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Fiscal sustainability in EMU countries: A continued fiscal commitment? ☆

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ABSTRACT

The aim of this paper is to study the sustainability of public finances in the Eurozone particularly after the 2007 financial crisis. This paper goes beyond the standard analysis of the univariate properties of the fiscal variables through the estimation of a time-varying fiscal reaction function on a 11-country panel for a period spanning from 1970 to 2014. Even if panel unit root or stationary tests may provide a rough first insight on the sustainability of the public finances, they fail to highlight the adjustment mechanisms to debt overhang in recent years. The main advantage of our empirical approach is that it clearly captures the government's dynamic response to debt accumulation, which signals its commitment to readjust public debt towards a sustainable path. Time-varying estimates of the fiscal reaction function shed new light on this respect and reveal certain heterogeneity among EMU countries on the way they manage their public finances. This paper helps ascertain whether the public resources destined to bail out troubled countries triggered effective fiscal responses.

1. Motivation: public finances at crossroad

Over the last decade most industrialized and developing countries have gradually increased public sector spending and size, leading in most cases to a significant increase of public debt, both measured in absolute terms or relative to GDP. This unprecedented process of accumulation of debt questions the sustainability of budgetary imbalances of these countries after the Great Recession. The crisis of confidence in the solvency of public finances has generated episodes of high risk premia in some peripheral European countries like Greece, Ireland, or Spain. As a result of that, different multilateral institutions have raised concerns about possible bankruptcy in the peripheral EMU countries (OECD, 2012). The OECD highlights the difficulty of achieving fiscal consolidation over a period of weak economic growth, the difficulty of getting the necessary structural

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adjustments in the labor market and retirement systems as well as the reforms to improve competitiveness in a short period of time. The aim of this paper is to study the sustainability of fiscal policies in the Eurozone, focusing on the adjustment dynamics of those EMU countries that suffered an intense increase of their sovereign debt spreads since 2007. In a monetary union this increasing spread reflected either a default (or liquidity) risk or an overreaction in a ''panic flight to safety'' towards bonds issued by a few countries considered as ''safe havens'' (de Grauwe, 2009).

An extant body of academic literature has tested the hypotheses of the sustainability of public finances. The seminal work of Hamilton and Flavin (1986) gave way to research on the government's fulfillment of the intertemporal budget constraint (IBC henceforth). This popular approach focuses on the stochastic behavior of fiscal variables, and particularly in the order of integration of public deficit and debt variables, and co-integration relationships between public revenues and expenditures. This seminal approach, originally applied to individual-country series and extended and refined to include panel data allowing for structural breaks, has been subject to criticism by Bohn (1998). Moreover, as pointed by Mendoza and Ostry (2008), intertemporal solvency can be perceived as an extremely weak criterion, since it requires only that the adjustments to bring policy back on track are perceived to occur at some point in the future.

Our research extends the existing literature by estimating a fiscal reaction function following Bohn (1998). As in previous literature, we inspect the corrective response in primary deficit to debt accumulation, along with the reaction to interest spending increase, which could also be ''crowding-out'' the primary surplus through the ''snowball'' effect. However, as there is overwhelming evidence suggesting that the relationship between primary surplus-to-GDP ratio and the debt-to-GDP ratio is time-varying, we analyze the question of the sustainability of the fiscal debt using a novel approach: we allow for a time-varying response to debt accumulation, which we estimate through the Kalman filter.

Our paper contributes to some recent literature that has focused on the case of the Euro area countries trying to ascertain whether fiscal responsiveness has increased since the launch of the euro or, at least, since the onset of the 2007 financial crisis.[1] We find that most of the member countries adjust their policy to rising levels of public debt, although in some cases they do it at a weaker pace. Moreover, the fiscal responsiveness to public debt appears to have generally increased since 2009.

Policymakers have undertaken several measures to ensure sustainability of high-risk countries. In 2010, the Eurozone countries and the International Monetary Fund accorded to a €110 billion loan for Greece and €85 billion for Ireland. Portugal received €78 billion in financial aid in 2011. In 2012, Greece received a second bailout package and Spain was granted with a financial support package of €100 billion. Our results help unravel whether this policies triggered sufficient fiscal responses in the bailed out countries.

The remainder of the paper is organized as follows: Section 2 briefly reviews previous empirical literature on IBC and its shortcomings; Section 3 describes the theoretical model and presents the empirical specification while Section 4 presents the empirical methodology and describes the data; Section 5 discusses the results, and finally Section 6 concludes.

2. A brief survey of the empirical literature

During recent decades, economists and policymakers' concern about public deficits and debt has grown in line with their absolute and relative size. In this context, the sustainability of public finances turns to be a key issue for economic policy, in particular for the European Monetary Union (EMU) members, who have ''tied their hands'' in monetary policy (Giavazzi and Pagano, 1988).

From an apparently naïve approach, Blanchard et al. (1991) defined a sustainable fiscal policy as a policy that allows the debt-to-GDP ratio to converge back to its initial level after some deviation. Since debt solvency is forward-looking, it requires large enough future primary surpluses to service the debt. Essentially, solvency is determined by future patterns of government expenditures and revenues, mainly income tax.[2] Public debt sustainability is commonly understood as the ability of a country to meet its debt obligations without requiring debt relief or accumulating arrears. In practice, it is, however, impossible to anticipate future primary balances, or future discount and re-finance rates since borrowing costs are also uncertain in the future. Furthermore, the government primary balance is a target policy variable as well, and inferences on future balances are affected by expectations not only about the government ability to generate the required surpluses, but also by its willingness to produce them.

Bearing the above arguments in mind, it seems relevant to distinguish between fiscal sustainability and the ''market perception'' about sustainability.[3] As Pinheiro (2012) highlights, financial markets risk aversion (or risk perception) may rule out fiscal trajectories which otherwise appear to be sustainable, making the interest on the sovereign debt rise sharply and losing market access.

Empirical studies on sustainability of public finances start at the late eighties and early nineties: Hamilton and Flavin (1986), Wilcox (1989), Trehan and Walsh (1988, 1991) or Hakkio and Rush (1991). Since then, a burgeoning literature has appeared, producing a huge amount of studies, particularly for European countries but also for the US and many developing countries. Applying time series analysis, the empirical literature has tried to conclude if the stochastic processes generating the observed time series are consistent or not with the IBC, which requires that the current market value of the debt must equal the discounted sum of expected future surpluses.

[1] See Checherita-Westphal and Ždarek (2015), Weichenrieder and Zimmer (2014), Baldi and Staehr (2015) and Berti et al. (2016).

[2] As Wyplosz (2007) states, solvency definition, while clearly formalized, implies serious implementation difficulties.

[3] The evolution of both variables have direct implications on the government ability to finance current deficits due to the time-varying risk premium required and the possibility of giving rise to credit rationing and serious liquidity problems.

Hamilton and Flavin (1986) is perhaps one of the best-known earliest attempts to test the fulfillment of the Government's IBC. Applying Flood and Garber (1984) test for price bubbles to the IBC for the US post-war period, they test for the bubble term value, suggesting that a stationary path for public debt is a sufficient (but not necessary) condition for fiscal sustainability. In general, a stochastic process is stationary when it tends to revert to its average or to its trend following a random shock.

A second bulk of papers (e.g., Wilcox (1989) or Hakkio and Rush (1991)), interpret Present Value Tests as tests of the sustainability of current fiscal policy, explicitly stating that they are testing whether the No-Ponzi game condition would be fulfilled should government revenue and expenditure continued to follow their past stochastic processes.

Alternatively, Trehan and Walsh (1988, 1991) developed a different framework to test the IBC fulfillment through the presence of a long-run cointegration relationship between government revenues and expenditures. Haug (1995) applied this cointegration framework to the US federal budget in the 80s, and Smith and Zin (1991) to the Canadian federal budget. More recently, under the same framework, unit root and cointegration developments have focused on the possible existence of structural changes affecting the US variables, such as in the work of Quintos (1995). For the Spanish case, Bajo-Rubio et al. (2008) re-examine the sustainability of the budget deficits, following the econometric approach developed by Bai and Perron (1998, 2003b), that allows testing endogenously for the presence of multiple structural changes.

Recent approaches have incorporated panel data cointegration techniques. Afonso and Rault (2010) test for the sustainability of public finances in the EU-15 over the period 1970–2006 using stationarity and cointegration analysis. Additionally, Byrne et al. (2011) employ Bai and Ng (2004) tests to find evidence of a cointegrating relationship between primary surplus and debt for emerging and industrialized countries, once taking account of a common stochastic trend related to global liquidity, as suggested in Eichengreen and Hausmann (1999). Finally, advances in panel cointegration techniques analysis,[4] have allowed testing for endogenously determined structural breaks while testing the IBC (Camarero et al., 2015).

However, Bohn (1998, 2007) remarks that the IBC fulfillment *per se* imposes very weak econometric restrictions. He proves that the IBC is satisfied if, either the debt series or the revenue and with-interest expenditure series, are stationary after any finite number of difference operations. Moreover, he shows that the sustainability test developed by Quintos (1995) is misleading to determine whether the necessary or sufficient condition holds based on the coefficient of a cointegration vector. Conversely, Bohn (2007) states that all cointegrating conditions are merely "sufficient" for transversality (i.e., avoiding explosive debt behavior). Therefore, Bohn (2007) proposes the estimation of a policy reaction function[5] as an alternative approach. However, Bohn (1998) approach may not be suitable for dealing with the long-run relationship between government revenues and expenditures. Although Bohn (1998) is currently widely considered as the workhorse model to test for the sustainability of public debt, it assumes that the relationship between primary surplus and the gross public debt ratio is time-invariant, which seems at odds with a simple visual data inspection.[6] Only some recent studies have allowed Bonh's policy rule to be time-varying.[7] Moreover, recent papers highlight the relevant role of time-varying parameters in finance, particularly sovereign spreads (Paniagua et al., in press). In the same vein, in this paper, we modify the original parametric specification proposed in Bohn (1998) to allow for a time-varying relationship estimated through the Kalman filter.

3. Theoretical background

Compliance with government IBC imposes restrictions on long-term behavior of government revenues and expenditures (including debt interest), which cannot deviate from the path set by the first. Following McCallum (1984), the government budget identity states the nominal government budget constraint in a period, determining the evolution of public debt stock, B_t, as reflected in the following equation,

$$B_t = G_t^0 - T_t + (1 + r_t)B_{t-1} \tag{1}$$

where G_t^0 represents government primary expenditure (excluding debt interest) in period t; r_t is the interest rate on public debt at the beginning of the period, T_t represents the revenues of the period, and r_tB_{t-1}represents the financial costs associated to lagged debt.

In this simple framework, the accumulation of debt would be determined by the primary deficit and the burden of interest on the debt balance at the beginning of the period, as follows:

$$\Delta B_t = B_t - B_{t-1} = G_t^0 - T_t + r_tB_{t-1} \tag{2}$$

For convenience, the debt level can be re-expressed as follows:

$$B_t = \rho_t(T_{t+1} - G_{t+1}^0 + B_{t+1}) \tag{3}$$

where $\rho_t = 1/(1 + r_{t+1})$.

[4] See Banerjee and Carrion-i Silvestre (2015) and Bai and Carrion-i Silvestre (2009).
[5] Originally developed in Bohn (1998).
[6] As can be observed, in Figs. 1 and 2, both surpluses and debt in the Eurozone peripheral countries, show a systematic relationship that seems to vary over time.
[7] See, for instance, Burger et al. (2012) for the case of some African and Latin American countries and Nguyen et al. (2017) for the US case.

According to Bohn (2007), in order to move from the budget identity to a budget constraint, additional assumptions on interest rates are needed. The most simplistic assumption relies, either on assuming a positive and constant interest rate, $r_t = r > 0$, or that the interest rate is uncorrelated over time with a positive and constant conditional expectation, $E_t r_{t+1} = r > 0$. Alternatively, following Quintos (1995), we assume that the real interest rate, r_t, is a stationary stochastic process with mean $r > 0$, subject only to implicit restrictions that may be required for the adjusted spending, $G_t = G_t^0 + (r_t - r)B_{t-1}$, to have similar properties (to be specified) as ordinary non-interest spending.

Then, if we define $\rho = 1/(1+r) < 1$, then,

$$B_t = \rho E_t[T_{t+1} - G_{t+1} + B_{t+1}] \quad (4)$$

Solving recursively by forward substitution, we obtain the government's IBC, which is equivalent to the expected present value constraint:

$$B_t = \sum_{i=1}^{\infty} \rho^i E_t(T_{t+i} - G_{t+i}) \quad (5)$$

In this framework, to avoid explosive debt behavior such as "Ponzi games",[8] fiscal sustainability requires the transversality condition, namely:

$$\lim_{t\to\infty} \rho^n E_t(B_{t+n}) = 0 \quad (6)$$

The no-Ponzi scheme restriction assures the fulfillment of the IBC and imposes testable restrictions on the time series of key fiscal variables: the stock of public debt, the budget deficit, and the long-run relationship between government expenditures and revenues. Trehan and Walsh (1991) posit that the sufficient and necessary conditions for the IBC's fulfillment are the existence of a cointegration relationship between primary deficit and debt, as well as the I(0) stationarity of the quasi-difference of the primary deficit/surplus. However, only very recently has the empirical literature tackled the problem of the relationship between debt and primary surplus. To overcome the problem of different order of integration of debt and deficit, Camarero et al. (2015) propose to work within an I(2) stochastic framework. However, the cointegration approach tackles only the sufficient condition. However, Bohn (2007) shows that any finite order of integration of the debt series can be compatible with the fulfillment of the IBC. In particular, strong sustainability implies that the debt is difference stationary, whereas an I(2) debt is associated with weak sustainability, or even absurdly weak when the order of integration is higher.[9] Consequently unit roots and cointegration techniques way lead to erroneous assumptions regarding the no-Ponzi scheme restriction and therefore present serious limitations in the analysis of fiscal sustainability.

To hedge the aforementioned limitations, Bohn (2007) proposes fiscal reaction functions as a more adequate framework to test for fiscal deficit sustainability. This analysis focuses on the government reaction to the evolution of debt by adjusting primary balances in the following periods. Even under uncertainty, if the primary surplus (*PS*) responds positively to an increase in gross debt (*B*), Bohn (2007) understands that the government fiscal policy is sustainable. Such a test resorts to examining whether the parameter β is positive in the fiscal reaction equation

$$PS_t = \beta B_{t-1} + \delta Z_t + \varepsilon_t = \beta B_{t-1} + \mu_t \quad (7)$$

where Z_t is a vector of determinants of the primary surplus which operate through their parameter δ, and ε_t represents an error term.

Eq. (7) is equivalent to the cointegration test suggested by Trehan and Walsh (1988), if both debt and primary surplus are nonstationary, while μ_t is stationary. Under these conditions, however, we need to take into account potential determinants of primary surplus in order to avoid biased coefficient estimates. To circumvent this issue, Bohn (1988) uses the tax-smoothing theory developed in Barro (1986). Bohn applies this framework to postwar U.S. data, finding evidence that $\beta > 0$, which suggests that U.S. fiscal policy had been sustainable in a time-invariant framework.

This linear reaction function has recently been extended to non-linear specifications using polynomial functions[10] or including exogenous[11] or endogenously determined debt thresholds[12] through regime-switching models. These alternative empirical models permit the analysis of thresholds beyond which fiscal responsiveness increases, weakens or even turns negative showing a kind of fiscal fatigue.

Additionally, Bohn (2007) suggests the possibility of a time-varying setup. Some studies enabling time-varying debt coefficients use penalized spline estimates as in Fincke and Greiner (2011, 2012), while others use state-space modeling as in Burger et al. (2012) and Legrenzi and Milas (2013). Our test of fiscal sustainability with time-varying parameters falls within this framework.

[8] A Ponzi game implies continuously relying on the issue of new debt to pay maturing old debts.

[9] Bohn (1998) has suggested that the analysis of the fiscal policy soundness should not be limited to the evaluation of the stationarity of the debt-to-GDP ratio. He considers that univariate analysis alone could be misleading.

[10] See Bohn (2005), Medeiros (2012) or Ghosh et al. (2013).

[11] See Lukkezen and Rojas-Romagosa (2012), Lukkezen and Rojas-Romagosa (2013) or Celasun et al. (2006).

[12] See Fournier and Fall (2015), Legrenzi and Milas (2013).

4. Data and empirical methodology

In this section we describe our data and the estimation of a fiscal reaction function for a panel of the EMU countries in a time-varying parameter framework. First, we perform unit root tests for the fiscal variables involved in the fiscal reaction framework: general government primary surplus (*PS*), gross debt (*B*), government expenditure excluding interests (*G*), interest service (rB_{t-1}), and tax revenue (*T*). All variables have been defined relative to GDP. After analyzing the univariate properties of the variables, we will test for the existence of relationships between them. We will focus on the existence of a time-varying fiscal reaction function, whose existence and size will assess the government commitment to redirect debt accumulation inside a sustainable path.

4.1. The data

All data are taken from the European Commission AMECO (Annual Macro-Economic Data) database, covering the period 1970–2014. We include peripheral EMU countries (Portugal, Ireland, Italy, Finland, Greece and Spain), as well as other core Eurozone members (Germany, France, Belgium, the Netherlands, and Austria). Eastern euro-area economies are not included due to relatively short availability of data. The evolution of the main variables involved in the reaction function, namely, the primary surplus ratio and the debt ratio is depicted in Fig. 1 separately for both groups of countries.

Surpluses and debt display a relatively systematic mirroring relationship that tends to vary over time. Overall, we can appreciate the persistent fiscal deficits and increasing debt accumulated over the 80s, the fiscal consolidation efforts made during the second mid-90s and, finally, the fiscal effects derived from the 2007 crisis. However, the discretionary fiscal measures taken by the Eurozone governments and the automatic stabilizers directly linked to the evolution of the business cycle vary across countries. While some peripheral countries like Spain and Ireland have focused on reducing their surplus and increased their debt, other core countries like Germany and Belgium reduced the debt with persistent surpluses.

To construct the series we had to account for the presence of both a break in accounting standards (ESA79 for the period 1970–1995 and ESA95 for subsequent periods) and a discontinuity due to the German unification. As in Paredes et al. (2009), in order to obtain homogeneous levels for the whole period 1970–2014, we removed level discontinuities by applying backwards the growth rates by the series in ESA79 terms (that exclude East Germany) to the levels of the ESA95 series, as it follows in the next equation:

$$Y_{t-1}^{ESA95^*} = \frac{Y_t^{ESA95}}{\left(\frac{Y_t^{ESA79}}{Y_{t-1}^{ESA79}}\right)} \tag{8}$$

Overall, our panel dataset has a reasonable dimension both in terms of time span and cross-section length to allow robust results.

4.2. Univariate data properties: unit roots with unknown multiple structural breaks

In this section we study the order of integration of the fiscal variables, in particular gross debt and primary surplus, both expressed as ratios to GDP. We consider the potential existence of unknown structural changes using a panel unit root test, which allows for cross-section dependence. Regarding the univariate properties of the primary surplus and debt ratios in our 11-country panel, we use the results from the Bai and Carrion-i Silvestre (2009) panel-unit root tests.

As stated in Perron (1989) and related literature, ignoring the eventual presence of structural breaks may lead to misleading conclusions about the order of integration of a time series.[13] This is not a trivial question since ascertaining whether the non-stationarity of the fiscal variables is deterministic or stochastic has outstanding economic policy implications. While stochastic trends in the data may suggest permanent effect of shocks and eventual insolvency of the government, stationarity around a shifting mean or trend imply transitory regime changes, and consequently, that any possible insolvency can be redressed through economic policy measures Nguyen et al. (2017).

Bai and Carrion-i Silvestre (2009) propose a set of panel unit root statistics that pool the modified individual series of Sargan-Bhargava (hereafter MSB) tests.[14] These panel tests account for the possible existence of multiple structural breaks[15] and cross-section dependence modeled as a common factors model.[16] The common factors may be non-stationary processes, stationary processes or a combination of both. The number of common factors is estimated using the panel Bayesian criterion information as in Bai and Ng (2002). Our implementation allows for a maximum number of 4 breaks, determined through the Bai and Perron (1998) procedure.[17]

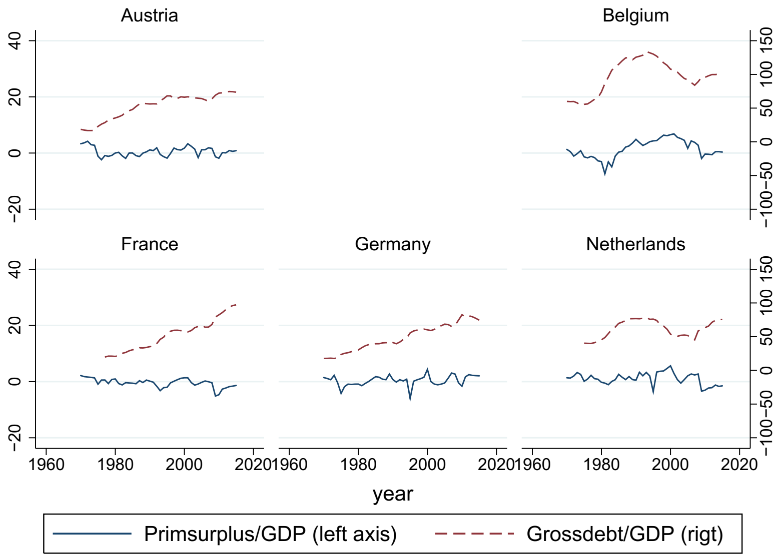
[13] As pointed out by Perron (1997), the simple inclusion of a break point in the analysis of integration is sufficient to weaken the evidence for the presence of unit root in many series of the data used by Nelson and Plosser (1982).

[14] Sargan and Bhargava (1983).

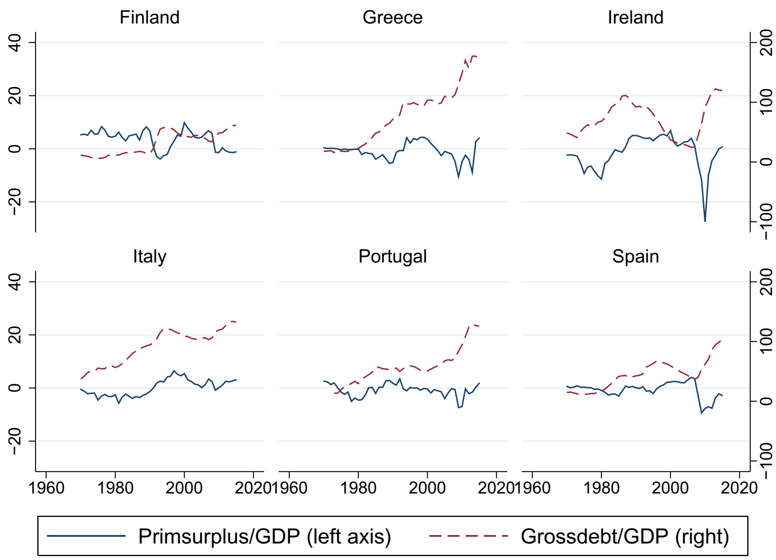
[15] Adapting Bai and Perron (2003a) methodology to a panel data framework.

[16] Following Bai and Ng (2004) and Moon and Perron (2004).

[17] We have implemented the GAUSS code provided by the authors; see Bai and Carrion-i Silvestre (2009) for details.



(a) Core Countries



(b) Periphery Countries

Fig. 1. AMECO fiscal data 1970–2014.

When conducting this test for our 11-country panel, we find strong evidence of multiple structural breaks affecting most of the fiscal variables analyzed, differing in number and position for each country, as shown in Table 1.

In Table 2 we present the panel-based unit root test results. We focus on the analysis of the primary surplus (PS_t) and its components, namely the government expenditure (G_t), the tax revenue (T_t) and the interest service (rB_{t-1}), together with the gross debt ratio (B_t). Even allowing for common factors and structural breaks, the panel-based unit root test results are not conclusive for most of the series, except for the primary surplus ratio, that seems to be clearly a stationary variable. For the rest of the variables analyzed, regardless the conventional or simplified tests[18] reported in Table 2, the results suggest the

[18] It is worth noting that the authors claim that the simplified set of tests are most appropriate for the level and trend break model, and suggest that the Z and P statistics have the best small sample properties.

Table 1
Variables relative to GDP. Structural Breaks (BIC estimates), 1970–2014.

	B	T	G	rB_{t-1}	No. obs
Portugal					40
Ireland	1990 2006	1984			43
Italy	1994	1982	1989	1989 1999	43
Greece	2006	1982 1988 2000	1982 1988	1985 1994 2005	43
Spain	1978 1998 2006		1979 1985		43
Finland	1996	1976		1987 1993	43
Belgium	1979 1985 1993 2006	1979		1990 1996	43
Germany		1977	1992 1999	1993	43
France					36
Netherlands		1983		1979 1985 1993 2002	38
Austria		1976	1987 1996	1987	43

Notes: Bai and Carrion-i Silvestre (2009), allowing for up to 4 breaks.

Table 2
Bai & Carrion-i-Silvestre panel unit root test with common factors and structural breaks (1970–2014).

Variable	Model 2. Trend Break Model									
	Z	P_m	P	Z^*	P_m^*	P^*	T	N	m	fr
B_t	−0.90	0.97	39.78*	1.664**	−0.3493	29.20	43	16	5	80
PS_t	−2.37***	3.12***	56.94***	−2.37***	3.12***	56.94***	43	16	5	80
G_t	−0.68	0.15	33.22	−0.64	−0.34	29.31	43	16	5	80
T_t	−1.55*	1.16	41.28*	−0.33	0.68	37.46	43	16	5	80
Br_{t-1}	−0.40	1.72*	45.79**	0.75	−0.26	29.91	43	16	5	80

Notes: Z, P and Pm denote the test statistics developed by Bai and Carrion-i Silvestre (2009). Z and P_m follow the standard normal distribution and their 1%, 5% and 10% critical values are 2.326, 1.645 and 1.282; whereas$P$ follows the Chi-squared distribution with n×(breaks + 1) degrees of freedom whose critical values are*46.459*, *43.188* and *37.485*, for 1%, 5% and 10% respectively). The number of common factors are estimated using the panel Bayesian information criterion proposed by Bai and Ng (2002). Z^*, P^* and P_m^*refer to the corresponding statistics obtained using the p-values of the simplified MSB statistics. The null hypothesis of a unit root is rejected at $^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$ significance level, respectively, if the statistic is greater than the upper level.

presence of a unit root. More specifically, the results clearly show that the null hypothesis of unit root can be rejected for PS_t at 1% of significance whereas for the rest of the variables, the null can only be rejected in a few cases and at 10% of significance.

Thus, following Trehan and Walsh (1988) these results are compatible with the sustainability of the public finances for the panel of countries. The test suggests the existence of a cointegrating vector combining revenue, expenditure and the interest service variables. However, the results in the case of the debt ratio are not conclusive. Therefore, the former empirical evidence can be misleading or, at least, hiding important country-heterogeneity in the dynamics of the individual adjustments undertaken across euro area countries, especially after some episodes of turbulence. This mixed evidence calls for a more refined analysis that may be provided by a time-varying fiscal reaction function. In addition, although multiple structural breaks seem to be affecting all the fiscal variables analyzed, as we can see in Table 1, they differ in number and position for each country. In order to obtain a deeper insight into the results, it is convenient to perform further analysis.

4.3. Time-varying fiscal reaction functions

Following Bohn's approach to fiscal sustainability, we test for the existence of a time-varying fiscal reaction function. This model captures the government dynamic reaction to debt increase by adjusting its primary surplus, which signals the markets its ability (and willingness) to restore its fiscal stance to a sustainable path. Bohn (1995, 2007) highlights an error correction mechanism: if the public debt/GDP ratio increases, government should respond by improving the primary balance, to offset and even reverse the rise in the public debt/GDP ratio.

Fiscal reaction functions usually specify, for annual data, the reaction of the primary balance/GDP ratio to changes in the one-period lagged public debt/GDP ratio, controlling for other influences. We introduce a lagged debt ratio since interest payments on debt and debt repayment on debt occur at later periods. In addition to the debt/GDP ratio, we will introduce other possible determinants of primary surplus.

Similarly to Burger (2012), we estimate a time-varying fiscal reaction function through the Kalman filter algorithm. A salient feature of our research is the use of time-varying parameters (TVP) in the estimation of the fiscal reaction function defined in (7). Our procedure borrows heavily from Paniagua et al. (in press); we adapt their mean-reverting (MRV) panel setting to define a more general modelization of the β parameter on gross debt ratio in (7), namely:

$$\beta_{i,t} = \Phi\beta_{i,t-1} + (1-\Phi)\bar{\beta}_i + v_{i,t} \tag{9}$$

where Φ is defined in the interval $[0,1]$, and v_{it} is a Gaussian error with a zero mean and a fixed variance, making the parameter return to its mean gradually. Mean-reversion model represents a general modelization of parameters: the OLS model is obtained when $var(v_{i,t}) = 0$; when $\Phi = 1$ we obtain a random walk model for the varying parameters; and when $\Phi = 0$ we have a random coefficient model where the coefficient fluctuates randomly around a mean value.

The MRV model in (9) can be rewritten as:

$$\left(\beta_{i,t} - \bar{\beta}_i\right) = \Phi\left(\beta_{i,t-1} - \bar{\beta}_i\right) + v_{i,t} \tag{10}$$

Time-varying coefficient regression models are an interesting application of state-space models, where the left hand side unobserved component in (10), $\xi_{i,t} = \left(\beta_{i,t} - \bar{\beta}_i\right)$ changes with time. As stated in Hamilton (1994), assuming the eigenvalues of Φ are all inside the unit circle, the fixed coefficient, $\bar{\beta}_i$, is the average or steady-state coefficient vector, while the TVP unobserved parameter $\xi_{i,t} = \left(\beta_{i,t} - \bar{\beta}_i\right)$ represents the varying deviation from its mean parameter.

This modelization allows us to include both fixed $(\bar{\beta})$ and varying (ξ_t) parameters for some regressors in the measurement equation (while constant-only parameters for the rest of determinants) as follows in (11):

$$y_t = x_t'\bar{\beta} + x_t'\xi_t + z_t'\alpha + \omega_t \tag{11}$$

Using the above framework, we estimate a time-varying fiscal reaction function for the Eurozone countries in a specification where, according to the Barro (1979) tax-smoothing model, we include other non-debt determinants of the primary surplus as control variables. The choice of these variable is not trivial in order to have a proper specification. As in Mendoza and Ostry (2008), who compare fiscal reaction functions for advanced and emerging economies, we include a business cycle variable (YVAR) and the level of temporary government spending (GVAR).[19] The latter captures unexpected expenditures, unrelated to the economic cycle. Both YVAR and GVAR are computed by detrending GDP and government expenditure, respectively, by applying the Hodrick-Prescott-Filter (HP-Filter) to their observed values. It is important to note that we are calculating these variables in the same fashion as in Bohn (1998). He constructs the measures of temporary fluctuations in output and government purchases that enter in the closed-form solution of Barro (1979) tax-smoothing model. In that case YVAR is the percent deviation of trend GDP from actual GDP times the ratio of trend government expenditure to actual GDP. Consequently, we should expect that the sign of the coefficient linked to this variable to be the opposite of that produced by specifications that use a simple output gap to measure the business cycle.[20]

The recent developments in the Eurozone may have induced changes in the public finances like increasing short-term fiscal multipliers or the impact derived from banking bailouts that imply government expenditure hikes that go beyond the size measured through a standard expenditure gap variable. However,our empirical approach makes no necessary to call for additional controlling factors or dummy variables in the econometric specification since we capture the time-varying nature in the public debt-primary balance relationship. Finally, in addition, we include an intercept and the lag of the primary balance/GDP ratio.

The equation to be estimated is:

$$PS_{i,t} = \beta_{i0} + \beta_{i1}PS_{i,t-1} + \bar{\beta}_{i2}B_{i,t-1} + \xi_{i,t}B_{i,t-1} + \beta_{i3}GVAR_{i,t} + \beta_{i4}YVAR_{i,t} + \omega_{i,t} \tag{12}$$

where $\xi_{i,t}$ represents the varying component for the parameter of the debt/GDP ratio, which can be interpreted as the deviation from mean-parameter, $\left(\beta_{i2,t} - \bar{\beta}_{i2}\right)$ for lagged gross debt ratio. The model is estimated through the Kalman Filter with a transition as described at (10). We focus on the debt-to-GDP variable because its evolution is supposed to trigger a reaction by the national fiscal authorities. Note that 2006 coincides with the eve of the global credit crisis that affected economic activity in the whole euro-area but with asymmetric effects depending on the individual degree of leverage across countries.

As highlighted in Greiner and Fincke (2014) or Nguyen et al. (2017), the above theoretical framework suggests a fiscal reaction function for the primary surplus with an expected positive coefficient for the debt ratio. Negative signs of the busi-

[19] Other additional control variables like the interest rate and inflation are also often included to account for financial market stress and value effects.

[20] See Mendoza and Ostry (2008).

Table 3
TVP fiscal reaction function 1970–2014. European countries.

	Intercept	PS_{t-1}	B_{t-1}	$YVAR_t$	$GVAR_t$
Portugal	−1.593***	0.093	0.0126	0.056	−0.739***
	(−2.666)	(0.718)	(0.811)	(0.852)	(−5.470)
Ireland	−5.347***	0.270***	0.033	−0.263***	−1.001***
	(−5.272)	(4.198)	(0.899)	(−2.917)	(−15.957)
Italy	−5.936***	0.229	0.065***	0.173*	−0.608***
	(−4.625)	(1.049)	(4.301)	(1.671)	(−3.456)
Greece	−1.336**	0.322**	0.011	−0.060	−0.677***
	(−2.168)	(2.334)	(0.812)	(−0.739)	(−6.196)
Spain	−0.979*	0.604***	0.016	0.126	−0.546***
	(−1.832)	(4.339)	(1.224)	(1.235)	(−3.612)
Finland	3.904***	0.304**	−0.050*	−0.044	−0.678***
	(3.637)	(2.307)	(−1.864)	(−0.540)	(−6.236)
Belgium	−5.113***	0.165	0.063***	−0.211*	−0.927***
	(−2.710)	(1.495)	(2.737)	(−1.952)	(−9.838)
Germany	−0.631**	0.004	0.020***	−0.149***	−0.988***
	(−2.176)	(0.064)	(2.744)	(−3.771)	(−17.910)
France	0.048	0.137	−0.010	0.026	−0.681***
	(0.170)	(1.124)	(−0.949)	(0.289)	(−5.302)
Netherlands	1.004***	0.027	−0.004	−0.199**	−0.954***
	(2.735)	(0.297)	(−0.358)	(−2.072)	(−10.685)
Austria	−0.681	0.633***	0.014	0.039	−0.458***
	(−1.311)	(6.247)	(1.526)	(0.3547)	(−3.697)
Observations	43				

Notes: *t*-tests in parentheses.
$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

ness cycle variable *YVAR* and the expenditure gap, *GVAR* are compatible with the tax-smoothing model. In principle, the output gap may be expected to be correlated to some extent with the primary balance through the fiscal multiplier effect, while the public debt could be correlated with the residuals, creating a downward bias on the estimated coefficient on debt. However, it is worth noting, as both Kim and Kim (2011) and Swamy et al. (2017) state, that an appropriate state-space representation of the model, can minimize the endogeneity concerns that are likely when estimating fiscal reaction functions due to the interactions between variables entering the equation.

Finally, note that in this notation we drop the assumption of a time-invariant β parameter for our fiscal reaction function, allowing it to be time-varying. Canzoneri et al. (2001) state that such a time-varying policy rule is sustainable provided that $\beta_{i2,t} = \bar{\beta_{i2}} + \xi_{i,t}$ is always non-negative. However, Greiner and Fincke (2015) consider this condition too restrictive and show that a sufficient condition for fiscal sustainability is for the reaction coefficient to be positive on average. In our framework, fiscal sustainability is signaled if the fixed-parameter component (its mean) turns to be positive and significant. Otherwise, fiscal sustainability is not guaranteed (or at least properly signaled).

5. Results and discussion

The estimates of the mean-reverting time-varying parameter fiscal reaction model, after adjusting for cyclical factors and fluctuations in government spending are reported in Table 3. The upper part of Table 3 displays the results found for the six peripheral countries considered in our study,[21] while the lower part gathers the results of the core countries, where Belgium is a borderline case due to its historically high indebtedness record. Only a few countries perform a continued reaction effort during the whole period responding to debt increase measured by the fixed-parameter on gross-debt ratio. More specifically, only Italy, Belgium and Germany have a positiveand significant fixed mean parameter, meaning that they are systematically responding to changes in the debt-GDP ratio. Italy and Belgium have historically exhibited a high debt problem and have to monitor its evolution very tightly in order to avoid further pressures from the markets. Conversely, the case of Germany is a more discretionary policy decision. Note that the coefficients are in line with those found by recent literature using different empirical approaches .[22]

A salient feature of our analysis is that, in contrast to other studies, the rest of EMU countries, (Portugal, Ireland, Greece, Spain, France, the Netherlands and Austria) do not exhibit this permanent fiscal reaction component. The majority of peripheral and core countries exhibit only a salient time-varying component (which has been estimated as an unobserved variable for each country).

[21] We consider Finland as a peripheral country in our study. Although this criterium is "ad hoc", this country shows some special economic and political characteristics during the sample period considered (e.g. transition from a close dependende from the former USSR) that can justify this decision.

[22] See, for example, Checherita-Westphal and Ždarek (2015), European Commission (2011) and Baldi and Staehr (2015) where the coefficient varies between 0.01 and 0.10. depending on countries. In our case they are comprised among 0.02 and 0.06.

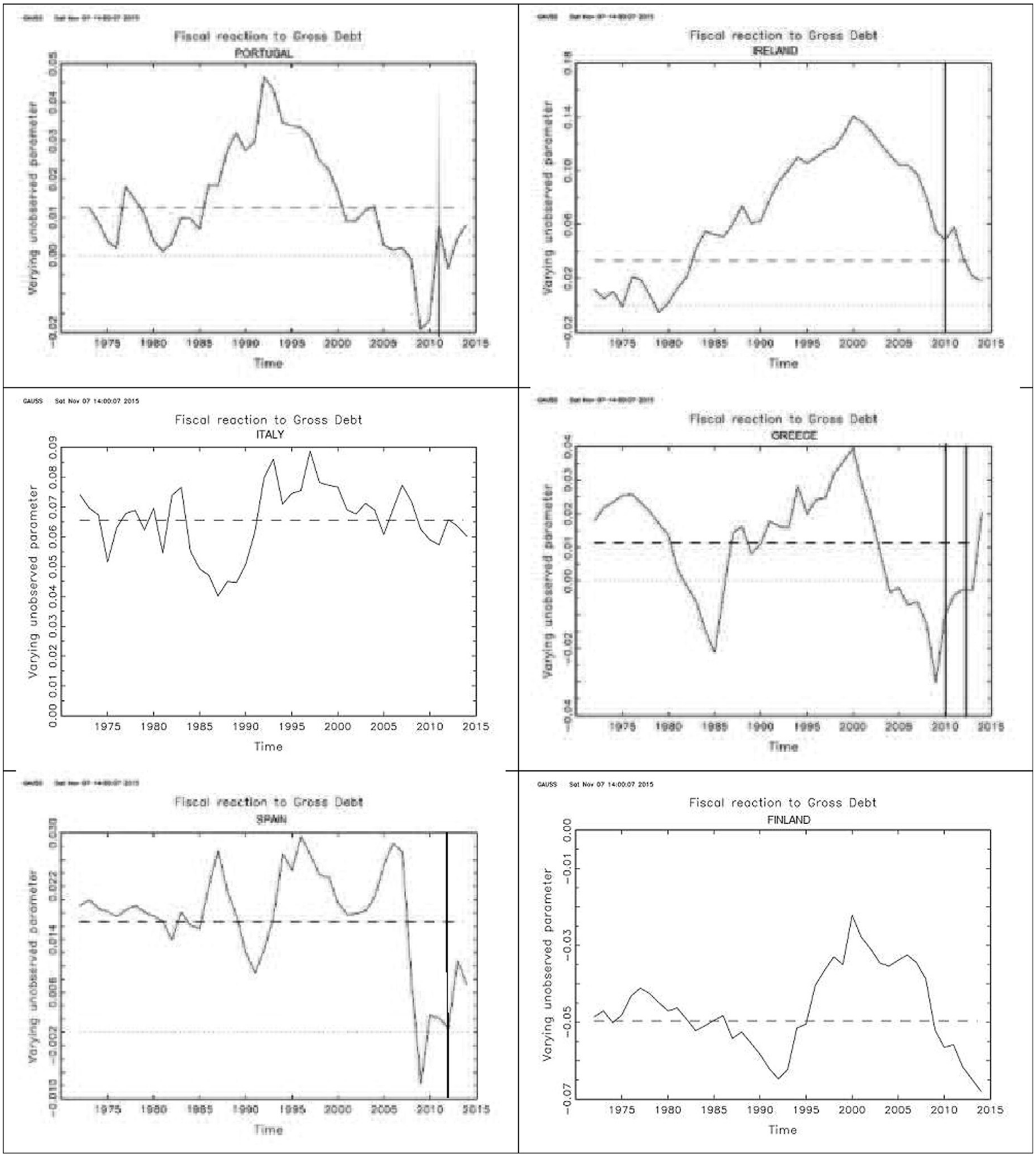


Fig. 2. Time-varying component of government primary surplus to gross debt ratio: peripheral EMU countries.

Therefore, the analysis of the permanent component has to be completed with the visual inspection of the evolution of the time-varying component in Figs. 2 and 3, where we plot graphs for individual countries. The vertical line show bailout episodes in Greece (2010, 2012), Ireland (2010), Portugal (2011) and Spain. Overall, we appreciate a highly heterogeneous time-varying response to debt accumulation across countries.

In a Mean Reverting Model, the time-varying component is identified with the number of reverting episodes (i.e., the number of times that the TVP crosses the mean) experienced by the different countries together with the sign (positive o negative) of its mean. Germany, Austria, the Netherlands among the core EMU countries and, to some extent, Italy and Spain (before the 2007 crisis) within the peripheral ones seem to react more actively to changes in the debt/GDP ratio. By contrast, most peripheral countries (Portugal, Ireland, Greece or Finland) together with France, show a slower reaction that only appears when some threshold in the debt ratio has been reached.

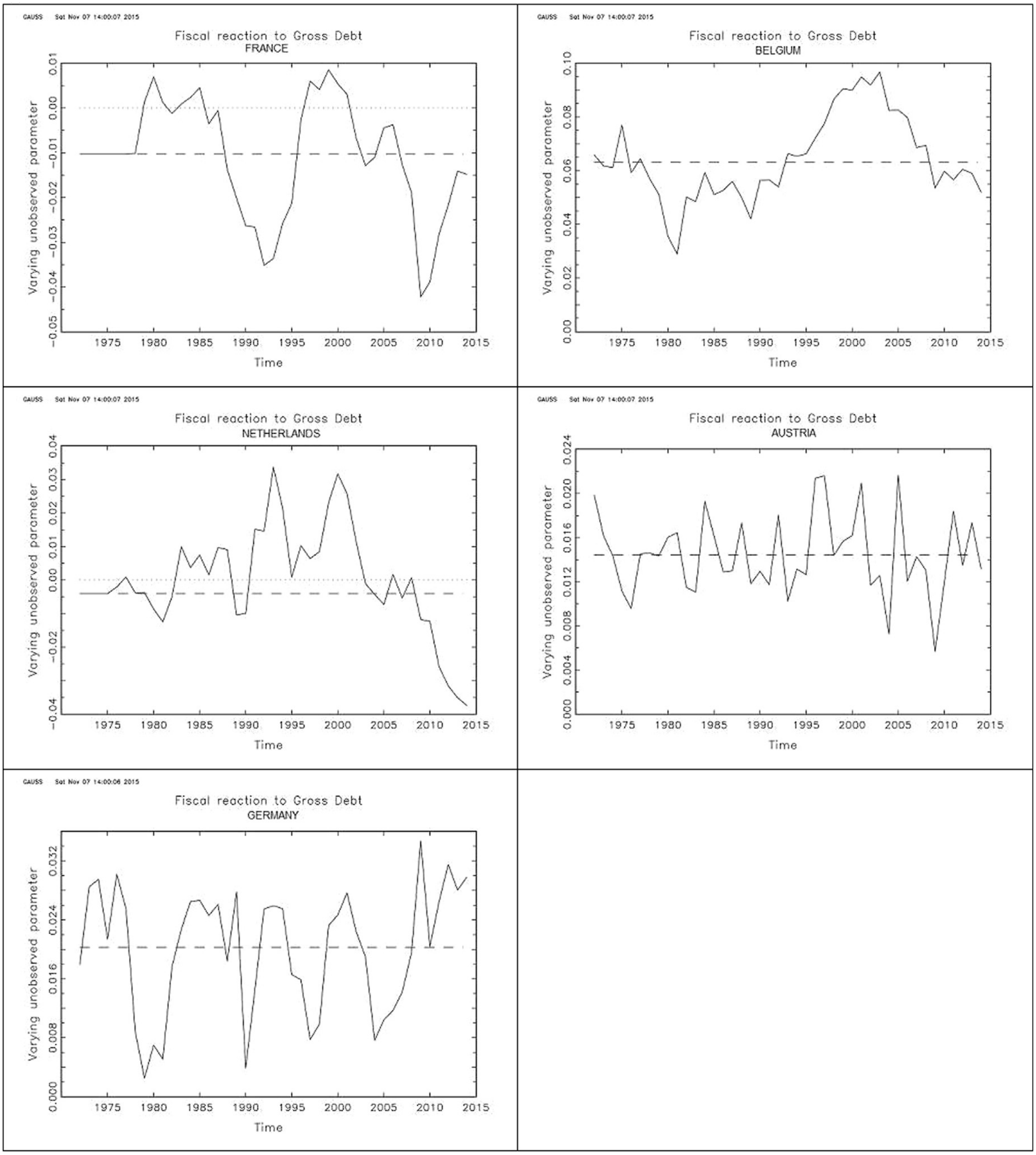


Fig. 3. Time-varying component of government primary surplus to gross debt ratio: core emu countries.

Focusing on Spain, Greece, Portugal, and Ireland, the plot displays a reduced emphasis of the government on a continuous debt stabilization. This behavior signals, despite transitory positive reaction coefficients, the lack of a pro-active and permanent willingness of the fiscal authorities to correct the increasing debt ratio. It is easy to detect crisis episodes (EMS crisis in the 90s) that trigger a response beyond a threshold in the TVP. Moreover, the responsiveness seems to have augmented after the 2007 crisis for the case of Portugal, Greece[23] and Spain, which is at odds with the fiscal fatigue hypothesis posited by some authors (Fournier and Fall, 2015) and in line with some other recent empirical evidence like Baldi and Staehr (2015).

Bailouts triggered heterogenous responses in different countries. Portugal and Ireland exhibit mirror responses. After their bailouts, both countries reverted shortly their paths towards the mean, but in opposite directions (Portugal with a

[23] In spite of some possible "gambling for redemption" periods.

decreasingly negative coefficient and Ireland reducing a positive one). Greece, on the other hand, initiated a fiscal response prior to the first bailout, which has amplified only by the second aid episode. In these three countries, the bailout relaxed the fiscal reaction which was already taking place. This evidence is consistent with the moral hazard associated with bailouts (Farhi and Tirole, 2012), which Dam and Koetter (2012) document for German banks. Conversely, the Spanish bailout (which only involved the banking sector) had a positive effect as the TVP approached the mean. However, its effects where worn out after one year, questioning the long-term efficiency of the bailout.

Finally, concerning the additional explanatory variables, GVAR and YVAR, their estimated coefficients in the fiscal reaction function are reported in the fourth and fifth columns of Table 3. The coefficients of both variables are negative[24] in line with previous results by Bohn (1995) and Barro (1986) or, more recently, in Mendoza and Ostry (2008). However, our findings indicate that the expenditure gap GVAR is significant for all the countries while in the case of the business cycle YVAR variable is only significant for Germany, the Netherlands, Ireland, Belgium and Italy.

6. Conclusions

In this paper we study the fiscal sustainability of EMU countries and its dynamic adjustments. Univariate tests provide inconclusive results regarding the stationarity the debt-to-GDP ratio. Furthermore, we find evidence of multiple structural breaks suggesting dynamic interaction between pro-active fiscal policies and particular events distorting the path of the fiscal series along time. However, the standard analyses remain silent on these dynamic adjustments.

With the time-varying estimate of the fiscal reaction function we are able to disentangle both long-term fiscal sustainability and the variation in the degree of responsiveness towards sustainability. In a stochastic environment, the magnitude and size of the fiscal reaction function not only counteracts the process of debt accumulation, but also introduces a credibility issue, by signaling the government's commitment to lead back public debt accumulation inside a sustainable path.

Our results reveal certain heterogeneity regarding fiscal reaction, showing that the core vs. peripheral taxonomy is rather arbitrary. Countries involved in the Eurozone bailouts (Greece, Ireland, Portugal and Spain) do not exhibit this permanent fiscal reaction component, but only a salient time-varying one. These countries have not been reacting in a systematic way to debt accumulation; they only show isolated episodes of fiscal reaction to debt under extreme circumstances.

The effects of bailouts have been rather limited measured through the dynamic fiscal reaction they triggered. The bailed countries reaction started before the rescue and in all cases excepting Spain we appreciate evidence pointing to the existence of moral hazard. The results suggest that these countries reacted only after a certain debt threshold was reached. For example, during the convergence process after the EMS crisis and prior to EMU or, more recently, after the 2007 financial crisis.

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[24] with the only exception of Italy in the case of YVAR.

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