Non-linearities in Fiscal Policy: Evidence from the Eurozone*

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Abstract: This paper investigates the existence and the policy implications of non-linear fiscal policy rule for the Eurozone for the period 1978 to 2015, focussing on differences between countries that were under pressure during the sovereign debt crisis and the ones that were not. We investigate these asymmetries regarding the response of the primary (cyclically-adjusted) balance to changes in the debt-to-GDP ratio and the output gap, thus capturing the trade-off between fiscal sustainability and output stabilisation. To do so we use a novel method to determine an endogenous threshold in the presence of regressor endogeneities. We provide evidence based on which national fiscal policies follow a non-linear path to output stabilisation and debt sustainability depending on the location of the economy. More specifically, core EMU countries seem to have followed an a-cyclical fiscal policy with regard to changes in output by allowing the automatic stabilisers to operate. This reaction is found to be non-linear, and is stronger in worse economic conditions. Their periphery counterparts followed a linear pro-cyclical fiscal policy with regard to output, which required a stronger reaction debt, in particular when debt is reaching high levels. Our analysis confirms that changing responses between fiscal sustainability and output stabilisation may reflect underlying differences between linear and non-linear fiscal policies in different EMU countries.

Keywords: Fiscal reaction function, Sustainability, Stabilisation, Rolling window, Dynamic panel data, Threshold effects.

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1. Introduction

The sovereign debt crisis, followed by an intensive consolidation period in many countries, and the double-dip recession in the Eurozone in 2012 led to debates on the scope, the size and the timing of the necessary adjustment as well as on the desirability and possibility of a counter-cyclical fiscal stance. These debates can be considered to be two sides of the same coin. The European sovereign debt crisis points to insufficient attention to fiscal sustainability before the crisis, while the subsequently necessary consolidation effort restricted the possibility for fiscal policy to contribute to stabilising output, in an environment when monetary policy hit the lower-bound.

In principle, fiscal stabilisation and sustainability can be compatible objectives of a fiscal strategy that aims to reduce debt in good times, thus creating the fiscal buffers to provide room for macroeconomic stabilisation in bad times. The mixed experiences of EMU countries over the past few years raises the question what fiscal stance actually has been pursued by various governments. In particular, is there a difference between the countries that came under market pressure and those that did not? Secondly, are there differences in the strategy over time or are there different regimes, for example when government debt-to-GDP has become very high?

To address these issues, we estimate fiscal reaction functions (FRF) for the euro area countries, using a dataset from 14 euro- and non-euro area countries covering fiscal and macroeconomic variables over the 1978-2015 period. From a policy perspective fiscal policy reaction functions are usually examined for two reasons: (1) to investigate whether fiscal policy is driven by efforts towards debt stabilisation, and (2) to examine the macroeconomic stabilisation properties of fiscal policy (see inter alia Bohn, (1998); Checheritta-Westphal and Ždarek, (2015); Nerlich et. al., (2015); Reicher (2014); Weichenrieder et. al., (2014))[2]. Recently, there has been a focus on non-linear FRF. So far these extensions refer either to typical ex ante imposed nonlinear versions of FRF, i.e. polynomial functions either quadratic or cubic (see Bohn, (2005); Gosh et. al., (2011), (2013); Medeiros,

[2] Fiscal policy reaction functions have been examined for additional reasons. Claeys (2006) examines the interaction between the fiscal and monetary policy setting by augmenting the fiscal reaction function with the short term interest rate. Celasun et. al. (2006) examine primary surplus behaviour and risks to fiscal sustainability in emerging market economies accounting for factors that are likely to be important drivers of primary balances such as, the real oil price, institutional quality, sovereign default status, commitment to an IMF program. Tangalakis (2011) investigates the links between financial market movements and fiscal policy outcomes.

(2012)), regime-switching models (see Fournier et. al., (2015); Legrenzi et. al., (2013)), time-varying debt coefficients using state-space modelling and penalized spline estimates (Fincke et. al., (2011); (2012)) and only few studies employ a non-linear impact analysis accounting for the effects of exogenously imposed debt thresholds (see Celasun et al., (2007), Cimadomo, (2012), Lukkezen et. al., (2012) (2013)).

Fiscal reaction functions typically consider the response of fiscal policy (usually measured as changes in the (cyclically-adjusted) primary balance) with regard to cyclical conditions (usually measured by the output gap) and fiscal conditions (measured by the lagged (cyclically-adjusted) primary balance and debt-to-GDP ratio). A positive response of fiscal policy to fiscal conditions is regarded as a "weak condition" for debt sustainability (see Bohn (1998) and (2005)). A positive response of the cyclically-adjusted primary balance to the output gap indicates a discretionary fiscal policy oriented towards countercyclical stabilisation, whereas a negative response indicates a procyclical policy. The primary balance includes the effect of automatic stabilisers and is therefore expected to respond stronger to improvements on the output gap than the cyclically-adjusted primary balance.

Based on the average effect of the automatic multipliers in European countries, a coefficient higher than 0.5 would imply a countercyclical stabilisation response of the primary balance. However, as Golinelli and Momigliano (2009) point out, despite a widespread consensus on the average value of automatic stabilisers, the difference between the cyclically-adjusted and non-cyclically-adjusted balance is depends on the actual value of the automatic stabilisers and the accurateness of the output gap estimates. In this paper, we estimate fiscal reaction functions for both the primary balance and cyclically-adjusted primary balance to the output gap, and consider a coefficient above a level "towards 0.5", respectively a positive coefficient, as an indication of a countercyclical fiscal stabilisation response.

We analyse the evolution of the fiscal policy mix for EMU as a whole, and for two groups of countries to investigate differences between the countries that came under market pressure during the crisis (“periphery”) and those that did not (“core”).[3] By examining a period of almost five decades and allowing differences over time, we consider whether the fiscal policy of EMU countries has evolved over during major economic changes, such as the transition from national fiscal and monetary policies to closer coordination in the period of the Maastricht Treaty and the SGP (1993 and 1997 respectively), the introduction of the common currency (2000), and the recent crisis episodes. While the focus of our analysis is on a backward-looking assessment of the fiscal reaction functions, knowledge of the past can inform policy conclusions for the future conduct of fiscal policy in EMU.

To the best of our knowledge, our paper adds to the literature in the following four ways. First, our paper focusses on cross-country heterogeneities in fiscal policy among EMU members, with particular interest to the crisis period**.**[4]

Second, this is the first study to analyse the existence of an endogenous threshold to the variables of policy interest i.e. debt (as % of GDP) and output gap. We treat the threshold variable as an endogenously determined parameter in a dynamic GMM panel data context that additionally relaxes exogeneity assumption of regressors. Effectively this means that we treat the sample split (threshold) value as an unknown endogenous parameter to be estimated from the data and accounts for the endogeneity of regressors using additional instruments as well as employing regime-specific heteroscedasticity of the error terms. Failure to capture this aspect may lead to biased and inconsistent estimators of the standard least squares (CLS) threshold estimator of Hansen (2000) used in the literature (see Yu, 2013).

Thirdly, similar to the study of thresholds to the debt-growth nexus in Reinhart and Rogoff (2010), and rather than treating non-linearities as a statistical artefact, we look into detail the underlying fiscal policy implications from non-linearities in fiscal policy rules.

[3] The division of EMU in periphery (Greece, Ireland, Italy, Portugal and Spain), and core (Austria, Belgium, Finland, France, Germany and the Netherlands) is motivated by the degree of market pressure during the crisis and follows a number of other studies (see Argyrou et. al. (2012), Afonso et. al. (2015), Palaiodimos et. al. (2015),).

[4] Baldi and Staehr (2015) also consider differences in fiscal reaction functions between Eurozone countries that were affected during the crisis and those that were not, based on quarterly data for the pre-crisis period 2001–2008 and for the crisis period 2009–2014. In contrast to our paper, they do not find difference in fiscal reaction functions before the crisis.

Lastly, we manage to avoid potential endogeneity bias rising from the output gap and the dependence of lagged debt on past values of primary balance (see Medeiros (2012)) by applying dynamic panel data GMM methods instrumented with a well-chosen set of variables. Employing these aspects to our empirical analysis guarantees that our estimates will not suffer from endogeneity bias and will not lead to inconsistent results.

Our findings provide important policy implications for the future conduct of fiscal policy and also may provide a narrative for introducing non-linearities to relevant theoretical models. More specifically, we provide evidence based on which policy conclusions drawn from the total number of EMU countries mask the significant heterogeneities between core and periphery EMU countries. Periphery EMU countries followed a procyclical fiscal policy with regard to output stabilisation, without a discernible differences across different states of the economy. They are also found to react stronger to debt than core countries, which is the flip side of the pro-cyclical stabilisation reaction as high debt levels eventually require a stronger reaction. When we test the thresholds find by our nonlinear model by a bootstrap approach, we find evidence of an endogenous debt threshold of 105% of GDP for periphery countries, which are more responsive to debt changes when in the high debt regime.

For core countries, our findings are a mirror image. They are found to have pursued an a-cyclical fiscal policy with regard to output stabilisation. An output gap threshold is found for core EMU countries at -0.95%. The operation of automatic stabilisers is more evident in the High regime case (i.e. $OG_{i,t} < -0.95$) , and limited when being in the Low regime (i.e. $OG_{i,t} < -0.95$) where output gap is close to closure or even positive. Moreover, in both cases our analysis suggests that while the operation of automatic stabilisers is more important for output stabilisation in the core EMU countries, they gain importance during the crisis period in both EMU country blocks. For core countries, we do not find support of a threshold for responses to debt.

The remainder of this paper is organized as follows. Section 2 presents our baseline and threshold fiscal policy rule. Section 3 describes our dataset. Section 4 provides estimates of the model and discusses the results. Section 5 concludes.

2. Methodology

2.1. A baseline fiscal reaction function

To capture the policy mix between effort to sustainability and the stabilisation properties of fiscal policy in EMU, we follow the seminal work of Bohn (1998, 2005)[5] on sustainability conditions of public finances described by the following formal definition:

$$d_k = -\lim_{T\to\infty} \sum_{t=k+1}^{T} s_t \cdot \left[\frac{1+i}{(1+\beta)(1+\pi)}\right]^{-t}. \quad (1)$$

Equation (1) states the condition for a sustainable fiscal policy i.e. the value of the initial debt-to-GDP ratio (d_k) is be equal to the negative present discounted value of all future primary deficits $\{s_{K+1}, s_{K+2}, \dots, s_{K+T,\dots}\}$.

We employ the "model-based sustainability" version based on which a sustainable fiscal policy requires that governments react to changes in sovereign debt by adjusting their primary balance. In its simplest form, the fiscal reaction function postulates a linear relationship between the level of lagged public debt, the output gap and the government's primary surplus at any given period, or:

$$s_t = \beta' X_t + \varepsilon_t = \alpha_d \cdot d_{t-1} + \alpha_y \cdot y_{it} + \alpha_m \cdot m_t + \gamma' \cdot \Omega_t + \varepsilon_t \quad (2)$$

s_t is the fiscal variable (i.e. at this stage of the analysis the ratio of primary balance to aggregate income (GDP) at time t), d_t is the ratio of public debt to aggregate income, y_t is the output gap, Ω_t is a set of other determinants of the primary surplus and ε_t is the error term. To capture any fiscal financial interlinkages, we augment our specification with a monetary policy variable m_t aimed at reflecting the monetary policy stance [6,7]. In a panel data context, our fiscal rule takes the following form:

$$Pb_{it} = a_{i,t} + \alpha_b \cdot Pb_{it-1} + \alpha_d \cdot D_{it-1} + \alpha_y \cdot OG_{it} + \alpha_m \cdot mon_{it} + \alpha_{y\_US} \cdot OG_{US_{it-1}} + a_{ir} \cdot IIR_{it} + n_i + \lambda_t + \varepsilon_{it}, \ for\ country\ i\ (i = 1, \dots, N)\ and\ period\ t\ (t = 1, \dots, T) \quad (3)$$

[5] As discussed in Bohn (1998 and 2005) this is a model reflecting a "weak condition" of fiscal sustainability. For the purpose of our analysis the relevant coefficient effectively captures the fiscal response and the fiscal effort towards sustainability depending on the use of the dependent variable i.e. the primary balance and the cyclically adjusted primary balance.

[6] Monetary policy is approximated by either the monetary aggregate and/or the interest rate. Due to the long span of our examination period we opt for the latter option and use the deviation of the real interest rate from its value as implied by the Taylor (1993) rule, with a negative (positive) value of this variable capturing the monetary excesses (shortages) resulting from the adoption of an expansionary (contractionary) monetary policy stance (see among others Clarida et. al., 1998; Taylor, 2009.

[7] Theoretical studies include those of Aiyagari et. al. (1985), Sims (1988), Leeper (1991) and Davig et. al. (2011) while empirically those of Taylor (2000), Fragetta et. al. (2010), Claeys (2006) address the same issue.

where Pb_{it} stands for the primary balance as a percent of GDP (current prices). D_{it-1} is the lagged general government consolidated gross debt (as a percent of GDP). OG_{it} denotes the gap between actual and potential gross domestic product at 2010 reference levels as a percentage of potential gross domestic product (constant prices). mon_{it} captures the monetary stance and is defined by the deviation of the interest rate implied by the Taylor-rule from the prevailing 3-month real interest rate. $OG_{US_{it-1}}$is the lagged US output gap (constant prices) while IIR_{it} stands for the implicit interest rate on government debt[8]. n_i and λ_t stand for unobserved country and time effects and lastly ε_{it} is the random component, which could be perceived as reflecting the non-systematic policy response or the fiscal policy shocks, which are independent across countries.

The presence of a lagged dependent variable implies that estimating eq. (3) with fixed effect OLS and IV estimators render the coefficient estimates inconsistent. Following Celasun et. al. (2006)[9], Candelon et. al. (2010), Golinelli and Momigliano (2009), Medeiros (2012), we use GMM estimators and take into account the possibility of endogeneity of the output gap to contemporaneous fiscal shocks and of the lagged debt to past values of primary balance. We instrument eq. (3) with instrumental variables and employ a dynamic panel data one-step system GMM estimator. In our specification we use one and two lags[10] of the endogenous variables i.e. output gap (OG_{it}), the debt to GDP ratio (D_{it-1}) and the Implicit interest rate (IIR_{it}) as instruments**.** The decision on the subset of instruments to be used in each case is based on the performance of the Sargan test of over-identifying restrictions and the absence of second order autocorrelation in first difference errors (i.e. that moment conditions are valid)[11]. Following the dynamic GMM approach in the specification below the 2nd parenthesis represent endogenous while the 3rd and 4th parentheses represent instrumental variables:

[8] Following Candelon et. al. (2010) and Debrun et. al. (2013) we incorporate in our fiscal reaction function model one lag values of the US output gap and also implicit interest rate.

[9] In addition, as pointed out by Celasun and Kang (2006) ‘‘if other regressors in the fiscal reaction function such as the output gap are potentially endogenous to contemporaneous primary balance shocks and would need to be instrumented”, then the Arellano and Bond (1991) and Blundell and Bond (1998) GMM estimators are ‘‘the best performing estimator for the coefficients of the endogenous variables”.

[10] According to Bond (2002) and Roodman (2009) omitting the more distant lags might not lead to significant loss of information.

[11] In all specifications, the test on over-identifying restrictions indicates that the hypothesis that instruments are valid cannot be rejected and that there is no higher than 2nd order autocorrelation. As a robustness test contemporaneous Government investment to GDP spending is also introduced in the estimation. Results in this case point to similar findings.

$$Pb_{it} = a_{i,t} + \alpha_b \cdot Pb_{it-1} + \alpha_{y_{US}} \cdot OG_{US_{it-1}} + \alpha_m \cdot mon_{it} + (\gamma_{ir} \cdot IIR_{it} + \boldsymbol{\gamma_y} \cdot OG_{it} + \gamma_d \cdot D_{it}) +$$

$$\underbrace{\left(\delta_{ir} \cdot IIR_{it-1} + \delta_y \cdot OG_{it-1} + \boldsymbol{\delta_d} \cdot D_{it-1}\right) + \left(\varepsilon_{ir} \cdot IIR_{it-2} + \varepsilon_y \cdot OG_{it-2} + \varepsilon_d \cdot D_{it-2}\right)}_{\text{Instruments}} + n_i + \lambda_t + \varepsilon_{i,t} \quad (4)$$

endoSet of endogenous

Our analysis mainly focuses to the coefficients that are relevant for fiscal policy analysis and these are captured by γ_y and δ_d that express the effort towards sustainability and stabilisation.

2.2. A fiscal reaction function with an endogenous threshold

There are reasons to expect that varying levels of debt and/or output prompt governments and/or central banks to form different preferences on the policy mix regarding stabilisation of the debt and/or the business cycle. Hence, a non-linear specification conceal valuable information about the state-dependent nature of the interaction between the government budget balance, on the one hand, and its macro and fiscal determinants, on the other. We augment our fiscal reaction function with a threshold parameter of interest that enables us to distinguish between regimes of fiscal policy regarding the two objectives.

Threshold regression models (see Hansen, 2000; Caner and Hansen, 2004) divide the sample observations in two regimes depending on the exogenous threshold value of a certain regressor and then provide different estimates of regression slopes for every regime. The latest addition to the threshold regression literature is the structural threshold regression (STR) model of Kourtelos et. al. (2015). This allows the estimation of an endogenous[12] threshold value to the variable of interest in a dynamic GMM panel approach accounting also for regime specific heteroskedasticity. This is quite relevant in this paper as we account for the endogeneity of fiscal variables i.e. out gap and debt. Failing to capture this aspect may lead to biased and inconsistent estimators of the standard least squares (CLS) threshold estimator of Hansen (2000) and Caner and Hansen, 2004 (see Yu, 2013)[13].

[12] Correlation at this point reflects contemporaneous correlation of the variable of interest with the error term in Equation (3).

[13] Using a GMM dynamic panel approach along the lines of Kourtelos et. al. (2013; 2015) and Kazanas et. al. (2015) and Seo et. al. (2016), to estimate the coefficients of interest, we address potential sources of endogeneity bias, not tackled up to now in the majority of existing fixed-effect applications employed in the literature. These refer to the contemporaneous correlation of the output gap to persistent fiscal policy shocks (ε_{it}), the dependence of lagged debt to past values of primary balance (A positive shock to the primary surplus in period t-1 would result to a decrease in the stock of public debt in the same period). According to Medeiros (2012), "countries able to generate higher primary balances on average - reflected in the higher values of the fixed-effects coefficient - will tend to have a lower level of public debt; if this correlation is not taken into account, the negative correlation between debt levels and the unobserved country fixed-effects would exert a

The threshold variable q_{it} - in our case the debt-to-GDP ratio and the output gap interchangeably – is splitting observations in two regimes according to the following indicator function:

$$I(q_{it} \leq \gamma) = \begin{cases} 1 & \text{iff } q_{it} \leq \gamma\text{: Regime 1} \\ 0 & \text{iff } q_{it} > \gamma\text{: Regime 2} \end{cases} \quad (5)$$

with $I(q_{it} > \gamma) = 1 - I(q_{it} \leq \gamma)$.

The assumed endogeneity of the threshold variable enables the below reduced form equation (an analogous to the selection equation in the literature on limited dependent variable models) determining which regime applies to take the form:

$$q_{it} = \pi_q' \cdot Z_{it} + v_{qit} \quad (6)$$

In contrast to previous sample selection models, where the threshold variable allowing the division of observations into different regimes is taken to be latent or given, here the threshold variable is treated as an estimable parameter.

Following Kourtelos et. al. (2015) we generalize equation (2) in a two regime form:

$$s_{it} = \beta_{X1}' \cdot X_{it} \cdot I(q_{it} \leq \gamma) + \beta_{X2}' \cdot X_{it} \cdot I(q_{it} > \gamma) + \kappa \cdot \Lambda_{it}(\gamma) + \varepsilon_{it}\ , \quad (7)$$

which can be also expressed as:

$$s_{it} = \beta' \cdot X_{it} + \delta' \cdot X_{it} \cdot I(q_{it} \leq \gamma) + \kappa \cdot \lambda_{it}(\gamma) + \varepsilon_{it}\ , \quad (8)$$

where $\mathrm{E}(\varepsilon_{it} - Z_{it}) = 0$.

In this equation λ_{it} is a scalar variable that involves an inverse Mills ratio term for each of the two regimes in order to restore the conditional mean zero property of the error ε_{it} and defined as follows:

$$\lambda_{it}(\gamma) = \lambda_{1it}(\gamma) I(q_{it} \leq \gamma) + \lambda_{2it}(\gamma) I(q_{it} > \gamma) \quad (9)$$

with $\lambda_1(\gamma - Z_{it}'\pi_q) = -\frac{\varphi(\gamma - Z_{it}'\pi_q)}{\Phi(\gamma - Z_{it}'\pi_q)}$ and $\lambda_2(\gamma - Z_{it}'\pi_q) = -\frac{\varphi(\gamma - Z_{it}'\pi_q)}{1-\Phi(\gamma - Z_{it}'\pi_q)}$ while $\varphi(\cdot)$ and $\Phi(\cdot)$ indicate the normal probability density function and cumulative density function respectively.

By defining the criterion $S_n(\gamma) = S_n(\widehat{\varepsilon_{it}}) =$

$$= \sum_{i=1}^{n} \left(s_{it} - \widehat{\beta_{X1}'} \cdot X_{it} \cdot I(q_{it} \leq \gamma) - \widehat{\beta_{X2}'} \cdot X_{it} \cdot I(q_{it} > \gamma) - \hat{\kappa}(\gamma) \cdot \hat{\lambda}_{it}(\gamma)'\right)^2$$

downward bias on the response of the primary surplus to lagged debt. The remaining sources of endogeneity may come from the correlation of the lagged debt with the country-specific and time-invariant determinants of primary surpluses as well as the persistence of errors making lagged debt endogenous.

the value of γ can be estimated[14] by minimizing the CLS criterion: $\operatorname{argmin}_{\gamma} S_n(\gamma)$.

Finally, contrary to the literature of non-linear fiscal policy rules, rather that accepting ex-ante the existence of non-linearities and a threshold, we test for its existence by extending Kazanas et. al.(2015) bootstrap methodology in a panel context[15]. This allows us to test the null hypothesis that the fiscal policy rule is given by the linear representation of Equation (4), against its alternative that of the non-linear fiscal policy rule model of Equation (8), formally $H_0: \delta' = 0$.

3. Data

The dataset consists of annual data on primary budget balance, government debt, and the output gap from the European Commission's AMECO database for the period 1978-2015.Our sample consists of 15 countries, based on data availability: 12 EMU countries (Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal and Spain), as well as Denmark, Sweden and the UK. Our dataset is based on the new European System of National and Regional Accounts (ESA 2010), which only covers the period starting in 1995. Therefore, to obtain a consistent series of historically primary balance data from 1979 onwards, we extend the ESA 2010 dataset backwards by using the annual growth rate of the primary balance as calculated according to the European System of Integrated Economic Accounts (ESA 79).

4. Empirical analysis

First, we present the results from our baseline model. Secondly, we investigate the difference in the fiscal reaction functions over time and between the two country blocks (core and periphery), based on fiscal outcomes during the crisis. This allows us to focus more on the potential country heterogeneities within EMU. Finally, in the last part of the analysis we present our empirical results on the existence of non-linearities in the employed fiscal policy rule and also present estimates for

[14] The consistency and asymptotic distribution of the threshold parameter γ is nonstandard as it involves two independent standard Wiener processes with two different scales and two different drifts, while the construction of confidence intervals is based on the inversion of the likelihood ratio test (see Kourtelos et. al., 2015). In technical annex A, we describe the threshold location in the case of variable endogeneity in a GMM dynamic panel data context.

[15] The procedure is analysed in more detail in the Appendix as a technical annex.

the variables of interest (i.e. L.Debt_to_GDP and Output_Gap) with particular interest into the policy implications of non-linearities between different groups of EMU countries.

4.1. Results from the benchmark fiscal policy model

Table (1) presents baseline estimations for the full period and the full sample of the countries from the fiscal reaction function in eq. (4) together with various alternative specifications regarding the use of endogenous and instrumental variables. Arellano and Blundell Bond estimators are presented in columns 1-4 and 5-7 respectively. We find evidence of a positive fiscal reactions towards debt sustainability ($\mathrm{D}_{i,t-1}$) and stabilisation ($\mathrm{OG}_{i,t}$) for the EMU as a whole, as the primary balance reacts to positively to the debt and the output gap, with the estimated coefficients being statistically significant and ranging between 0.23-0.30 and 0.22-0.24.

In the case of the sustainability coefficient, our estimates are on the high side but still relatively close to estimates in previous literature (i.e. Medeiros (2012), Tangalakis (2011), Weichenrieder et. al. (2014); Checherita et. al. 2015, Debrun et. al. (2013). The difference might be due to the dynamic GMM estimations that accounts for the endogeneity bias of debt and other fiscal variables, as well as also the inclusion of the crisis period in our sample, during which counties responded to debt in a stronger way following market pressures. The lagged primary balance (Pb_{it-1}) appears to have also a significant positive impact on the primary balance, with our estimates being close to findings in the literature.

Moreover, our estimates only partially confirm the findings from Debrun et. al. (2013) of a "stabilising influence of interest payments cost to debt through primary balance" (p. 12) as the coefficients of the contemporaneous and the previous periods effect of Implicit interest rate (IIR_{it}& IIR_{it-1}) even though positive are not significant. According to our estimates there is no clear and significant direct link between fiscal policy in EMU and ECB's monetary policy and US output gap, as captured by exogenous variables i.e., mon_{it} and OG_US_{it-1}. Results from the Sargan (1958) test of over identified restrictions indicate that the hypothesis that the employed instruments are valid cannot be rejected. Lastly, tests on the existence of 2^{nd} order (or higher) autocorrelation indicates its absence in first difference errors (i.e., all moment conditions are valid).

4.2. The fiscal policy mix over time, for core and periphery EMU

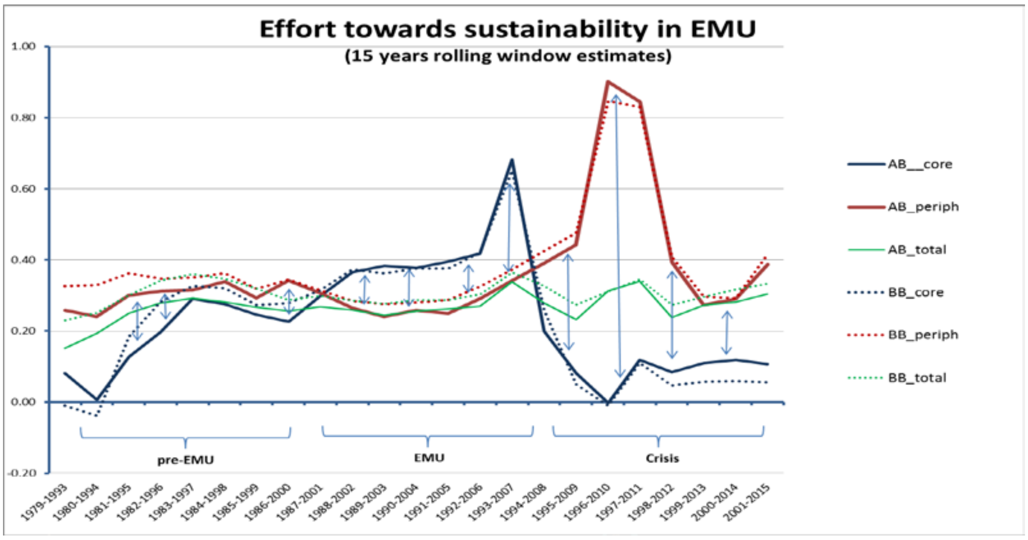
4.2.1. Rolling window estimates

To obtain better insight of fiscal policy mix across time in EMU we re-estimate equation (4) for a series of rolling windows. The resulting time-varying reaction function coefficients allow us to picture any potential non-linearities leading to a differential fiscal policy regime. Analogous approaches have been employed to various monetary policy and financial applications (for details see Swanson (1998), Pesharan et. al. (2002), Kose et. al. (2008), Diebold et. al. (2009) and Fama et. al. (1973)) with windows length ranging between five and ten years. More specifically, we employ a sequential (recursive) estimation of the fiscal rule expressed in eq. (4) for a fixed window refering to a fixed length of 15 years[16]. Following iterative estimation results for the coefficients on the effort to sustainability and output stabilisation objectives (i.e. γ_y and δ_d) of equation (4), figure 1 and 2 present results from the 15-year rolling window estimation during the period 1978-2015 for the Arellano-Bond and the Blundell-Bond methodology.

Figure 1 depicts the estimates of fiscal reaction with regards to debt changes for the EMU counties as a whole and for the core and for the peripheral EMU countries (*AB_i and BB_i, i: total, core, periph*). Our estimates provide evidence that even though average responses of primary balance to debt change tend move in the same direction in EMU there is considerable heterogeneity over time and also between country blocks. In the pre-EMU period, signs of a parallel response can be seen between core and periphery countries expressing increased efforts to enter the Eurozone. The launch of the euro and the convergence of interest rates are followed by a milder fiscal response of the periphery members to reduce debt. This is coupled with an increase in the sustainability effort for the core countries until before the crisis with an average response equal to 0.4 compared to the pre EMU average. When crisis years are included in the estimates, strongly heterogeneous responses between periphery and core EMU to increases in debt are observed.

[16] By construction the estimated coefficients on sustainability and stabilisation from this time varying estimations do not refer to a year specific impact but provide a smoothed or an average effect refering to the number of years included in the window. While restricting the sample may be problematic when going into subgroup of countries, the number of observation per window is kept at minimum around 80. Robustness of results is also performed with the same specifications and alternative window length of 10 and 12 years. Again coefficients of interest and policy conclusions on the fiscal policy remain unchanged. Results are available from the authors upon request.

Figure 1. Fiscal reactions towards sustainability/Arellano-Bond & Blundell-Bond rolling window estimates (15 years)



Note: Endogenous and instrumental variables (Implicit interest rate, Debt as % of GDP, output gap) are included in the specification. Pre-EMU, EMU and Crisis period refer to 1979-2000, 2001-2008 and 2009-2015.

While the total group of EMU countries provide an unchanged profile, underlying heterogeneities are present as core countries respond to the crisis quicker and milder compared to the periphery countries primarily due to the different debt levels. In both cases, the observed extremes in fiscal responses are of a temporary nature as members return to historical averages after some time. Lastly, post crisis differences regarding sustainability efforts remain considerable compared to the pre-crisis period.

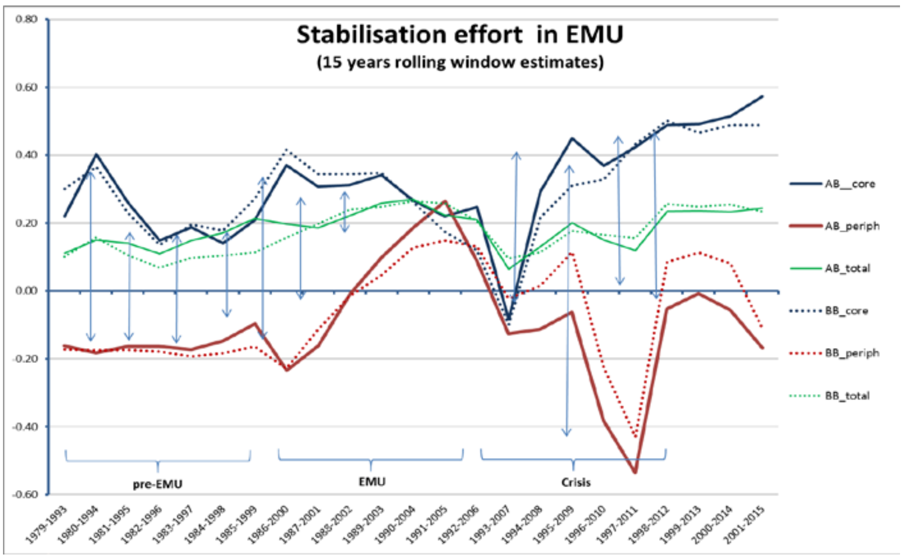
Regarding the stabilisation role of fiscal policy, the differences between both country blocks and over time are more pronounced (see figure 2). While the average EMU response of the primary balance vary around 0.2-0.3 and are in line with previous literature estimates (e.g. Berti et. al. (2016), IMF (2015)[17], Cimadomo (2012)), the coefficient for peripheral countries is estimated to be negative or close to zero for most of the recursive estimates, strongly implying a pro-cyclical fiscal stance. The estimated negative coefficient reaches values close to (+/-) 0.4-0.5, is similar to coefficients reported in recent studies using a system generalised method of moments (Tangalakis (2011), Medeiros (2012), Checherita et. al. (2015)). Looking into the crisis period, the stabilisation efforts in

[17] For more information please see p. 38 of the report with figure 2.1.1 on the impact of the output gap on the fiscal balance and relevant note

this country group from highly pro-cyclical have turned to countercyclical but still remains volatile and not stable pointing however to a change compared to the performance of stabilisers in the pre EMU and part of the EMU period. In this sense crisis has acted as a disciplinary device for stabilisation a finding also met in the reactions towards sustainability.

In contrast, for the core countries, the coefficients are positive for almost all recursive estimates, and vary between 0.2-0.4 before to the crisis to 0.4-0.6 after the crisis. Based on the average value of automatic stabilisers, one would consider a coefficient above 0.5 evidence of a clear counter-cyclical fiscal policy. This can be considered the case only for the core countries where the response to the output gap is increasing for the estimates including the crisis years, with coefficients exceeding 0.5, which suggest discretionary fiscal policy targeting output stabilisation. For the pre-crisis period, the positive coefficients support the view of a traditional automatic countercyclical stabilisation operating in the core countries, resulting in a more or less a-cyclical fiscal stance. In all, our estimates support the observation that the overall fiscal stabilisation over the cycle tends to be more pronounced during recessionary episodes while more contained during expansions[18].

Figure 2. Fiscal reactions towards Stabilisation/Arellano-Bond & Blundell-Bond rolling window estimates (15 years)



Note: Endogenous and instrumental variables (Implicit interest rate, Debt as % of GDP, output gap) are included in the specification. Pre-EMU, EMU and Crisis period refer to 1979-2000, 2001-2008 and 2009-2015.

[18] According to the IMF Fiscal Monitor (2015), p. 28:"Fiscal stabilization tends to operate mostly during recessionary episodes and is virtually absent during expansions (Figure 2.8, panel 1)"

4.2.2. An extended fiscal reaction function capturing country group differences

In this section, we investigate further the difference of the fiscal stance between the core and periphery EMU countries. Since the reaction of the primary balance includes both the effect of automatics stabilisers and discretionary action by the government, it is not a priori clear to what extent the difference in the fiscal stance between the core and periphery is due to discretionary policy or to the functioning of the automatic stabilisers. In this respect, we include the reaction of the cyclically-adjusted primary balance to focus on the role of the discretionary fiscal policy. Indexation rules, significant tax deductions and earmarking rules for revenues for particular spending programs can automatically stimulate public spending during boom times and dampens revenues in bad times (see IMF (2015)).

More specifically we assess differences between groups of EMU countries by re-estimating an extension of eq. 4 that differentiates between the core and the peripheral EMU countries as presented below:

$$Pb_{it} = a_{i,t} + \alpha_b \cdot Pb_{it-1} + \alpha_{y_{US}} \cdot OG_{US_{it-1}} + \alpha_m \cdot mon_{it} + (endog_{i,t} + \boldsymbol{\zeta_X} \cdot X_{it} + \boldsymbol{\zeta_{X\_P}} \cdot X_{it} \cdot periph_{i,t} + \boldsymbol{\zeta_{X\_C}} \cdot X_{it} \cdot core_{i,t}) + (instr_{it}) + n_i + \lambda_t + \varepsilon_{i,t} \quad (10)$$

Where X_{it}: denotes the variable that is relevant to the fiscal policy target i.e. OG_{it} and D_{it-1} while $periph_{i,t}$ and $core_{i,t}$ refer to cross sectional dummies that equal to 1 if country i belongs to peripheral or core EMU countries and 0 otherwise. $endog_{i,t}$ denotes the remaining list of endogenous variables used previously and $instr_{it}$ denotes the full list of instruments (with 2 lags as explained previously). At this point, coefficients of interest are denoted as: ζ_{X_P}, ζ_{X_C} and ζ_X with the first one refering to the additional effect for the periphery countries and the second one to the core EMU countries.

4.2.2.1. Primary balance

As we are interested into the potential changes of fiscal policy over the course of the crisis years we consider for illustrative purposes three sub-samples in our analysis i.e. one referring to before crisis period covering 1978-2007 (capturing also the Great moderation period[19]), the second from 1978-2011 and the third one for the period 1978-2015. Estimation output from both AB and BB of fiscal reactions towards debt and output stabilisation are reported in Tables 2 and 3.

Based on these findings periphery EMU countries have actively used fiscal policy to respond to previous year's debt increases. Compared to sample pool estimate (ζ_d) which is rather stable and estimated around 0.2, their response while more moderate in the pre-crisis period (ζ_{d_p}: 0.21) increases during the crisis (ζ_{d_p}: 0.25) in the presence of elevated market pressures. An analogous response is not found in the case of the core EMU group of countries as a positive and statistically significant effect depends on the method of estimation. Even in the case of the BB estimators (col. 7-9) where a weaker significant reaction is estimated, this is lower compared to that observed for the peripheral group of EMU countries. As previously analysed, signs of a fiscal fatigue are also observed when combining group of EMU countries specific coefficient estimates (i.e. ζ_{d_P}, ζ_{d_C}) with pool sample estimates (ζ_d) across time. However, for core EMU countries, there are no clear indications of an additional contribution (ζ_{d_P}) on top of the baseline estimate (ζ_d). In the case of the peripheral countries, adding both coefficients provides support of fiscal fatigue as the coefficients in the full sample returns to the pre-crisis levels (col. 4-6 and 7-9) after peaking for the sample ending in 2011.

Differences between both groups of EMU countries regarding the reaction of the primary balance towards output stabilisation are presented in table 3. It needs to be noted that estimators in this case do not distinguish between the automatic stabilisers and the discretionary response to cyclical fluctuations, but instead represent the combined reaction. The estimated responses of fiscal balances to cyclical fluctuations in economic activity as measured by the output gap are quite different between the peripheral and core EMU countries. In the first case, fiscal policy has been pro-cyclical (negative and statistically significant coefficient on the output gap) starting before the crisis but also during the crisis years (see Table 3). Yet, this pro-cyclical response (the sum of coef. ζ_{OG} and ζ_{OG_P}) appears to gradually diminish when more crisis years are factored in our estimates.

[19] According to Tangalakis (2011) "…over the course of the last 15–20 years (prior to the 2008–2009 financial crisis) the volatility of economic cycles had fallen either due to smaller shocks or due to better policies…This implies that discretionary and automatic responses to cyclical fluctuations could be more subdued".

The case of the core countries appears to be different as the relevant coefficient (the sum of coef. ζ_{OG_C} and ζ_{OG}) is positive, significant and close to 0.5 pointing to an a-cyclical fiscal policy response. Moreover, during the crisis this a-cyclical response found for the core EMU countries is enhanced further (i.e. coefficient estimates increase from 0.31 to 0.42 on average), which might reflect additional stabilisation needs during and after the crisis due to the stronger functioning of automatic stabilisers in recessions. In all, these findings provide evidence of a consistent a-cyclical fiscal policy in core countries during the period of Great moderation and also during the crisis. This is not the first time an a-cyclical policy is supported in the case of the EMU countries[20]. Findings from Buti and Van den Noord (2004); Fatas and Mihov (2009) provide also evidence of an a-cyclical fiscal policy in EA until the beginning of the global financial crisis. Our analysis confirms these findings and also proves that this tendency is also met to the period during the crisis[21].

4.2.2.2. Cyclically adjusted Primary balance

In this part, we investigate the response of discretionary fiscal policy towards the two fiscal policy objectives of debt sustainability and output stabilisation. Changes in fiscal balances, usually adjusted for effects of the cycle and interest payments, represent a top down measure of discretionary fiscal policy. We use the cyclically adjusted primary balance. Typically, interpretations of the coefficients to debt and output variations reflect the discretionary response towards enhancing debt sustainability and stabilising the economic cycle, with the strong caveat that adjusting for the cycle is inherently uncertain as it is unobservable.

[20] The results depend also on whether the analysis is conducted with ex post or real time data. In general, the evidence of procyclicality is weaker when real time data is used, suggesting that there could be a difference between the ex-ante intentions of governments and ex post outcomes (Forni and Momigliano 2005; Cimadomo 2012; Golinelli and Momigliano 2006. Other studies based on the full sample of EMU countries report evidence of procyclicality for EMU on average, especially in good times and following the introduction of the SGP in 1999 (Cimadomo 2005; Candelon, Muysken, and Vermeulen 2010; Deroose, Larch, and Schaechter 2008). Gali and Perotti, (2003) and Tangalakis (2011) in their work confirm this countercyclical policy in EMU as a total before the crisis and attribute this fiscal response met in the EMU before the crisis to a tendency towards fiscal prudence and concerns about the long term sustainability of fiscal balances.

[21] Gali and Perotti (2003) found that the pre-crisis periods and the years of Great moderation are characterised by a global trend towards more prudent fiscal stance. Tangalakis (2011) also argues that this has been the case due to the effects of the creation of the EMU and the necessity to abide by the rules of the Stability and Growth Pact after the Maastricht Treaty in 1992.

Table 4 presents results for discretionary policy response to variations of debt for both groups of EMU countries. The discretionary response of peripheral countries to debt increases is positive and statistically significant ranging between 0.34 and 0.42 (combined effect of coefficients ζ_{d} and $\zeta_{\mathrm{d\_P}}$) across Arellano bond (col. 1-6) and Blundell bond estimates (col. 7-12). These responses are larger compared to the responses of core countries that accordingly range between 0.11 and 0.27 (combined effect of coefficients ζ_{d} and $\zeta_{\mathrm{d\_c}}$). Moreover, estimates including the crisis years imply a diminishing discretionary reaction for the core countries, which might reflect the strong debt increases during the crisis years. On the other hand, periphery countries during the same period seem to enhance the discretionary part of fiscal policy to counterbalance the previously observed fatigue (ζ_{d_p}). These heterogeneities regarding fiscal policy reaction to debt changes is attributed to different levels of debt also reflecting different financing needs that need to be serviced through higher surpluses.

Results of discretionary policy towards stabilisation are presented in **Table 5** in the annex. Coefficient estimates provide evidence of a-cyclical discretionary policy for the total sample of EMU countries and this is broadly met in the case of the core countries as the relevant coefficient is insignificant before and also during the crisis (col. 1-3 &7-9). The case of the periphery countries is a bit different as evidence of a discretionary procyclical fiscal policy are provided with estimates ranging from -0.25 to -0.46 across a number of estimates. Also here, our estimates imply a procyclical discretionary policy that also provides signs of fiscal fatigue during the crisis across the full sample.

Comparing estimates from the total primary balance (tables 2-3) with those from the cyclically adjusted primary balance (tables 4-5) provides an indication of the effective operation of the automatic stabilisers.[22] Following this comparison between groups of EMU countries a number of findings are evident. When it comes to output stabilisation and discretionary fiscal policy, core countries rely mostly to automatic stabilisers rather than discretionary policy. This finding confirms arguments in favour of the full operation of automatic stabilizers and against the use of discretionary

[22] Following Gali and Perotti (2003), the implicit automatic response is measured as the difference between the total fiscal response (referring to the estimates regarding total primary balance) and the relevant discretionary response (referring to the estimates regarding cyclically adjusted primary balance).

fiscal policy (IMF 2015)[23]. The role of stabilisers while operational towards output stabilisation is also less important in the case of the EMU periphery compared to the core counties as the implied coefficient estimates for automatic stabilisers are approximately between 0.2 and 0.3 for the peripheral countries and approximately around 0.36 to 0.43 for the core countries. Lastly, it is important to note is that during the crisis automatic stabilisers have become stronger in both groups as the relevant contribution increases from -0.1 (before the crisis) to 0.3 for periphery countries and from 0.32 to 0.43 to the case of core counties. These results provide support to the previous "eye-ball" rolling windows estimate for the crisis period.

4.3. Existence of an endogenous threshold in the fiscal policy rule of Core and Periphery EMU

The existence of a threshold in our policy rule is tested following a two stage approach. At the first stage, the methodology of Kourtelos et. al. (2016) is employed to estimate one endogenous threshold to the variable of interest. The second stage refers to the non-parametric bootstrapping approach of Hansen (1996) and Kazanas et. al. (2015) used in a dynamic panel GMM context[24] testing the existence of one threshold of our model. Testing the linearity hypothesis by means of this two stage approach allows firstly to address previous bias in the literature coming from the exogeneity assumptions of the regressors and the threshold variable[25] (addressed also by Seo et. al. (2016) and

[23] According to the IMF Fiscal monitor (2015): "Automatic stabilizers are generally perceived to be the most efficient tool for fiscal stabilization. Operating in real time, they do not suffer from the information, decision, and implementation lags that often impair the timeliness and relevance of discretionary actions during normal business cycles … In addition, there is less risk that political and other factors will prevent the necessary retrenchment of such measures when growth rebounds …".

[24] Based on the non-parametric bootstrap simulation procedure, significance levels (probability values) of statistic Wald-Stat are obtained (see, for example, Hansen 1996) from the following steps. First, based on the GMM procedure linear model (4), which assumes no regime switching under the above null hypothesis is estimated. Then values are drawn from the saved residual series with replacement. These are added to the fitted values of dependent variable based on the parameter estimates of the threshold model (DGP) to obtain a new series. This series is then used to estimate threshold parameter q and then calculate the value of test statistic Wald-Stat. The above procedure is repeated x5000 times so that the sampling distribution does not depend on the threshold estimate and coefficient estimate. The obtained 5000 values of q and Wald-Stat are used to estimate the probability value of Wald-Stat reported in Table 7.

[25] Hansen (2000) and Seo and Linton (2007) assume exogeneity of covariates. Caner and Hansen (2004) relax this requirement by allowing for endogenous regressors but the threshold variable is exogenous. See also Hansen (2011) for an extensive survey. According to Kourtelos et. al. (2015)*"if the threshold variable is endogenous, the above approaches will yield inconsistent slope coefficients for the two regimes".*

secondly to investigate whether threshold fiscal reaction functions are supported by data and they are not a working assumption.

Following our baseline specification (eq. (4)) we test separately the stability of the sustainability and the stabilisation coefficients by means of a Wald test (Wald-Stat) under the following hypotheses testing:

$$H_0\colon \delta_{i,\_H} = \delta_{i\_L} \text{ against its alternative } H_1\colon \delta_{i\_H} \neq \delta_{i\_L}$$

$$H_0\colon \gamma_{i,\_H} = \gamma_{i\_L} \text{ against its alternative } H_1\colon \gamma_{i\_H} \neq \gamma_{i\_L}$$

where γ_{i_H} and δ_{i_H} depict the relevant coefficients when in the High regime (H) (i.e. above the threshold (H)) and γ_{i_L} and δ_{i_L} when being in the Low regime (L) (i.e. below the threshold (H)). The null hypothesis implies that the fiscal policy rule is given by a linear model and its' alternative is consistent with the existence of a threshold fiscal policy rule.

Estimates from the Kourtelos et. al. (2015) methodology of an endogenous threshold for the debt to GDP and the output gap are presented in table 6 of the annex. For the period of examination (1978-2015) the debt threshold for the core country sample is estimated approximately at 54% of GDP but with wide confidence of intervals. Forthe Periphery the estimated threshold is higher at 105% of GDP. To abstract from out of sample effects and check robustness of our estimates in the case of periphery EMU group we exclude one country at a time and re-estimate thresholds. When excluding Greece the threshold estimate increases to 110% of GDP. Excluding Spain reduces marginally the threshold to 99% of GDP. Taking out Italy and Ireland provides also close estimates while replacing Greece with Belgium results to a lower threshold (93% of GDP). Moreover, in the case of the debt threshold estimates from the period before the crisis provide thresholds that are quite close to the estimates of the full sample period.

For the output gap, the threshold estimates found for the core group support the existence of a different regime when the output gap is above -0.95. For the periphery countries, the estimated threshold (-2.98) is significantly larger than the case of core EMU and with wide confidence intervals. These threshold estimates provide an indication of higher responsiveness from the core EMU countries to stabilise output following countercyclical policies. In the case of periphery this responsiveness is loose and refers to periods of significant economic downturns. Comparing with estimates with the period before the crisis (1978-2008) the obtained threshold estimates become positive and are more homogeneous between group of countries reflecting the response to fiscal policy in EMU in periods of higher inflation and positive output gap.

Table 7 presents results of the bootstrap simulation to the p-value Wald test statistics for the existence of non-linearities to fiscal variables of interest (i.e. L.Debt_to_GDP and Output_Gap). In the case of the peripheral EMU countries, the existence of a threshold is validated only for the case of debt (p-value equal to 0.04) as the relevant null hypothesis is strongly rejected. On the other hand, the null hypothesis of a linear stabilising effort cannot be rejected as the estimated p_value equals 0.9. For the core EMU countries only the existence of a threshold in the response to the output gap is confirmed. The case of a threshold to the debt is rejected as the corresponding probability is quite high (p-value equal to 0.84). The relevant p-value ranges between 0.01 and 0.02 rejecting with a low probability level (almost 1%) the null hypothesis of a linear fiscal policy rule with respect to output gap as described in eq. (4).

4.4. Policy implications from non-linearities in the Core and Periphery EMU

In the last part of the analysis, we employ an augmentation of our model aimed to capture the effect of the observed asymmetries (threshold) to the fiscal policy objectives i.e. sustainability and stabilisation. More specifically, in the case of the debt threshold estimate obtained in the previous part we capture the threshold effect of the high debt regime (H) in the case of the periphery countries by introducing a dummy variable. This dummy is denoted as $I(D_{i,t} > \gamma)$ and is equal to 1 if debt is above the threshold and country i belongs to the Peripheral group and 0 otherwise. In the context of eq. 4 we allow this dummy to interact with lagged debt and apply it to the total pool of EMU countries[26]. The relevant coefficient of interest is coefficient δ'_d (please see eq. 11). This dummy

[26] Due to collinearity issues in the case of debt threshold we avoid adopting both above and below threshold dummies i.e. $\mathrm{I}(\mathrm{D}_{i,t} > \gamma)$ and $\mathrm{I}(\mathrm{D}_{i,t} < \gamma)$ in our specification. This is attributed to the slow moving path of debt leading to high correlation between countries. These collinearity issues are not observed when output gap threshold is considered as shown in the specification below. Following this specification, the relevant

specification allows the use of the entire data span for all EMU countries increasing the number of sample observations in our estimates thus providing robust findings. A statistically significant interaction term would support the view of a non-linear response when it comes to debt stabilisation.

$$Pb_{it} = a_{i,t} + \alpha_b \cdot Pb_{it-1} + \alpha_{y\_US} \cdot OG_{US_{it-1}} + \alpha_m \cdot mon_{it} + (endog_{i,t}) + (\delta_d \cdot D_{it-1} + \delta'_d \cdot I(D_{i,t} > \gamma) \cdot D_{it-1} + other\_instrum_{i,t-1}) + (instrum_{i,t-2}) + n_i + \lambda_t + \varepsilon_{i,t}, \; i=1,\ldots 15, \; t=1978\text{-}2015 \quad (11)$$

As a consistency check of our findings we also employ the same estimation to the case of core EMU countries to provide an additional proof for the lack of an endogenous threshold. Practically the below specification is applied using the estimated thresholds γ =54 and 105 (% of GDP) as estimated from the Kourtelos et. al. (2013) method for the case of peripheral and core countries.

Lastly an analogous specification is also employed in the case of the Output gap threshold to gain insight into implications from the non-linear adjustment to output deviations. More specifically:

$$Pb_{it} = a_{i,t} + \alpha_b \cdot Pb_{it-1} + \alpha_{y\_US} \cdot OG_{US_{it-1}} + \alpha_m \cdot mon_{it} + (\gamma_y \cdot OG_{it} + \gamma'_y \cdot I(OG_{i,t} > \gamma) \cdot OG_{it} + \gamma''_y \cdot I(OG_{i,t} < \gamma) \cdot OG_{it} + Endog_{i,t}) + instrum_{i,t-1} + instrum_{i,t-2} + n_i + \lambda_t + \varepsilon_{i,t}, \; i=1\ldots 15, \; t=1978\text{-}2015 \quad (12)$$

As seen coefficients of interest refer to γ'_y and γ''_y. Apart from the core EMU countries, we also employ the same model using the threshold estimate obtained for the periphery EMU counties in the previous part of the analysis to confirm previous findings of a linear fiscal reaction function.

Table 8 presents estimation results from both panel estimators for the estimated threshold variables on debt. Following results for the case of Periphery countries it is proved that the interaction term expressing the High debt regime i.e. δ'_d is positive and statistically significant. This implies that when this group of EMU countries is above the 105% threshold it responds more actively increasing the average effort from 0.26-0.28 to 0.35-0.38. For the core counties as the relevant factor is not statistically significant, which confirms our previous findings of a linear response of core countries to debt changes. These findings suggest that periphery counties are facing a high cost to preserve

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interaction term is introduced as an endogenous variable and also relevant instruments employed refer to 2 lags of the endogenous variables debt stabilisation in the presence of elevated debt values, while core EMU countries follow a more constant fiscal policy rule in the presence of comparatively lower debt levels.

Lastly, following output gap estimates of eq. 11 differentiating between High (H) and Low (L) utput gap regimes, (see table (9) of the annex) support a threshold for the core EMU countries. If the output gap is below -0.95 (i.e. the Low), an additional countercyclical effort is observed leading close to the effective operation of automatic stabilisers as the total response of the core countries as expressed by the sum of coefficients γ_{d} , with γ'_{d} or γ''_{d} is close to 0.5. These estimates confirm our previous findings of the importance of automatic stabilisers for the core EMU countries and also support findings of a threshold effect regarding their operation. Comparing the coefficients of interest it is proved that the operation of automatic stabilisers is mostly evident in the High regime case[27] (i.e. $OG_{i.t}$<-0.95) while their effectiveness to stabilise output is more limited when being in the Low regime case (i.e. $OG_{i.t}$>-0.95) for the core EMU countries. The case of the periphery countries is less evident as the obtained interaction term is either insignificant (col. 1 and 3) or the threshold effect varies based on the panel estimator employed (see col. 2 and 4 in the same table). These findings also confirm our previous analysis on the non-existence of a threshold in the response to output gap for periphery countries. In this case a linear model may be more appropriate to fit better the stabilisation objective of fiscal in peripheral EMU countries.

5. Conclusions

This paper provides an empirical assessment of a fiscal policy rule for the Eurozone economy following an extended data covering the period from 1978 until 2015 for a panel of 15 EMU member states. Fiscal consolidation has been one of the main themes in the economic policy debate in Europe since the onset of the financial and sovereign debt crises, as well as the contribution of fiscal policies to output stabilisation. These debates have rekindled interest to the mixed experiences of EMU countries over the past few years, raising the question what fiscal stance actually has been

[27] In the case of High regime for output stabilisation we refer to periods of "bad economic conditions" with persistent and negative output gaps. The case of Low regime for output stabilisation refers to "good economic conditions" where output gaps are being close zero i.e. being close to total factor utilisation.

pursued by various governments and if there have been differences between the countries coming under market pressure during the crisis and those that did not.

Compared to the existing literature on linear fiscal reaction functions, we assess fiscal policy in EMU across time focusing on heterogeneities between core and periphery EMU counties. In addition, we employ both linear and non-linear versions of fiscal reaction functions to different groups of EMU countries, looking also in the existence of potential non-linearities with regard to the fiscal policy objectives of fiscal sustainability and stabilising output. When doing so, we analyse the policy implication from these non linearities, an analysis that is typically not very extensive in the literature. A key issue when employing these fiscal policy rules is the endogeneity bias of fiscal policy relevant variables, i.e. the level of debt and output gap due to the interlinkages between fiscal and macro variables. In this respect, we employ a novel non-linear empirical approach makes use of an endogenous threshold in the presence of endogenous regressors and instruments that accounts for these possible endogeneities and interlinkages.

Our findings provide important policy implications for the future conduct of fiscal policy and also may provide an argument for introducing non-linearities to relevant theoretical models. More specifically, we find that policy conclusions on all EMU countries mask the significant heterogeneities between core and periphery EMU countries.

Periphery EMU countries followed a procyclical fiscal policy with regard to output stabilisation, without a discernible differences across different states of the economy. They are also found to react stronger to debt than core countries, which is the flip side of the pro-cyclical stabilisation reaction as high debt levels eventually require a stronger reaction. When we test the thresholds find by our nonlinear model by a bootstrap approach, we find evidence of an endogenous debt threshold of 105% of GDP for periphery countries, which are more responsive to debt changes when in the high debt regime.

For core countries, our findings are a mirror image. They are found to have pursued an a-cyclical fiscal policy with regard to output stabilisation. An output gap threshold is found for core EMU countries at -0.95%. The operation of automatic stabilisers in core countries is more evident in the High regime case (i.e.$OG_{i,t} < -0.95$), and more limited when being in the Low regime (i.e. $OG_{i,t} >$

−0.95) where output gap is close to closure or even positive. Moreover, in both cases our analysis suggests that while the operation of automatic stabilisers is more important for output stabilisation in the core EMU countries, they gain importance during the crisis period in both blocks. For core countries, we do not find a threshold for the response to debt.

A main policy implication of our research is that when assessing the euro area fiscal stance, analysis needs to also account for cross-country differences. According to our findings the differences in country experiences during the crisis are rooted in differential national priorities regarding the operation of fiscal reactions before the crisis. These can be useful to draw lessons from, for the purposes of economic surveillance in EMU.

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Annex

Table 1: Baseline estimates (Eq. 4) Arellano-Bond & Blundell-Bond (1978-2015)

A. Dependent variable: prim_balance_GDP & Method: Arellano-Bond & Blundell_Bond

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
panel estimator$^{\alpha}$	AB	AB	AB	AB	BB	BB	BB
$Pb_{i,t-1}$	0.585***	0.600***	0.596***	0.527***	0.614***	0.607***	0.529***
	(0.0485)	(0.0456)	(0.0454)	(0.0375)	(0.0375)	(0.0353)	(0.0294)
$Pb_{i,t-2}$	-0.0307	-0.0411	-0.0424	-0.0303	-0.0307	-0.0360	-0.00933
	(0.0407)	(0.0400)	(0.0399)	(0.0327)	(0.0308)	(0.0300)	(0.0244)
$mon_{i,t}$	-0.00145	-0.0131	-0.0109	-	0.00964	-0.00455	-
	(0.0134)	(0.0119)	(0.0118)	-	(0.0105)	(0.00957)	-
$OG\_US_{i,t-1}$	-0.131*	-0.123*	-	-	-0.150**	-0.136**	-0.0568
	(0.0758)	(0.0675)	-	-	(0.0615)	(0.0569)	(0.0476)
$D_{i,t}$	-0.228***	-0.219***	-0.218***	-0.219***	-0.236***	-0.225***	-0.220***
	(0.0282)	(0.0268)	(0.0267)	(0.0214)	(0.0242)	(0.0239)	(0.0197)
$\mathbf{OG_{i,t}}$	0.258***	0.251***	0.244***	0.159***	0.300***	0.301***	0.202***
	(0.0710)	(0.0695)	(0.0692)	(0.0444)	(0.0585)	(0.0580)	(0.0378)
$IIR_{i,t}$	0.121	-	-	-	0.0501	-	-
	(0.148)	-	-	-	(0.134)	-	-
$\mathbf{D_{i,t-1}}$	0.283***	0.284***	0.286***	0.232***	0.308***	0.303***	0.242***
	(0.0465)	(0.0433)	(0.0432)	(0.0344)	(0.0394)	(0.0381)	(0.0316)
$D_{i,t-2}$	-0.0307	-0.0470	-0.0497*	0.00468	-0.0644**	-0.0694***	-0.00503
	(0.0313)	(0.0294)	(0.0292)	(0.0230)	(0.0264)	(0.0254)	(0.0208)
$OG_{i,t-1}$	0.0593	0.0803	0.0349	-0.0656	0.0853	0.102	-0.0419
	(0.0954)	(0.0941)	(0.0905)	(0.0569)	(0.0771)	(0.0763)	(0.0499)
$OG_{i,t-2}$	-0.160**	-0.158**	-0.127*	-0.0368	-0.233***	-0.208***	-0.0783**
	(0.0708)	(0.0698)	(0.0676)	(0.0419)	(0.0580)	(0.0569)	(0.0358)
$IIR_{i,t-1}$	0.284	-	-	-	0.319**	-	-
	(0.178)	-	-	-	(0.158)	-	-
$IIR_{i,t-2}$	-0.249*	-	-	-	-0.290**	-	-
	(0.132)	-	-	-	(0.113)	-	-
$\alpha_{i,t}$	-1.758***	-0.675	-0.663	-0.610**	-0.382	-0.0619	-0.596***
	(0.517)	(0.412)	(0.411)	(0.254)	(0.354)	(0.308)	(0.202)
Observations	491	504	504	723	506	519	751
Number of Country_id	15	15	15	28	15	15	28
chi_sq	1108	1101	1104	1324	1906	1891	2179
Sargan test of overidentifying restrictions (F-Stat)	471.4	495.3	501.6	725.8	642.9	662.8	905.9
Residual's 2nd order AR (p-values)	0.222	0.271	0.268	0.233	0.183	0.251	0.288
Instruments: First differences equation GMM type$^{\beta}$	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*

Note: Standard errors in parentheses and *** p<0.01, ** p<0.05, * p<0.1. The Sargan test is a test of overidentifying restrictions. The joint null hypothesis is that the instruments are valid instruments, i.e., uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation.

$^{\alpha}$ AB: Arellano bond estimator, BB: Blundell bond estimator

$^{\beta.}$ Instruments used: $Pb_{i,t-1}$, $D_{i,t-1}$, $OG_{i,t}$, $IIR_{i,t}$

Table 2

Primary balance (% GDP)-Effort to sustainability

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
panel estimator[α]	AB	AB	AB	AB	AB	AB	BB	BB	BB
	1978-2007	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*
$Pb_{i,t-1}$	0.620***	0.537***	0.561***	0.617***	0.539***	0.563***	0.695***	0.596***	0.612***
	(0.0543)	(0.0521)	(0.0480)	(0.0548)	(0.0523)	(0.0482)	(0.0418)	(0.0404)	(0.0369)
$D_{i,t-1}$	0.190***	0.201***	0.195***	0.217***	0.222***	0.119**	0.221***	0.235***	0.123**
	(0.0728)	(0.0682)	(0.0597)	(0.0684)	(0.0615)	(0.0526)	(0.0626)	(0.0582)	(0.0512)
$D_{i,t-1}$*Periphery*	0.210***	0.225***	0.250***	0.197***	0.216***	0.233***	0.194***	0.192***	0.245***
	(0.0609)	(0.0562)	(0.0487)	(0.0540)	(0.0477)	(0.0401)	(0.0514)	(0.0481)	(0.0417)
D_{t-1}*Core*	0.109	0.0627	0.0773	-	-	-	0.162**	0.123*	0.136*
	(0.0715)	(0.0640)	(0.0611)	-	-	-	(0.0797)	(0.0649)	(0.0698)
$OG_{i,t}$	0.171*	0.185**	0.270***	0.169*	0.181**	0.268***	0.157**	0.217***	0.288***
	(0.0902)	(0.0743)	(0.0685)	(0.0907)	(0.0746)	(0.0688)	(0.0743)	(0.0608)	(0.0554)
$IIR_{i,t}$	0.0796	0.130	0.0746	0.105	0.156	0.0929	0.0396	0.0691	0.0357
	(0.139)	(0.148)	(0.142)	(0.140)	(0.148)	(0.142)	(0.125)	(0.134)	(0.128)
$mon_{i,t}$	0.00476	-0.0107	-0.00724	0.00655	-0.00924	-0.00706	0.0103	0.00660	0.00817
	(0.0131)	(0.0139)	(0.0131)	(0.0131)	(0.0139)	(0.0131)	(0.00988)	(0.0106)	(0.0101)
$OG\_US_{i,t-1}$	-0.134*	-0.160**	-0.165**	-0.151**	-0.166**	-0.163**	-0.130**	-0.171***	-0.159***
	(0.0738)	(0.0760)	(0.0735)	(0.0742)	(0.0761)	(0.0736)	(0.0594)	(0.0614)	(0.0587)
$\alpha_{i,t}$	-1.365**	-1.647***	-1.722***	-1.155**	-1.562***	-1.680***	-0.679*	-0.746**	-0.840**
	(0.574)	(0.563)	(0.503)	(0.576)	(0.565)	(0.505)	(0.382)	(0.378)	(0.341)
Observations	371	431	491	371	431	491	386	446	506
Number of Country_id	15	15	15	15	15	15	15	15	15
chi_sq	1036	1206	1244	1006	1191	1228	1730	2051	2156
Sargan test of overidentifying restrictions (F-Stat)	336.1	418.1	466.9	336.6	418.6	468	484.2	594.8	673.3
Residual's 2[nd] order AR (p-values)	0.219	0.279	0.317	0.303	0.222	0.264	0.277	0.253	0.249
Instruments: First differences equation GMM type[β]	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*

Notes: Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[α] AB: Arellano bond estimator, BB: Blundell bond estimator

[β.] Instruments used: $Pb_{i,t-1}$, $D_{i,t-1}$, $D_{i,t-1}$*Periphery, D_{t-1}*Core, $OG_{i,t}$, $IIR_{i,t}$

Table 3

Primary balance (% GDP) - Effort to stabilisation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
panel estimator[α]	AB	AB	AB	AB	AB	AB	BB	BB	BB	BB	BB	BB
	1978-2007	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*
$Pb_{i,t-1}$	0.610***	0.527***	0.545***	0.613***	0.526***	0.544***	0.653***	0.552***	0.568***	0.660***	0.556***	0.568***
	(0.0537)	(0.0527)	(0.0486)	(0.0540)	(0.0526)	(0.0485)	(0.0404)	(0.0397)	(0.0367)	(0.0416)	(0.0402)	(0.0371)
$D_{i,t-1}$	0.320***	0.337***	0.291***	0.321***	0.337***	0.291***	0.364***	0.381***	0.322***	0.368***	0.392***	0.332***
	(0.0621)	(0.0594)	(0.0459)	(0.0623)	(0.0593)	(0.0458)	(0.0509)	(0.0488)	(0.0375)	(0.0522)	(0.0497)	(0.0380)
$OG_{i,t}$	0.300*	0.357***	0.421***	0.348***	0.378***	0.440***	0.279**	0.341***	0.404***	0.331***	0.382***	0.440***
	(0.155)	(0.119)	(0.111)	(0.106)	(0.0843)	(0.0803)	(0.126)	(0.0930)	(0.0873)	(0.0889)	(0.0673)	(0.0640)
$OG_{i,t-1}$*Periphery*	-0.412**	-0.521***	-0.482***	-0.468***	-0.545***	-0.507***	-0.494***	-0.543***	-0.478***	-0.532***	-0.580***	-0.514***
	(0.186)	(0.155)	(0.148)	(0.152)	(0.132)	(0.126)	(0.154)	(0.126)	(0.119)	(0.127)	(0.108)	(0.102)
OG_{t-1}*Core*	0.0840	0.0310	0.0329	-	-	-	0.0881	0.0523	0.0535	-	-	-
	(0.191)	(0.152)	(0.147)	-	-	-	(0.161)	(0.120)	(0.116)	-	-	-
$IIR_{i,t}$	0.0903	0.116	0.0852	0.120	0.135	0.102	0.0940	0.112	0.0805	0.124	0.125	0.0913
	(0.136)	(0.146)	(0.144)	(0.138)	(0.147)	(0.144)	(0.120)	(0.128)	(0.125)	(0.122)	(0.130)	(0.127)
$mon_{i,t}$	0.0123	0.00726	0.00730	0.0183	0.0104	0.00984	0.0234**	0.0235**	0.0232**	0.0258***	0.0233**	0.0231**
	(0.0129)	(0.0138)	(0.0132)	(0.0129)	(0.0137)	(0.0132)	(0.00937)	(0.0101)	(0.00984)	(0.00959)	(0.0103)	(0.00998)
$OG\_US_{i,t-1}$	-0.0899	-0.142*	-0.142*	-0.117	-0.156**	-0.152**	-0.0848	-0.166***	-0.156**	-0.112*	-0.178***	-0.164***
	(0.0743)	(0.0780)	(0.0763)	(0.0735)	(0.0764)	(0.0752)	(0.0605)	(0.0629)	(0.0611)	(0.0603)	(0.0621)	(0.0608)
$\alpha_{i,t}$	-1.375**	-1.756***	-1.503***	-1.235**	-1.671***	-1.428***	-0.365	-0.249	-0.114	-0.295	-0.243	-0.0925
	(0.543)	(0.549)	(0.506)	(0.545)	(0.550)	(0.507)	(0.358)	(0.351)	(0.322)	(0.368)	(0.361)	(0.332)
Observations	371	431	491	371	431	491	386	446	506	386	446	506
Number of Country_id	15	15	15	15	15	15	15	15	15	15	15	15
chi_sq	1052	1195	1178	1037	1197	1180	1829	2171	2146	1722	2119	2103
Sargan test of overidentifying restrictions (F-Stat)	346.4	428.9	474.9	340	426.5	471.7	483.2	625.5	706.7	471.4	605.3	685.2
Residual's 2[nd] order AR (p-values)	0.441	0.424	0.479	0.331	0.362	0.304	0.461	0.491	0.525	0.434	0.446	0.497
Instruments: First differences equation GMM type[β]	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*

Notes: Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[α] AB: Arellano bond estimator, BB: Blundell bond estimator

[β.] Instruments used: $Pb_{i,t-1}$, $D_{i,t-1}$, $D_{i,t-1}$*Periphery, D_{t-1}*Core, $OG_{i,t}$, $IIR_{i,t}$

Table 4

Cyclically adjusted primary balance (% potential GDP) - Discretionary effort towards sustainability

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
panel estimator[α]	AB	AB	AB	AB	AB	AB	BB	BB	BB	BB	BB	BB
	1978-2007	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*
$CAPB_{i,t-1}$	0.725***	0.599***	0.634***	0.722***	0.601***	0.634***	0.776***	0.640***	0.663***	0.767***	0.642***	0.660***
	(0.0538)	(0.0524)	(0.0474)	(0.0539)	(0.0525)	(0.0475)	(0.0410)	(0.0403)	(0.0362)	(0.0412)	(0.0406)	(0.0365)
$D_{i,t-1}$	0.203***	0.201***	0.110*	0.239***	0.233***	0.142***	0.215***	0.235***	0.146***	0.236***	0.266***	0.178***
	(0.0671)	(0.0645)	(0.0570)	(0.0627)	(0.0580)	(0.0502)	(0.0567)	(0.0544)	(0.0484)	(0.0536)	(0.0501)	(0.0431)
$D_{i,t-1}$**Periphery*	0.190***	0.214***	0.233***	0.159***	0.187***	0.205***	0.162***	0.158***	0.214***	0.150***	0.132***	0.183***
	(0.0562)	(0.0535)	(0.0466)	(0.0493)	(0.0453)	(0.0383)	(0.0467)	(0.0451)	(0.0393)	(0.0402)	(0.0377)	(0.0318)
D_{t-1}**Core*	0.110*	0.0798	0.0828	-	-	-	0.102*	0.0913*	0.0989**	-	-	-
	(0.0657)	(0.0606)	(0.0584)	-	-	-	(0.0537)	(0.0511)	(0.0491)	-	-	-
$OG_{i,t}$	-0.397***	-0.357***	-0.263***	-0.402***	-0.360***	-0.266***	-0.344***	-0.304***	-0.234***	-0.347***	-0.300***	-0.231***
	(0.0838)	(0.0707)	(0.0658)	(0.0835)	(0.0707)	(0.0658)	(0.0688)	(0.0572)	(0.0528)	(0.0700)	(0.0580)	(0.0535)
$IIR_{i,t}$	0.100	0.139	0.0793	0.101	0.141	0.0750	0.0536	0.0544	0.0107	0.0727	0.0649	0.0169
	(0.129)	(0.140)	(0.136)	(0.128)	(0.139)	(0.136)	(0.116)	(0.127)	(0.122)	(0.116)	(0.128)	(0.123)
$mon_{i,t}$	0.00136	-0.0138	-0.00777	0.00303	-0.0130	-0.00831	-0.000299	-0.00362	0.000305	0.00389	-0.00106	0.00222
	(0.0121)	(0.0132)	(0.0126)	(0.0120)	(0.0131)	(0.0126)	(0.00903)	(0.00998)	(0.00958)	(0.00911)	(0.0101)	(0.00966)
$OG\_US_{i,t-1}$	-0.119*	-0.136*	-0.157**	-0.126*	-0.139*	-0.154**	-0.117**	-0.138**	-0.142**	-0.135**	-0.173***	-0.162***
	(0.0691)	(0.0727)	(0.0709)	(0.0689)	(0.0727)	(0.0709)	(0.0554)	(0.0585)	(0.0564)	(0.0559)	(0.0596)	(0.0573)
$\alpha_{i,t}$	-1.619***	-2.090***	-2.053***	-1.459***	-2.007***	-1.982***	-0.894**	-1.124***	-1.124***	-0.784**	-1.014***	-1.056***
	(0.536)	(0.537)	(0.485)	(0.533)	(0.538)	(0.485)	(0.358)	(0.365)	(0.331)	(0.370)	(0.376)	(0.340)
Observations	371	431	491	371	431	491	386	446	506	386	446	506
Number of Country_id	15	15	15	15	15	15	15	15	15	15	15	15
chi_sq	937.2	990.9	1017	926.4	985.5	1012	1641	1702	1732	1521	1618	1649
Sargan test of overidentifying restrictions (F-Stat)	339	428.8	474.8	341	430.4	476.8	479.2	593.3	667.7	462.7	575.6	649.9
Residual's 2nd order AR (p-values)	0.444	0.461	0.501	0.531	0.611	0.566	0.436	0.497	0.521	0.367	0.439	0.474
Instruments: First differences equation GMM type[β]	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*	*2 lags*

Notes: Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[α] AB: Arellano bond estimator, BB: Blundell bond estimator

[β.] Instruments used: $CAPB_{i,t-1}$, $D_{i,t-1}$, $D_{i,t-1}$*Periphery, D_{t-1}*Core, $OG_{i,t}$, $IIR_{i,t}$

Table 5

Cyclically adjusted primary balance (% potential GDP) - Discretionary effort towards stabilisation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
panel estimator[α]	AB	AB	AB	AB	AB	AB	BB	BB	BB	BB	BB	BB
	1978-2007	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*	*1978-2007*	*1978-2011*	*1978-2015*
$Capb_{i,t-1}$	0.695***	0.575***	0.602***	0.712***	0.584***	0.610***	0.742***	0.617***	0.637***	0.757***	0.622***	0.636***
	(0.0533)	(0.0531)	(0.0480)	(0.0534)	(0.0531)	(0.0480)	(0.0400)	(0.0401)	(0.0362)	(0.0409)	(0.0405)	(0.0367)
$D_{i,t-1}$	0.299***	0.324***	0.290***	0.310***	0.325***	0.291***	0.330***	0.368***	0.323***	0.330***	0.371***	0.329***
	(0.0576)	(0.0568)	(0.0441)	(0.0581)	(0.0570)	(0.0442)	(0.0474)	(0.0468)	(0.0362)	(0.0486)	(0.0477)	(0.0367)
$OG_{i,t}$	-0.227	-0.151	-0.0931	-0.191	-0.209	-0.182	-0.158	-0.131	-0.0936	-0.101	-0.119	-0.138
	(0.145)	(0.114)	(0.107)	(0.198)	(0.185)	(0.179)	(0.117)	(0.0894)	(0.0844)	(0.185)	(0.165)	(0.1624)
$OG_{i,t-1}$**Periphery*	-0.241	-0.389***	-0.369***	-0.138	-0.405***	-0.389***	-0.375***	-0.451***	-0.397***	-0.245***	-0.467***	-0.419***
	(0.173)	(0.149)	(0.143)	(0.141)	(0.127)	(0.122)	(0.142)	(0.121)	(0.115)	(0.118)	(0.104)	(0.0985)
OG_{t-1}**Core*	-0.191	-0.196	-0.174	-	-	-	-0.229	-0.181	-0.150	-	-	-
	(0.178)	(0.146)	(0.142)	-	-	-	(0.149)	(0.116)	(0.113)	-	-	-
$IIR_{i,t}$	0.0708	0.105	0.0767	0.0883	0.111	0.0785	0.0829	0.107	0.0645	0.0942	0.0967	0.0540
	(0.127)	(0.140)	(0.139)	(0.128)	(0.140)	(0.139)	(0.112)	(0.124)	(0.122)	(0.115)	(0.126)	(0.124)
$mon_{i,t}$	-0.00220	-0.00689	-0.00279	0.00531	-0.00318	-0.000424	0.00598	0.00608	0.00956	0.00657	0.00438	0.00814
	(0.0118)	(0.0130)	(0.0126)	(0.0120)	(0.0131)	(0.0127)	(0.00867)	(0.00966)	(0.00948)	(0.00895)	(0.00989)	(0.00967)
$OG\_US_{i,t-1}$	-0.0734	-0.114	-0.129*	-0.0937	-0.124*	-0.136*	-0.0889	-0.157**	-0.149**	-0.0947*	-0.147**	-0.140**
	(0.0697)	(0.0752)	(0.0740)	(0.0694)	(0.0741)	(0.0733)	(0.0573)	(0.0614)	(0.0599)	(0.0575)	(0.0609)	(0.0599)
$\alpha_{i,t}$	-1.761***	-2.290***	-1.920***	-1.423***	-2.110***	-1.809***	-0.821**	-0.838**	-0.605*	-0.617*	-0.773**	-0.586*
	(0.509)	(0.528)	(0.488)	(0.518)	(0.536)	(0.494)	(0.340)	(0.344)	(0.315)	(0.350)	(0.356)	(0.326)
Observations	371	431	491	371	431	491	386	446	506	386	446	506
Number of Country_id	15	15	15	15	15	15	15	15	15	15	15	15
chi_sq	943.9	964.8	953.1	917.1	952.1	941.9	1751	1779	1712	1549	1653	1599
Sargan test of overidentifying restrictions (F-Stat)	350.3	435.8	480.9	346	435.1	479.2	490.3	633.7	710.1	470.2	608.3	683.2
Residual's 2nd order AR (p-values)	0.221	0.209	0.263	0.274	0.244	0.304	0.355	0.366	0.394	0.401	0.421	0.423
Instruments: First differences equation GMM type[β]	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[α] AB: Arellano bond estimator, BB: Blundell bond estimator

[β.] Instruments used: $Capb_{i,t-1}$, $D_{i,t-1}$, $Capb_{i,t-1}$*Periphery, $Capb_{t-1}$*Core, $OG_{i,t}$, $IIR_{i,t}$

Table 6: Threshold estimates employing Kourtelos et. al. (2013) approach

Threshold variable: Public debt as % GDP
Endogenous variables: Debt to GDP , Output Gap, Implicit Interest rate

		(1)	(2)
	Time span	*1978-2015*	*1978-2008*
Total 15			
	Threshold estimate (q)*	0.8300	0.5148
	Jstat	3.19E-19	8.08E-19
	CI	[0.21485 1.4733]	[0.1111 1.2233]
Core			
	Threshold estimate (q)*	0.5447	0.5411
	Jstat	2.89E-18	4.10E-19
	CI	[-1.4532 2.09407]	[-1.3532 2.04467]
Periphery			
	Threshold estimate (q)*	1.0533	1.0122
	Jstat	3.66E-18	2.93E-17
	CI	[0.71565 1.1966]	[0.78465 1.2194]
Threshold estimate (q*) excluding:			
	Portugal	1.04	-
	Spain	0.99	-
	Italy	1.05	-
	Ireland	1.04	-
	Greece	1.09	-
	Replacing Greece with Belgium	0.92	-

Threshold variable: Output Gap (percent of potential GDP)
Endogenous variables: Debt to GDP , Output Gap, Implicit Interest rate

		(1)	(2)
	Time span	*1978-2015*	*1978-2008*
Total 15			
	Threshold estimate	-1.7921	2.0946
	Jstat	3.88E-19	2.75E-21
	CI	[-2.7466 2.8654]	[-2.1279 2.1992]
Core			
	Threshold estimate	-0.95	1.4136
	Jstat	4.55E-20	1.27E-19
	CI	[-1.0068 0.5829]	[0.9113 1.9911]
Periphery			
	Threshold estimate	-2.9862	1.6851
	Jstat	2.94E-21	1.04E-19
	CI	[-3.8866 3.8604]	[-2.0029 2.1419]

Note: The table presents GMM threshold estimates of non linear model (7) following Kourtelos et. al. (2013) approach using the same set of instruments as those used for the estimation of linear model (2). CI(q) denotes the heteroscedasticity corrected asymptotic confidence interval of the threshold parameter follwoing the same approach. Upper part presents threshold estimates for debt while the lower part presents estimates for the output gap as a threshold. J-stat stands for Sargan's overidentifying restrictions test statistic implied by the GMM estimation procedure.

Table 7: Non parametric bootstrap test statistics (Fstat & p_value) for the existence of one threshold

Country Group: *Periphery ms*			
Output-gap	Threshold effect test (bootstrap=5000):	*Fstat*	*p_value*
		1.96	0.91
Debt	Threshold effect test (bootstrap=5000):	*Fstat*	*p_value*
		14.26	0.04
Country Group: *Core ms*			
Output-gap	Threshold effect test (bootstrap=5000):	*Fstat*	*p_value*
		44.81	0.02
Debt	Threshold effect test (bootstrap=5000):	*Fstat*	*p_value*
		1.69	0.84

Note: Table presents non parametric bootstrap test statistics (Fstat & p_value) for one threshold employed in the linear fiscal policy reaction specifications of eq. 4.

Table 8

Threshold effects to debt sustainability. Dependent variable: Pbi,t. Dummy refering to Periphery (col. 1-4), Periphery (col. 5-8).

panel estimator[α]	AB	BB	AB	BB
period covered	1978-2015	1978-2015	1978-2015	1978-2015
EMU Country group dummy refers to:	Periphery	Periphery	Core	Core
	(1)	*(3)*	*(5)*	*(7)*
$Pb_{i,t-1}$	0.560***	0.607***	0.559***	0.623***
	(0.0863)	(0.0958)	(0.0853)	(0.0968)
$D_{i,t-1}$	0.263***	0.292***	0.278***	0.312***
	(0.0376)	(0.0363)	(0.0468)	(0.0464)
$D_{i,t-1}$*I($q_{i,t}$>105)	0.0885***	0.0971***	-	-
	(0.0114)	(0.0116)	-	-
$D_{i,t-1}$*I($q_{i,t}$>54)	-	-	-0.0358	-0.0300
	-	-	(0.0278)	(0.0242)
$OG_{i,t}$	0.285***	0.304***	0.262***	0.303***
	(0.0770)	(0.0806)	(0.0809)	(0.0822)
$IIR_{i,t}$	0.112	0.0907	0.0528	0.0982
	(0.142)	(0.185)	(0.146)	(0.216)
$mon_{i,t}$	-0.00378	0.00708	-0.00817	0.00861
	(0.00934)	(0.0119)	(0.00882)	(0.0112)
$OG\_US_{i,t-1}$	-0.146**	-0.141***	-0.124*	-0.143**
	(0.0574)	(0.0465)	(0.0634)	(0.0573)
$\alpha_{i,t}$	-1.533**	-0.365	-1.893***	-0.470
	(0.611)	(0.500)	(0.512)	(0.485)
Observations	491	506	491	506
Number of Country_id	15	15	15	15
chi_sq	996.3	1401.5	1222.8	1097.7
Sargan test of overidentifying restrictions (F-Stat)	339.4	388.1	446.6	448.4
Residual's 2[nd] order AR (p-values)	0.22	0.27	0.36	0.32
Instruments: First differences equation GMM type[β]	2 lags	2 lags	2 lags	2 lags

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[α] AB: Arellano bond estimator, BB: Blundell bond estimator

[β.] Instruments used: $Pb_{i,t-1}$, $D_{i,t-1}$, $D_{i,t-1}$*I(qi,t>γ), $OG_{i,t}$, $IIR_{i,t}$

Table 9

Threshold effects to Output stabilisation. Dependent variable: Pbi,t. Dummy refering to Periphery (col. 1-4), Periphery (col. 5-8).

panel estimator[α]	AB	AB	BB	BB	AB	AB	BB	BB
period covered	1978-2015	1978-2015	1978-2015	1978-2015	1978-2015	1978-2015	1978-2015	1978-2015
EMU Country group dummy refers to:	Periphery	Periphery	Periphery	Periphery	Core	Core	Core	Core
	(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
$Pb_{i,t-1}$	0.564***	0.564***	0.617***	0.617***	0.579***	0.579***	0.613***	0.613***
	(0.0829)	(0.0829)	(0.0852)	(0.0852)	(0.0886)	(0.0886)	(0.0958)	(0.0958)
$D_{i,t-1}$	-0.233***	-0.233***	-0.231***	-0.231***	-0.231***	-0.231***	-0.234***	-0.234***
	(0.0506)	(0.0506)	(0.0437)	(0.0437)	(0.0515)	(0.0515)	(0.0477)	(0.0477)
$OG_{i,t}$	0.206***	-	0.222***	-	0.199**	0.201**	0.231**	0.251***
	(0.0947)	-	(0.0995)	-	(0.0996)	(0.0996)	(0.0961)	(0.0882)
OGi,t*I($q_{i,t}$>-2.98)	-	0.107*	-	0.292***	-	-	-	-
	-	(0.0564)	-	(0.0866)	-	-	-	-
OGi,t*I($q_{i,t}$<-2.98)	-0.199*	0.217***	-0.0299	0.201***	-	-	-	-
	(0.103)	(0.0947)	(0.128)	(0.0995)	-	-	-	-
OGi,t*I($q_{i,t}$>-0.95)	-	-	-	-	-	0.276*	-	0.295*
	-	-	-	-	-	(0.162)	-	(0.161)
OGi,t*I($q_{i,t}$<-0.95)	-	-	-	-	0.310**	0.322***	0.276**	0.271***
	-	-	-	-	(0.131)	(0.131)	(0.138)	(0.118)
$IIR_{i,t}$	0.119	0.119	0.110	0.110	0.107	0.107	0.0614	0.0614
	(0.134)	(0.134)	(0.187)	(0.187)	(0.144)	(0.144)	(0.217)	(0.217)
$mon_{i,t}$	-0.00208	-0.00208	0.0112	0.0112	-0.000667	-0.000667	0.0129	0.0129
	(0.0114)	(0.0114)	(0.0117)	(0.0117)	(0.0107)	(0.0107)	(0.0112)	(0.0112)
$OG\_US_{i,t-1}$	-0.141**	-0.141**	-0.155***	-0.155***	-0.132**	-0.132**	-0.133**	-0.133**
	(0.0586)	(0.0586)	(0.0567)	(0.0567)	(0.0559)	(0.0559)	(0.0519)	(0.0519)
$\alpha_{i,t}$	-1.785***	-1.785***	-0.439	-0.439	-1.673***	-1.673***	-0.251	-0.251
	(0.612)	(0.612)	(0.466)	(0.466)	(0.546)	(0.546)	(0.503)	(0.503)
Observations	491	491	506	506	491	491	506	506
Number of Country_id	15	15	15	15	15	15	15	15
chi_sq	890	941	992	1014	963	1121	1211	1311
Sargan test of overidentifying restrictions (F-Stat)	322.5	312.7	333.6	371.3	412.6	419.5	466.2	502.4
Residual's 2nd order AR (p-values)	0.282	0.293	0.330	0.304	0.344	0.420	0.329	0.480
Instruments: First differences equation GMM type[β]	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags	2 lags

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

[α] AB: Arellano bond estimator, BB: Blundell bond estimator

[β.] Instruments used: $Pb_{i,t-1}$, $D_{i,t-1}$, $OG_{i,t}$*I(qi,t>γ), OGi,t*I(qi,t<γ), $OG_{i,t}$, $IIR_{i,t}$

Technical Annex:

Threshold location in the case of variable endogeneity in a GMM dynamic panel data context (Kourtelos et. al. 2015)

In the case where the slope variables are also endogenous and therefore X_{it} is not a subset of Z_{it}, then X_{it} can be expressed as:

$$X_{it} = \Pi_X' \cdot Z_{it} + v_{Xit} \ ,$$

and the STR model can be written as follows:

$$s_{it} = \beta_{X1}' \cdot \Theta_{Xit} \cdot I(q_{it} \leq \gamma) + \beta_{X2}' \cdot \Theta_{Xit} \cdot I(q_{it} > \gamma) + \kappa \cdot \Lambda_{it}(\gamma) + \varepsilon_{it}^* \ ,$$

where $$\varepsilon_{it}^* = \beta_{X1}' \cdot v_{it} \cdot I(q_{it} \leq \gamma) + \beta_{X2}' \cdot v_{it} \cdot I(q_{it} > \gamma) + \varepsilon_{it}$$

with $E(\varepsilon_{it}^* | F_{i-1}) = 0.$[28]

As stated above the STR model treats the sample split value γ as an unknown parameter to be estimated. Hence, to facilitate the estimation, we follow Kourtelos et al. (2015) and first estimate the reduced form parameters π_q and Π_X by least squares (LS) to obtain $\hat{\pi}_q$ and $\hat{\Pi}_X$, respectively. The fitted values are then given by $\hat{q}_{it} = \hat{\pi}_q' z_{it}$ and $\hat{X}_{it} = \hat{\Theta}_{Xit} = \hat{\Pi}_X' z_{it}$, along with the first stage residuals, $\hat{v}_{Xit} = X_{it} - \hat{X}_{it}$ and $\hat{v}_{qi} = q_{it} - \hat{q}_{it}$, respectively.

The threshold parameter γ is estimated by employing the predicted values of the endogenous regressors $\hat{X}_{it}$ and the predicted inverse Mills ratio term $\hat{\Lambda}_{it}(\gamma)$ by concentration. Conditional on γ, the estimation problem is linear in the slope parameters $\psi = (\beta_{X1}', \beta_{X2}', \kappa)'$, yielding conditional 2SLS or GMM estimator $\hat{\psi}(\gamma) = (\hat{\beta}_{X1}(\gamma)', \hat{\beta}_{X2}(\gamma)', \hat{\kappa}(\gamma))'$ by regressing s_{it} on $\hat{X}_{it}(\gamma)$ and instruments $\hat{Z}_{it}(\gamma)$. Then, by defining the criterion

$$S_n(\gamma) = S_n\left(\gamma, \hat{\psi}(\gamma)\right) =$$

$$= \sum_{i=1}^{n} \left(s_{it} - \hat{\beta}_{X1}(\gamma)' \cdot \hat{\Theta}_{Xit} \cdot I(q_{it} \leq \gamma) - \hat{\beta}_{X2}(\gamma)' \cdot \hat{\Theta}_{Xit} . I(q_{it} > \gamma) - \hat{\kappa}(\gamma) \cdot \hat{\Lambda}_{it}(\gamma)\right)^2$$

the value of γ can be estimated[29] by minimizing the CLS criterion $\hat{\gamma} = \mathrm{argmin}_\gamma S_n(\gamma)$.

[28] Here F_{i-1} is the sigma field generated by $\{z_{it-j}, \ \chi_{it-1-j}, \ q_{it-1-j}, \varepsilon_{it-1-j} : j \geq 0\}$.
[29] The consistency and asymptotic distribution of the threshold parameter $\gamma$is nonstandard as it involves two independent standard Wiener processes with two different scales and two different drifts, while the construction of confidence intervals is based on the inversion of the likelihood ratio test.