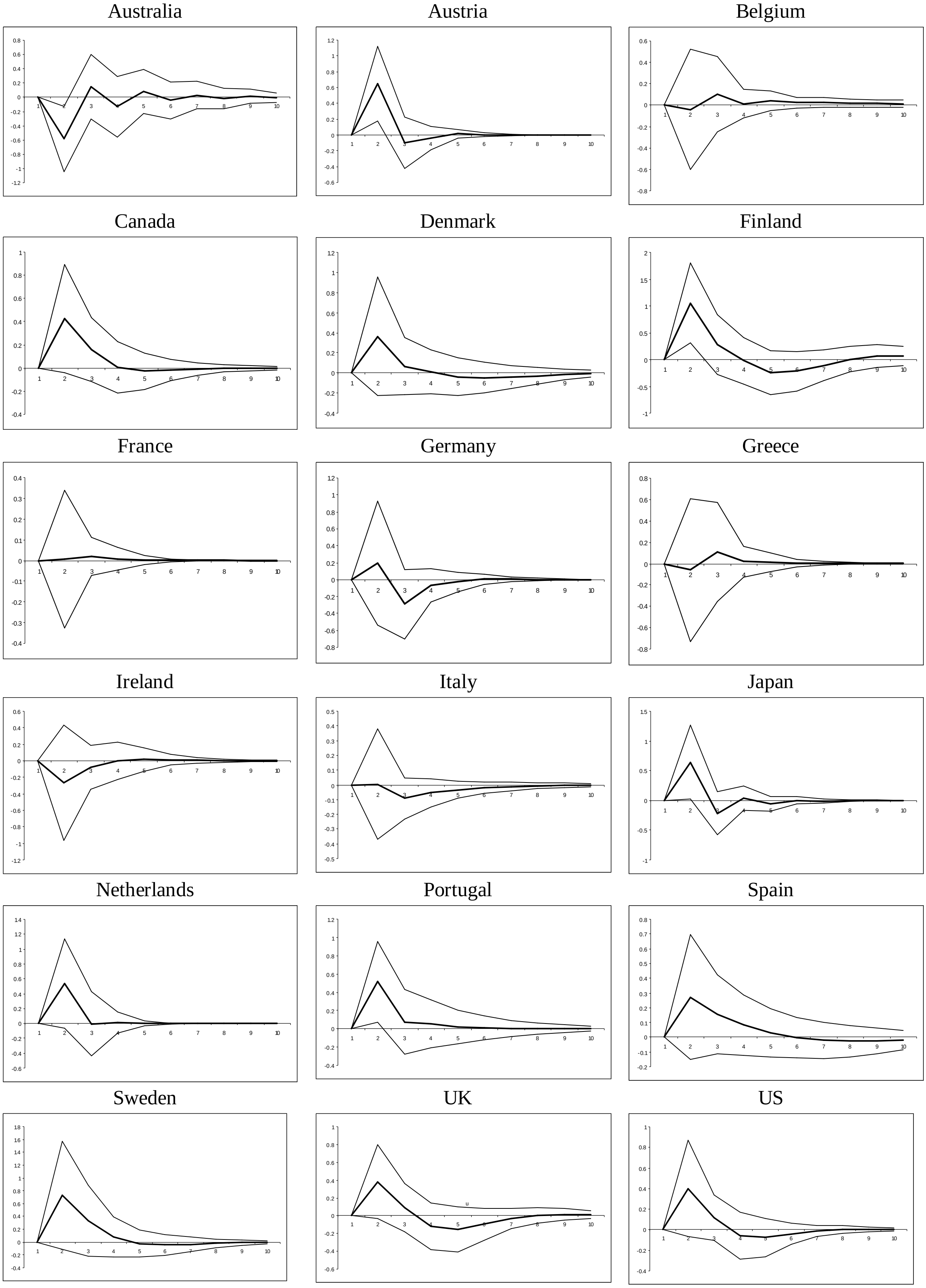
Appendix B: Country-based VARs controlling for the Business Cycle

Figure B1. Responses of debt ratio to output gap, country-by-country VAR



Source: authors' calculations.
Note: responses debt ratios of to one S.D. innovation in the output gap with two standard error bands. Variables in first differences.

Figure B2. Responses of primary balance ratio to output gap, country-by-country VAR



Source: authors' calculations.

Note: responses primary surplus of to one S.D. innovation in the output gap with two standard error bands. Variables in first differences.