Fiscal Responses in the Euro Area and the Sovereign Debt Crisis

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Abstract: This paper analyses national fiscal policy responses among twelve Euro Area member states. Time-varying fiscal responses are approximated by two types of fiscal rules. One that follows macro-fiscal response literature explicitly allowing for the effect coming from financial markets, the other resembling a monetary policy Taylor rule, that is, a micro-based optimal fiscal response function. Our paper is one of the first studies that estimates fiscal rules for Euro Area countries employing Bayesian time-varying parameter technique, using a novel quarterly dataset of fiscal and economic determinants over the period 1980q1–2015q4. Our results reveal that the process has been driven by three factors: output gap synchronization, changes in the conduct of monetary policy, and institutionalization of fiscal policy. Mainly the last one endorsed during the pre-Euro period led to more synchronized responses in late 1990's approximated by their standard deviation. This trend was partially reversed during first years of the monetary union and at the outset of the European sovereign debt crisis. However, the crisis itself resulted in a new phase in the EU-wide macro-fiscal regulation that has brought our measure of dispersion of fiscal responses to the lowest levels since the late 1980's. Since the achieved level of harmonization could pose a threat in itself because of symmetrical responses to asymmetrical shocks and negligible 'federal budget' flows (transfers) in the Euro Area, some alternatives for a reform are discussed.

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Keywords: Bayesian models, debt crisis, Euro Area, fiscal rules, financial markets spillovers, time-varying parameter estimation

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1 Introduction

The Global Recession and related Euro Area sovereign debt crisis (henceforth, ESDC) resulted in heightened volatility and uncertainty that have already persisted for several years. Large and increasing debt ratios, high private and sovereign indebtedness have placed limits on economic environment of many countries. More recently, a mix of low GDP growth, low inflation rates and low or even negative interest rates has contributed with another dimension (zero-lower-bound). Likewise, rather non-standard monetary measures that had been implemented in several developed countries have changed the standard economic and fiscal landscape prevailing during tranquile times. Bond yields and interest rates attacking not-for-very-long-time or ever seen lows, in some cases even entering the negative territory, have substantially reduced pressure on severely strained public finances.

High importance of fiscal policy in the context of monetary unions has been emphasised several times in the literature since the seminal paper of Mundell (1961) came about (the classical *Optimum Currency Areas* theory, henceforth OCA). However, the theoretical justification has changed several times since then. While Mundell (1961) and also Mundell (1973) considered 'fiscal policy' (predominantly 'transfers') rather an extraordinary tool for the case of non-existing market forces or not being able to cope with asymmetrical shocks (slightly changed views in later contributions), later authors treated transfers as an important part of any monetary union, see for example Kenen (1969).[2] First contributions assumed that independent and flexible national fiscal policy could deal with any shock(s) on its own and therefore, there was no need to propose any common framework for national (decentralised) fiscal policies. However, this argument rests upon two important implications: (*a*) fiscal policy can remain sustainable (increased indebtedness after a negative shock is reduced in 'good times') and/or (*b*) the overwhelming majority of shocks occurs because of exogenous factors (affecting more or less all members in a symmetrical manner).[3] However, neither of them has been met since most of the shocks affecting Euro Area countries have had their roots in their economies (asymmetrical business cycles, degrees of openness).[4]

In this paper, we aim to shed some light on the issue of harmonization of national fiscal policies in the Euro Area. As it has been briefly outlined above, a smooth functioning of a

[2] In his view, a system of fiscal transfers was necessary to mitigate effects of adverse shocks in parts of the monetary union, funded by resources coming from taxation. Recently, a report prepared by four top official in the Euro Area (see van Rompuy *et al.*, 2012) has highlighted the need for an integreated budgetary framework comprising of issuance of common debt instruments, and strenghtening of euro area fiscal capacity by creating a shock-absorbing mechanism (system of transfer payments). However, a very similar argument can already be found in reports in the pre-EMU period – the *MacDougall Report* (see EC, 1977a,b) or the *Delorse Report* (see Delors, 1989).
Interestingly, a recent publication – Buba (2015) – considering future paths in case of European fiscal policy, operates with country specific responses to asymmetric shocks.

[3] This has been challenged by several authors, for example Ferrero (2009) shows in a simplified two-country model that the role of fiscal authorities is essential, even without proper coordination of the two governments.

[4] Most recent evidence for Euro Area countries (since 1995 with effects of the Global Recession) can be found in De Grauwe and Ji (2016), for a longer time span (from 1980) see for example Allard *et al.* (2013).

monetary union with national fiscal policies requires a toolkit for limiting fiscal spillovers and ensuring sustainable fiscal policy, so that the single monetary policy does not have unnecessarily tied hands. Since this particular set-up holds for the Euro Area, it is not surprising that already the pre-EMU report (EC, 1990) in early 1990's put a great deal of emphasis on guaranteeing it. Despite having spent much time and effort on the issue,[5] results have been rather ambiguous so far. Moreover, given the series of recent events that have shaken up several Euro Area members and repeated efforts to increase resilience of the monetary union towards endogenously generated shocks by setting rules of the 'fiscal game', a set of potential questions emerges. Our interest here lies in trying to empirically assess effects of changes of the institutional environment on fiscal policy behaviour (for example because of (time-)varying preferences of elected representatives) over recent years of various phases of the monetary integration process.

We analyse harmonization of fiscal policy by using a novel quarterly dataset of fiscal and macroeconomic variables of twelve 'old' EU members (euro area members, EA-12) and three stand-alone EU countries.[6] Our dataset covers not only periods of cyclical fluctuations and several external shocks affecting the EU, but also the Great Recession and years of the financial and debt crisis and therefore, it seems to be potentially a suitable 'candidate' for such an exercise.[7] As a proxy for fiscal responses, two models of fiscal rules are utilized in this paper: one in line with the Bohn (1998)'s strand of literature explicitly allowing for effects coming from financial markets ('macro-fiscal rule'), the other resembling 'optimal monetary rules' in line with a Taylor rule ('micro-based rule').[8] Under harmonization is understood (in a graphical representation) that if national fiscal responses were plotted, they should become more aligned, which would be captured for example by a narrower dispersion around a mean (median) fiscal response (for example for EA-12). This paper builds upon time-varying parameter (TVP) model literature and Bayesian techniques that allow us to address several problematic aspects associated with commonly carried out model's estimations (such as structural breaks). The latter offers larger flexibility when estimating 'fully specified conventional' models of fiscal responses compared with a classical (frequentist) estimation and/or a reduced form estimation such as vector autoregression technique (VAR).

To preview our results, national fiscal policies were quite heterogeneous over the entire sample period. Most of the Euro Area countries experienced periods of low or even nega-

[5]For a brief overview, see EC (2013); EC (2015) or more recently Masten and Gnip (2016).

[6]Denmark as a country with the opt-out clause, however, with a tight monetary policy linkages; Sweden as a country that rejected its participation in the EMU in September 2003 and have followed quasi-independent monetary policy since, and the United Kingdom, the other opt-out country and potentially soon-to-be non-EU country, usually analysed outside the EMU that has applied a number of monetary strategies, potentially affecting its fiscal policy decisions.

[7]The early 1980's recession (effects of oil shocks and Volcker's monetary tightening), the Reunification of Germany (1990), the pre-EMU period (Maastricht period), the 'Black Autumn' in EMS 1992/1993, the Euro launch (1999), the '9/11' crisis, fiscal sustainability problems of EMU countries (around 2003), and the Great Recession (2007–) and its European 'spin-off' – the Sovereign Debt Crisis in Euro Area countries (2009–).

[8]Because of increased importance of financial markets in recent years, a proxy in form of an interest rate on public debts is included, so that estimated values of response coefficients are not biased downward.

tive response coefficients (including effects of financial markets), especially during the Great Recession and/or the European sovereign debt crisis, which indicates problems with (short-term) sustainability and possible problems if another shock emerged. Similar patterns can be seen in case of three stand-alone EU countries. Turning to the estimates of harmonization of fiscal policies, three factors are considered: (1) output gap synchronization seems to have contributed to the process, however, the reduction of dispersion is only imperfectly aligned with observed harmonization. (2) as a result of changes in institutional set-ups, effects related to the Maastricht period can be identified, but not to early years of the Euro Area, when the Stability and Growth Pact (henceforth, Pact) was fully implemented (including enforcement). On the contratry, our results confirm even a mild worsening (increase) of dispersion of national responses in early years of the Euro Area (a sort of the 'Olympic effect'). However, the outset of the ESDC and a series of reforms seem to have had an impact – there has been an increased harmonization of fiscal policies measured by their dispersion that reached lowest levels since the start of our sample in the 1980's. (3) monetary policy related effects ('soft'/'hard' budget constraints), not measured directly however, have also contributed to changing shape of national fiscal policies.

This study is the first one that aims to analyse harmonization of fiscal responses in a monetary union (with help of the TVP technique). The only exception has been few papers presenting statistical evidence on (cyclically-adjusted) primary balances or exogenous component of fiscal policy (error terms from a simple fiscal rule) such as Fatás and Mihov (2010) to the best of our knowledge. However, there have been a large number of studies aiming to analyse various aspects of fiscal policy in a monetary union ranging from estimates of fiscal responses and multipliers, fiscal spillovers coming from periods of budgetary consolidations, effects of fiscal policy on output volatility, public investments spillovers to long-term (fiscal sustainability) issues (see below our literature review). We also discuss implications of increased harmonization in the Euro Area.

The remainder of the paper is structured as follows. Section 2 reviews the main theoretical concepts and links to the relevant literature. Section 3 describes the dataset and reviews the steps necessary for variables (re)construction. Section 4 presents the time varying model of fiscal rules utilized in the paper (Bayesian TVP model) and illustrates the main parts of the estimation methodology. Section 5 discusses the empirical results both for individual EA and stand-alone EU countries and for the Euro Area as a whole. Last section concludes and offers some suggestions for further research.

2 Review of literature and methodology

2.1 A theoretical review: fiscal rules, fiscal regimes and interactions with monetary policy

The knowledge of fiscal policy measures, their effects and related implications have improved substantially over recent years. However, there are still wide gaps and lack of 'rigorous' understanding of many aspects in comparison to well-studied monetary policy (as a consequence of the Great Moderation) as outlined in Alessina and Givazzi (2013).[9] Those 'problematic' areas are: (1) effects of policy interventions (multiplication effects), (2) long-term implications of fiscal policy measures (such as long-term trends bringing about changes in the workforce), (3) ways of tackling (high levels of) indebtedness and (4) the links between fiscal policy and political processes (institutions), mainly in finding efficient (robust) ways of putting constraints on fiscal policy. This paper aims to provide some further evidence within the area ad (4) that is predominantly concerned with fiscal rules and fiscal institutions.

In a similar vein, contrary to monetary policy with already well-established and relatively simple policy rules (mainly those of the Taylor's and/or McCallum's type) that have been subject to thorough theoretical and empirical scrutiny recently, fiscal policy has substantially lacked clearly formulated rule(s) that would be applicable in analyses of fiscal behaviour.[10] In spite of the fact that rules allow us to structure our way of thinking about key variables and main relationships and to differentiate between various types of policies (mainly discretionary *vs.* rule based ones) with ample implications for practical policy-making.[11] Reasons for this substantial gap in case of fiscal policy are manifold and usually concentrated on the differences between the conduct of monetary and fiscal policy *inter alia*: ways of setting (selecting) and possible choices of pursued targets, independence of considerations and/or political influences alongside well-known problems such as lack of (higher frequency) fiscal series, identification and explanatory problems (fiscal policy heterogeneity, see Claeys, 2008; Leeper, 2010).

Nevertheless there have been many simpler rules or rules attached to a particular type of fiscal policy behaviour ('problematic aspect') for almost 30 years now (at least those systematically documented). Some limitations put on fiscal policy behaviour are even of much older date.[12] More recently, a larger number of national (independent) fiscal institutes have been

[9] A strong incentive was the Great Recession and/or the European sovereign debt crisis that have led to the use of unconventional monetary policy instruments alongside or as a substitute for the lack of fiscal measures.

[10] Apart from those suggested by Taylor (2000) that is similar to a Taylor rule and/or Bohn (1998) that presents a rule focused primarily on providing a testable sustainability condition. In addition, Yoshino *et al.* (2015) derive a fiscal rule extending the Bohn's rule that includes both public debt, its change and a measure of output gap as a combination of optimal spending and taxation rule. Its use enables to achieve both fiscal sustainability and support economic growth.

[11] There are also some potential pitfalls that are related to simplifications of reality so that it can be approximated via a rule, which may turn unfavourable during large business cycles or in case of shocks.

[12] A document that lists all rules for countries around the world is Fiscal rules database prepared by the IMF (see IMF, 2015), in case of the EU (numerical rules only and for its members) there has been a similar

established alongside the existing ones (that can be traced back to as early as mid-1940's such as the Dutch 'watchdog' CPB) to strengthen public scrutiny (mitigate 'fiscal bias') as a result of fiscal problems during the Global Recession.[13] The existence and importance of some sort of rules for conduct of fiscal policy is thus not a completely recent phenomenon compared to monetary policy.[14]

As briefly outlined above, for countries in a monetary union another layer becomes important, mainly when considering a classification of fiscal authorities behaviour according to the so-called Fiscal theory of the Price level (henceforth, FTPL). FTPL originated in the seminar work of Sims (1994) and that of Leeper (1991), even though Buiter (2002) mentions even earlier contributions.[15] Both fiscal and monetary policy are considered perfect substitutes for price level determination and government debt stabilization, while the former belongs to monetary policy and the latter to fiscal policy conventionally. Fiscal policy behaviour can be classified as *active* or *passive* (alternatively Ricardian or non-Ricardian) with respect to its link between public debt and prices/output.[16] Only the latter is, however, compatible with sustainability since outstanding liabilities are expected to be balanced by future revenues, that is, fiscal solvency is envisaged responding (primary balance) to debt development.[17] In this framework, as pointed out by Creel and Le Bihan (2006), the existence of a passive fiscal policy (a Ricardian) regime across Euro area countries is very essential for the European Central Bank (henceforth, ECB) to be able to control inflation so that price stability according to their definition can be achieved. The existence of a fiscal rule (Pact) itself, however, is not a unique way of guaranteeing the passive regime as can be shown (see *ibid.*).

When analysing fiscal rules in a monetary union, as an example the Maastricht criteria and/or the Pact are usually mentioned. Beetsma and Giuliodori (2010) or Badinger (2009)

activity by the Commission (see EC, 2016a). Going to ancient times, one could find some institutions even in the Ancient Rome or Greece.

[13] In case of EU-28, there were as many as 47 independent fiscal and other institutions in 2014 (see EC, 2014). A formal test of effects of fiscal institutions presents Baldwin and Giavazzi (2016).

[14] An example of monetary rule *sui generis* is so-called $k-$percent rule suggested by Milton Friedman in the early 1960's. Simple monetary rules were also applied during the so-called Gold standard in late 19$^{\text{th}}$ century or even before.

[15] Woodford (1995, 1996) shows that price setting does lead to important differences in this concept.

[16] 'Passive fiscal policy' (regime) means that it does respond to debt and the intertemporal budget constraint (IBC) is satisfied for all price paths (Ricardian policy). Conversely, 'active fiscal policy' (regime) implies smaller than necessary responses to debt (in fact, it can follow any process even in contrast with the notion of sustainability). Fiscal policy gets eventually the upper hand over monetary policy for determination of prices (monetary authority can only deal with the consequences, i.e. inflation). In terms of our equation (4.1) or (4.2), $\alpha > 0$ can be interpreted as a Ricardian policy, that is, the latter case. The notion of active/passive can reflect changes in taxation as well. For example a passive policy is only when taxation responses to debt are large enough to the real interest rate payments (see Davig and Leeper, 2007). An implication of active fiscal regime can be a lower response coefficient in an estimate of a Taylor rule (the so-called Taylor principle would not be satisfied). The labelling of these policies as 'Ricardian' and 'non-Ricardian' is due to work of Aiyagari and Gertler (1985).
Results of empirical testing have been quite ambiguous, however, because of the observational equivalence (for examples see Afonso *et al.*, 2011).

[17] However, there may exist a situation when both fiscal and monetary policy are 'active', which is an instability region and prices would be still affected by fiscal policy measures, for discussion see Creel and Le Bihan (2006).

outline the need for some fiscal rules in such an environment: ($a1$) guaranteeing fiscal sustainability and ($a2$) coordination and harmonization (limiting the size of deficits and potentially unsound fiscal policies), (b) helping to achieve economic stability (setting limits to discretionary policies). Such rule(s) when implemented, complement the role fiscal policy as outlined in many classical papers such as (Mundell, 1961, 1973), stating the need for fiscal transfers in case of market rigidities and/or limited mobility of factors, or work by Kenen (1969) highlighting the need of some form of a fiscal union.[18]

2.1.1 A brief review of the literature

There have been a large number of studies that have estimated some type of a fiscal rule ('fiscal response'), whose specification has varied subject to main interest of the study (usually a panel with yearly fiscal series). Without a great deal of simplification, these can be classfied as belonging to one out of three substantially heterogeneous strands in the literature on fiscal policy rules (irrespective of a country's involvement in a monetary union) that is briefly summarised further below:[19]

1. simple fiscal rules (and their outcomes) resembling monetary (Taylor type) rules are analysed for individual countries or regional integration groups such as Taylor (2000) for the US economy or Galí an Perotti (2003) in case of EU states and the Maastricht Treaty;

2. fiscal rules following the spirit of seminar work of Bohn (1998, 2008) – fiscal response function (FRF) – , whose estimates provide an empirical test of fiscal policy sustainability ('model based sustainability', MBS); these estimates are utilized *inter alia* in the debt sustainability analysis (DSA) since they lie at the heart of model-based debt simulation exercise (for example Burger *et al.* (2011) or Berti *et al.*, 2016).[20] [21]
   More recent contributions put emphasis both on sustainability and on other characteristics (such as economic recovery, see Yoshino *et al.* , 2015), which has gained importance in the wake of periods of depressed/slow-growth economies, for example in Japan.

[18] While the '$1:n$' case in a monetary union is tacitly ignored in early literature, more recent contributions concerned with discretionary fiscal policy include: 'unpleasant' volatility of output and/or inflation (Sargent and Wallace (1981); Badinger (2009), unsustainable fiscal path (Sargent, 2012), negative spillovers (Beetsma and Giuliodori (2010).

[19] An overview of earlier literature and questions addressed can be found in Bayar and Smeets (2009).

[20] Burger *et al.* (2011) was also one of the first studies to use directly non-linear estimation techniques. They utilize yearly data (both cash (GFS) and accrual (SNA) definition) for South Africa over the period 1946/1974–2008 and find strong(er) positive responses to indebtedness in late 1970's and the 1980's and after 1998 in particular. Their estimation allowing for non-linear effect is, however, simply based on the use of Kalman filter.

[21] Focusing on the second group of studies, empirical analyses of fiscal rules and their effects have also followed few alternative routes: either country-specific estimations or panel analyses. Importantly, employed specifications considered both public debt and output gap and/or further variables shaping fiscal policy (and institutions). However, there has not been an attempt to consider a larger group of countries and analyse their behaviour both a group and individuals.

3. rules related to the aforementioned work on the FTPL employing techniques enabling to capture fiscal policy changes, with two broad sub-strands: one for fiscal policy rule estimations based on primary balances, the other for fiscal rules using revenues or expenditures while allowing for mutual interactions (see Afonso *et al.* (2011) for references; a recent survey of the FTPL literature and main strands is provided by Bajo-Rubio *et al.* (2009) complementing an early review by Buiter, 2002).[22]

In spite of a large number of studies, only few of them have employed higher than yearly frequency of fiscal series and/or attempted to find reasons for changes in fiscal behaviour (switches) either conditional on external events or as a result of policymakers game. In addition, they have not explicitly focused on harmonization as a result of institutional or other changes in a monetary union. Among those few exceptions, for example Thams (2007) utilizes quarterly series for Germany and Spain and Bayesian Markov-switching techniques (BMSM) and finds changes in fiscal policy regimes in both countries around end of 1990's (more sustainable), that is, around the launch of the Euro, with less stable behaviour in case of Germany and stronger responses resembling non-Ricardian policy in case of Spain. Relatively often has been analysed both major EU/EA members and/or Greece, Italy, Portugal and Spain being countries with a 'history' of fiscal issues. Schoder (2014) finds the Pact to be supportive for restoring/preserving fiscal policy sustainability in countries with high responses, while was not for others (Greece, Portugal and France). In contrast with our study, they utilize a model without covariates (derived from stochastic optimization problem in sense of Bohn (1998, 2007)) and use 'mechanically' reconstructed quarterly fiscal series (Chow and Lin approach for primary balances and net debt) from 1980's to 2010 for 15 OECD countries including non-European members.

A close to our approach is Cuerpo (2014) that utilizes quasi-Bayesian time-varying technique (proposed by Ciapanna and Taboga, 2011), however, only for Spanish quarterly fiscal series (1986q1–2012q4) reconstructed by De Castro *et al.* (2014). Spanish fiscal policy is found to have behaved in a sustainable manner during the 1996–2008 period, otherwise characterized by the zeal of meeting convergence criteria allowing to join the first wave of Euro adoption and years of robust conjuncture of the Spanish economy. These findings then confirm conclusions of De Castro *et al.* (2014), while Ricci-Risquete *et al.* (2016) with the same data but MSM VAR technique do find only one change fiscal policy regime in Spain (in late 1992). These studies, however, lack more recent data that show significant worsening and sluggish recov-

[22]The FTPL literature estimates fiscal policy behaviour and its changes using (Bayesian) Markov-switching techniques or more recently (Bayesian) time-varying parameters estimators which allow to identify up n individual regimes (usually only two for the dichotomy) and associated turning points. Modelling regime changes or time-varying responses pose a challenge for estimation due to the length of available time series and the high sensitivity of MSM techniques to the analysed data.
A complication of testing the FTPL is linked to the fact that intertemporal budget constraint is understood as an equilibrium condition in both concepts (active/passive) and not as a constraint *per se*. However, it is the way of achieving solvency that allows to differentiate between these concepts (endogenous/exogenous). For a discussion see Creel and Le Bihan (2006).

ery of Spanish fiscal policy after 2009. Also Afonso *et al.* (2011) analyses fiscal behaviour in one country – Portugal between late 1970's until 2008 – and utilize MSM technique. That study finds a change in fiscal regimes in 1988 (two subtypes of a non-Ricardian regime) and mixed evidence of more restrictive fiscal policy in the period before the launch of the Euro and around 2002, when Portugal was as the first EA country facing sanctions in the EDP process as a result of violating the Pact. Afonso and Toffano (2013) estimate optimal (fiscal) reaction functions on quarterly data (from 1970's/1980's to late 2000's) coupled with monetary reaction functions for three EU economies (Germany, Italy, and the UK). Allowing for regime-switching in parameters (MSM), they find fiscal policy in Germany rather passive (sustainable), while in Italy only in the pre-EMU period; several changes are identified in the UK with periods of sustainable policies between the 1980's and early 1990's and from late 1990's until the beginning of the Great Recession and its spread to Europe (2007/2008). Therefore, this paper provides an important contribution to the literature by utilising flexible Bayesian TVP technique allowing for smooth identification of changes in fiscal regimes (not limited to two types) that are necessary to analyse a process of fiscal harmonization across EA members.

2.1.2 Fiscal policy rules

A fiscal rule or a fiscal reaction function usually takes a form formalised in (Bohn, 1998), which is a specification allowing for estimation of fiscal responses and testing of (macro) fiscal sustainability (MBS). The standard (functional) form then resembles monetary policy rules (Taylor rules) because of the use of output gap or its proxy (growth rates of potential or real GDP) and in some specifications further variables. A fiscal policy rule explicitly laid out by Taylor (2000) can take the following form:[23]

$$bs_t = \alpha d_t + \beta og_t. \tag{2.1}$$

The model (2.1) links primary (sometimes cyclically adjusted) balance (bs_t) and the outstanding debt (d_t) of a country i over a period of time (for example as a forward-looking role for $k < \infty$ period, $\langle t, t+k \rangle$) with or without explicitly controlling for further determinants (economic, financial, institutional, etc.) such as output gap (og_t). The estimated coefficient on public (government) debt ($\widehat{\alpha}$) characterises the response of primary balance to debt and in the Bohn (1998)'s inspired literature is interpreted as a (weak) test of public debt sustainability, that is, no-Ponzi Game (for details see for example D'Erasmo *et al.*, 2015).[24] However, short-

[23] Arguments for the inclusion of debt level into a fiscal rules can be found for example in Favero and Giavazzi (2007). In addition, Fatás and Mihov (2010) find evidence for cyclically-adjusted primary balance and growth rates, while no significant evidence for output gaps in case of EU countries (dataset included only first years existence of the Euro Area). Since output gaps are commonly utilized and they are in line both with Taylor rules and optimal behaviour in a micro-based type of models, our preference is to follow this approach.

[24] Some authors claim that primarily the failure to control for the role of financial markets results in too low estimates of fiscal responses. Therefore, a reformulation of the rule (2.1) can be viewed as a sufficient sustain-

comings of this specification lie in the fact that the debt response coefficient α is commonly treated as time invariant,[25] the standard Euler equation in the background (general equilibrium conditions). Since the rule defined above can be expressed in relative terms (as a share of GDP) and should take into account feedback coming from financial markets, a stricterto-be-satisfied condition for sustainability can be formulated (in the form of a debt adjusted interest rate, that is $r_t - g_t$). Either in the simple or in the more complex approach, empirical estimations of such a rule are so-called MBS tests (see D'Erasmo *et al.*, 2015).

Recent studies on fiscal functions have emphasised two important links between fiscal responses and a broadly defined environment: (a) optimising behaviour of fiscal agents, (b) the importance of a link between fiscal policy behaviour and monetary policy actions. For that purpose, an extension of the simple model (2.1) can be realised: for example a model explicitly allowing for optimising behaviour and inflation spillovers (Kirsanova *et al.*, 2005). The 'static' form of such a rule then reads:[26]

$$bs_t = \alpha d_t + \beta og_t + \gamma \pi_t. \tag{2.2}$$

where π_t is the rate of inflation and other variables have the same interpretation as above. In contrast to monetary policy rules, fiscal rules usually do not include expectation terms for output gap and/or inflation.

2.1.3 Further extensions of fiscal rules

Since a linear rule is only an imperfect proxy of real fiscal policy reactions and plots showing (primary) fiscal balance and debt can even reveal a non-linear relationship, there have been several attempts to modify it. One approach, already tested in Bohn (1998)'s paper, rests upon adding higher-degree of a debt polynomial. Either in the form of a difference with respect to a country's average value (capturing deviations from a country specific 'steady state') or as additional polynomial terms, usually a second and also a third term. A theoretical justification for a non-linear model is linked to the so-called *fiscal fatigue hypothesis* (henceforth, ff hypothesis), empirically examined for a sample of developed countries in Ghosh *et al.* (2013). This hypothesis assumes different behaviour of fiscal authorities depending on the actual debt level, which

ability condition, only if the value of ($\widehat{\alpha} > 0$) is large enough, possibly conditioned on further determinants including interest payments on the current stock of debt and if there is no upper limit on positive value of primary surpluses, for example as shown in Daniel and Shiamptanis (2013).

[25] The validity of this point, however, relies on the actual specification (country/time dimension). For further discussion see for example Berti *et al.* (2016).

[26] They develop a three/five equation model with a goods market (dynamic IS curve), an expectation augmented version of the Phillips curve (PC), a Taylor type monetary rule (output and inflation, MP), a debt accumulation equation and a rule for fiscal authorities (output and debt). In this model fiscal authorities respond not only to debt, but also to inflation and output. This leads to the specification (2.2) of the fiscal rule. Assuming monetary policy is capable of stabilising the economy, then small responses to debt and only negligible to output and/or inflation should be found in case of fiscal authorities (*ibid.*).

can bring about larger or smaller responses of fiscal balance.[27] Another approach consists of various attempts to model fiscal policy environment usually approximated via a linear switch (dummy) for elections, that is, deal with structural differences in use of fiscal policy measures. More recently, there have been studies using time-varying estimation (Kalman filter based) or Markov-Switching technique for individual countries such as Burger and Marinkov (2012); Afonso and Toffano (2013) or Ricci-Risquete *et al.* (2016). The identification of various fiscal regimes also allows to assess policy-makers' behaviour according to the FTPL.

3 Data and their treatment

The quarterly data utilized in this paper covers the period between 1980q1 and 2015q4, which means that all major steps in the process of European integration in the 1990's and 2000's are included. Our dataset consists of twelve old EU countries (including two members that entered in the 1980's and three members in mid 1990's) forming a monetary union and three stand-alone old EU member states – Denmark, Sweden and the United Kingdom.[28] This composition of EU countries will make possible to analyse effects and reactions of fiscal policies across different types (usage) of fiscal policy and therefore, levels of indebtedness.

For our estimation of country-specific fiscal rules over time not only fiscal time series are needed, but also other macro-economic variables, and there are several sources of macroeconomic series utilized in this study. Despite the fact that quarterly fiscal time series have been published by Eurostat for EU countries for some time, their length and coverage vary across countries substantially.[29] For the purpose of this study, it was necessary to reconstruct quarterly fiscal series and our approach (Kalman filter based) is described in detail below. There have also been few attempts to reconstruct quarterly fiscal series from individual revenue and expenditure items using macroeconomic aggregates based on the System of National Accounts (SNA) or its European version (European System of National Accounts, ESA), such as Paredes *et al.* (2014) for the Euro Area (EA-15) covering the period 1980q1–2013q4) and using similar methodology for Spain (currently 1986q1–2014q4), see De Castro *et al.* (2014). The applied decomposition method seems to provide observations very similar to those reconstructed with help of SNA. In spite of the fact that a reconstruction is not without problems

[27] For example, for very high debt levels can a fiscal authority respond with stabilization leading to a reduction of deficits (and consequently of debt) or the current debt level can be so high that the fiscal authority will not adjust and default will follow. However, there is no guarantee that fiscal behaviour will follow such a non-linear pattern since this approach is more mechanical than related to fiscal capacity, fiscal space of a country or past behaviour of policy-makers.

[28] Because of different starting conditions (public debt were mostly erased by high inflation rates in first years of transformation processes in the early 1990's), structural characteristics and general lack of availability of data before 1990(95), none of the 'new' EU member states that has joined the Euro Area is considered in this study.

[29] Otherwise, one would have to start as late as around first quarter of 2002 for most EA countries with few exceptions such as France or Finland. Somewhat better situation is in case of the stand-alone countries. This is because of the 'obligatory' beginning of publishing fiscal quarterly series that goes back to first quarter of 1999.

even in this approach because of several methodological changes (ESA 1979, ESA 1995 and ESA 2010). As it can be seen in case of Spain, our generated fiscal series (primary balance) is matching the SNA-reconstructed series very closely, which provides a visual check of our method (robustness) and gives support to the Bayesian approach.[30]

3.1 Reconstruction of quarterly series

In this section only main steps utilized for reconstruction quarterly fiscal and economic time series are summarised, for more details on data treatments see the data section in the appendix. The main source of quarterly series for our dataset is Eurostat for fiscal time series (*Government finance statistics*, ESA2010 and *Quarterly national accounts*, ESA2010) and OECD (*Economic Outlook database* and *Quarterly National Accounts*). Yearly fiscal policy variables are primarily taken from the database of the European Commission (*Annual macro-economic database, AMECO*) that is compatible with Eurostat and from a historical dataset of fiscal variables prepared by the IMF (*Public Finances in Modern History Database*, see Mauro *et al.*, 2013). In order to have comparable series, the same database is used for country/year observations in line with arguments in Berti *et al.* (2016). Furthermore, to eliminate 'spurious' responses coming from (*one-off*) interventions in financial institutions in few EA countries related to the Sovereign Debt Crisis (so-called government support to financial institutions – GAFS, for further details see the data subsection in appendix); these effects are eliminated in our primary balances. Since these measures did not directly affected public debt series (but changed so-called contingent liabilities), no adjustment of public debt series was carried out. Moreover, there were various one-off operations realised in the past (before 2007), however, there is no consistent and systematic evidence on these items even for EA countries. Some authors have tried to adjust series for these effects; one approach uses differences in dynamics of net capital transfers see Joumard *et al.* (2008). However, their implications were also related to countries' debt series and therefore, we decided not to distort the dynamics with our imprecise corrections of our fiscal series any further.

Since quarterly fiscal time series are rather short or missing (such as output gap, see below),[31] for a majority of EU countries are available from 1999:q1 onwards, they are extended for the whole sample period with quarterly series created with help of the Kalman filter technique and a Bayesian approach for decomposition of low frequency series.[32] One of the biggest

[30] I thank Javier Pérez (BdeE) for providing me with the latest version of their fiscal dataset accompanying De Castro *et al.* (2014).
Furthermore, an empirical illustration for GIIPS countries and the Netherlands (with and without GAFS series) is shown in panels of figures (A.1) in appendix. Details on one-off items and their treatment can be found in EC (2015).

[31] For example even the most recent OECD publication on output gaps for individual OECD countries is for yearly frequency only, see Turner *et al.* (2016); the same holds true for the ECB; however, Jarocinski and Lenza (2016) discuss methods of estimating output gap at quarterly frequency for the Euro Area as a whole.

[32] This way of reconstructing quarterly series draws upon contributions of Giannone *et al.* (2015) and Bańbura *et al.* (2015). I thank Giovanni Ricco for sharing an earlier version of their Matlab code utilized

advantages of this approach compared to commonly used mechanical techniques for temporal disaggregation such as Chow-Lin, Fernandez or Litterman (for overview and details on available methods with references see for example Quilis, 2004) is that quarterly series are constructed with help of the information provided by using other (macro) quarterly series that are highly correlated with to-be-reconstructed fiscal series.[33] A similar procedure was employed when reconstructing other quarterly series (interest yields and government expenditures). As a proxy for effects coming from financial markets, *implicit* interest rate (i_{IIR}) was utilized. This rate is defined as interest payments in the period t (IRP_t) over the outstanding debt from last period (D_{t-1}).[34] Further details are provided in the data section in the appendix.

Output gap and cyclical component of total current expenditures for individual quarters are calculated with help of the Baxter and King (Band-pass) filter with commonly used parameters ($BK_{12}(6, 32)$ covering main business cycle frequencies in the range $1\frac{1}{2} - 8$ years) that provides better estimates compared to the Hodrick-Prescott filter (with $\lambda = 1600$) on quarterly frequency (HP filtered series are utilized in robustness section).[35] Since both filters have been shown to have problems in case of the beginning and end of a time series ('*end-points*'), and in case of BK filter are few initial periods lost because of the filter construction), series are extended with three or four years (12 or 16 quarters of observations) using forecasting and backcasting in a bivariate $VAR(p)$ model.[36] To these extended series, both filtering techniques were applied, fitted values were stored, the extensions of series were dropped. All series were seasonally adjusted (either directly when accesses in particular databases or before any calculations using the ARIMA X-13 method).[37]

Because of data revisions, several studies have shown the importance of data vintages' effects on fiscal series (such as Golinelli and Momigliano, 2009), mainly government balances (in particular on cyclically adjusted fiscal series). Unfortunately, real-time analysis cannot be carried out in case of quarterly time series that are published by Eurostat. Even in case of

in Caruso *et al.* (2015).

[33]We also tried to recalculated quarterly series utilizing both techniques and results were broadly similar in terms of trends and turning points.

[34] *Prima facie* evidence shows that our measure is a good proxy for trends in financial markets despite the fact that the outstanding amount of debt consists of both accrued coupon payments and capital gains/losses. Some authors then use the label 'period-holding return on the stock of outstanding debt', for example see Wilcox (1989).

[35]Other high values of smoothing parameters for the HP filter were utilized such as that recommended by Perron and Wada (2009) or Market and Ravn (2007) for GDP, however, their gains compared to the standard HP filter were given by the length of available time series. Market and Ravn (2007) argue that setting the BK filter equal to $BK_{12}(6, 32)$ works well for quarterly series; the closest counterpart of the HP filter for quarterly data would be $BK_{12}(2, 32)$ according to Baxter and King (1999).
We will treat HP filtered series as a robustness check following a recent paper – Hamilton (2016) – arguing that one should use different filtering techniques that the HP filter in empirical applications.

[36]We follow Watson (2007) for GDP series, where the VAR is with GDP and prices (Okun/Phillips relationships), in case of expenditures, we use a model with GDP (Wagner's law). Alternatively, $AR(p)$ models were utilized; for details see appendix.

[37]Some authors have also employed a much simpler approach in the context of exchange rates models, rolling mean over four quarters utilized in Engel *et al.* (2015). However, we preferred the more standard method for comparability of seasonally adjusted series coming directly from statistical offices (commonly applying the same method) in our dataset.

yearly series, the AMECO database that has been running since 2002 and comparable series are available since 2008, OECD Economic Outlook database provides yearly series as well.

4 Time-varying parameter fiscal functions

As it was outlined in previous section of this paper, fiscal responses functions or fiscal rules are usually estimated as time invariant for a country or a group of countries. Commonly used specifications draw upon the Bohn (1998)'s model, similar to the model (2.1). A flexibility to the estimation is added with help of time or state-dependent interactions. The former is represented by time or event-related dummy variables, the latter by a Markov-switching model, where two or more types of responses are assumed, that is, in a more flexible manner.[38] Since our aim is to capture the changing nature of fiscal policy over time given both endogenous and exogenous changes in economic, financial, institutional... environment, several techniques could be applied to investigate empirically their effects (see below). A particular choice of a technique can be also driven by the availability of fiscal data that still varies substantially, even for many European countries (for a recent summary see Irwin, 2015).

4.1 Model specification

In this paper, two modifications of the simple fiscal rule presented in the equation (2.1) above are considered, in line with the aforementioned modifications. Firstly, the restriction (time invariability) put on estimated parameters is relaxed and our fiscal rule is allowed to change over time, that is, our model will capture time-varying fiscal responses. Secondly, the traditional approach based on a linear response rule in the spirit of (Bohn, 1998, 2008) allowing for persistence of fiscal measures is complemented with a set of controls:

$$bs_t = \varrho_t bs_{t-1} + \alpha_t d_{t-1} + \boldsymbol{\Gamma_t \Theta}_{(.)}, \tag{4.1}$$

where bs_t, bs_{t-1} is the current and lagged primary balance, $\boldsymbol{\Theta}_{(.)}$ stands for a set of determinants (economic, financial, ...) of fiscal policy, and ϱ_t, α_t, and $\boldsymbol{\Gamma_t}$ represent a set of time-varying coefficient to be estimated. Regarding the determinants, there has not been reached a consensus in the literature as to which are the most important (apart from the debt variable and a proxy for economic conditions). As a result, we consider two versions of the fiscal rule:

(*i*) **Fiscal Rule I** (FR I) – a model with interest rate (i_{IIR}, defined implicitly, see below) that combines the idea of fiscal policy taking into account inflation rates (indirectly) and also the effects of fiscal policy on financial environment and *vice versa* that is closer to

[38] Regimes are usually found to be quite persistent with low switching probabilities, which may or not may be a good description of fiscal policy. In case of imperfect information, changes of regimes may remain unidentified, similarly in case of the existence of temporary sub-regimes that are not allowed for.

the sustainability strand of the literature,[39]

(*ii*) **Fiscal Rule II** (FR II) – a specification along the lines outlined in Kirsanova *et al.* (2005) and briefly above ('optimal fiscal policy'), with inflation rate and a proxy for taxation motives in line with the original Barro (1979)'s argument (and thus more in the vein of the FTPL literature).

Models such as (4.1) are meant to capture short-run fiscal policy behaviour at the yearly frequency, not considering explicitly lags related to policy-makers actions. Since policy-making reality is different though, one can specify a fiscal rule explicitly taking into account these lags, which can be also viewed as an example of differences between fiscal and monetary policy necessarily reflected in their policy rules. In addition, our model will be estimated at quarterly frequency, so it cannot be a simple transposition of a yearly-based model to the quarterly environment. Its seems more reasonable, given the nature of fiscal policy, to allow for the possibility that fiscal responses are more aligned with four-quarter changes (i.e. one year) that those from quarter to quarter as has been commonly done in the literature simply bringing a Bohn's type yearly model to quarterly data.[40] There have been only with few exceptions so far that considered such differences for example Burger and Marinkov (2012).[41] Therefore, our specification for quarterly series based on the model (4.1) reflects the difference and with interest rate ($i_{(.)}$, FR I) takes then the form:[42]

$$bs_t = \varrho_t bs_{t-4} + \alpha_t d_{t-4} + \boldsymbol{\Gamma_t \Theta'_{(.)}}, \tag{4.2}$$

where $\boldsymbol{\Theta'_{(.)}} \in \{ogap_{t-4},\, i_{IIR,\,t-4}\}$ and the interpretation of individual remaining variables is the same as above.

[39]Since in advanced countries with data after 1970's inflation rates are usually not found significant, we do not distinguish explicitly between nominal and real interest rates. A simple check for few countries in our dataset does reveal only negligible differences in fiscal behaviour. Results upon request from the author.

[40]This also mitigates serial correlation and potential problems with endogeneity.

[41]Quarter-to-quarter changes $[{}^{(q+1)}/_{(q)}]$ of government expenditures are rather limited and mostly associated with unexpected events requiring immediate fiscal intervention (such as catastrophes). Changes of taxation are only very rarely carried out on a quarterly basis because of their implications for economic subjects. One exception is a crisis management in fiscal stress aimed to stabilise public finances such as measures adopted recently in Greece. It has also been shown that the role of automatic fiscal stabilisers is rather limited except for Scandinavian countries.

[42]The choice of interest rate for fiscal policy behaviour is important (for a discussion see for example Fourier and Fall, 2015). While the short-term rate would emphasises a focus on liquidity problems, the long-run rate than problems with solvency and/or trends of public finance in a country. Alternatively, implicit interest rate (i_{IIR}) on outstanding debt can be calculated (current year interest payments over past year debt level): $i_{IIR,\,t} = \frac{IRP_t}{D_{t-1}}$. Since debt structure on quarterly basis going back to the 1980's is rather a Herculean task, its simple approximation is done with i_{IIR}. However, i_{IIR} is not a perfect measure either since its calculation suffers problems with time structure of (re-)payments of accrued interest and the underlying principal (*cash* vs. *accrual*), see the previous footnote no. 34. While our definition is a proxy for weighted average of market interest rates, there is a list of possible modifications interest rates, see for example Debrun and Kinda (2016). As a robustness check, two other measures of interest rate 'pressures' are utilized: (*i*) long-run interest rate on government bonds adjusted for prices (GDP deflator) and economic growth – this interest rate is called here *de iure interest rate* and (*ii*) the previously defined IRP adjusted for prices and economic growth (the same definition as in (*i*) above) labelled as *de facto interest rate*.

The alternative specification with inflation rate and expenditure/tax smoothing variables (FR II) takes the form:

$$bs_t = \varrho_t bs_{t-4} + \alpha_t d_{t-4} + \mathbf{\Gamma_t \Theta''_{(.)}}, \tag{4.3}$$

where $\mathbf{\Theta''_{(.)}} \in \{ogap_{t-4},\ \pi_{t-4}, gcout_{t-4}\}$, π_{t-4} is the rate inflation (CPI) and $gcout_{t-4}$ stands for the trend deviations of total current expenditures. The interpretation of remaining variables is the same as above.

Based on the theoretical considerations and work of (Bohn, 1998, 2008), it can be expected that the coefficient ϱ on lagged primary balance would be positive (persistence of fiscal measures). The coefficient for the variable of main interest, the lagged debt ratio, α would be positive as long as the government responds with a reduction of primary balance deficit (i.e. an increase of primary surplus) for rising debt and *vice versa*. Its sign is thus ambiguous beforehand. Given the flexibility of our parameters, they will also capture changes in other determinants mainly institutional factors that are usually controlled for in traditionally estimated (frequentist) regression models. Since both output and expenditure gap can be included (our second specification), their interpretation will be slightly different. With both variables included in the model (model (4.3) above), the output gap captures effects of business cycle on fiscal position and therefore, Γ_{ogap} should be negative (i.e. a worsening of fiscal balance in a recession/depression) as a result of the work of automatic stabilizers. A priori, the coefficient on rate of inflation can be both positive and negative (since a faster growth of prices will help balance budget, however, the sensitivity of both budget sides matters and the expenditure side can turn the effect though). Similarly, the coefficient on interest rate, $\Gamma_{i_{IIR}}$, is expected to be positive since higher debt payments will require corrections of primary balance. Conversely, the coefficient on deviations from trend total current expenditures (Γ_{gcout}) would be negative, when tax/expenditure smoothing is at work (for example an increase as a result of windfall profits due to a commodity boom).

Since response coefficients estimated in our models (4.2) or (4.3) stand for short-run fiscal responses only ($\widehat{\alpha}_t$), which can be viewed only as partial information. Therefore, long-run responses can be added ($\widehat{\alpha}_t^{LR}$), that can be calculated for a particular time period t as: $\widehat{\alpha}_t^{LR} = \frac{\widehat{\alpha}_t}{1-\widehat{\varrho}_t}$, where $\widehat{\varrho}_t$ is the estimated coefficient of the lagged primary balance.

Since some studies have raised the issue of estimating fiscal responses with lagged dependent variable – our models (4.2) or (4.3) – because of effects of automatic stabilisators for fiscal responses. Even though this particular problem seems to be relevant for reduced version of fiscal rules, not explicitly controlling for any determinants but output gap (and for cyclically adjusted primary balances as the dependent variable), we estimate our rule I and II without the lagged term without and with an AR(1) error term as a robustness check.[43] This specification

[43] See for example Golinelli and Momigliano (2009), Fourier and Fall (2015) or Plödt and Reicher (2015).

does not allow to distinguish time frame of the response as it is in the more common model.

$$
\begin{aligned}
bs_t &= \alpha_t' d_{t-1} + \mathbf{\Lambda_t \Omega_{(.)}} + \varkappa_t \\
\varkappa_t &= \beth \varkappa_{t-1} + \xi_t
\end{aligned}
\tag{4.4}
$$

where $\mathbf{\Omega_{(.)}}$ includes the same variables as in (4.2) or (4.3) and $\varkappa_t$ is an AR(1) error term.

4.2 Estimation technique

There have been few techniques applied in the literature, when estimating effects of determinants on fiscal policy variables: (*i*) **VAR technique** (and its modifications), however, VAR estimates have been subject to various opinions (see Afonso, 2005) because of their reliance on causality or the effect of variables' ordering. (*ii*) Since fiscal series are usually short, in case of quarterly frequency in particular, **panel techniques** have been used since they enable testing fiscal regimes even in countries facing that problem. Moreover, panels can help address some further empirical challenges, however, the implicit assumption of one regime across the panel may be too strict. (*iii*) Another choice can be **Markov-switching** that has been subject to issues both with the choice of the number of states and are rather data-demanding (sensitive). (*iv*) Further, a **rolling regression** and/or the **Kalman filter** has been used to estimate a model sequentially and to allow so for time-variation of parameters. However, both the former and the latter work with 'fiscal flexibility' in a particular manner in comparison to more flexible TVP models. And more recently, (*v*) **quasi-Bayesian methods** (with the Kalman filter and maximum likelihood estimation) have been applied to data.

In this paper, we utilize a full Bayesian technique so that some potential issues when applying Bayesian approach jointly with the MLE estimation are avoided.[44] Our extended dataset allows to carry out country-specific estimation and capture time variation at the same time because of utilization of Bayesian methods for time-varying parameter estimation in the state-space model framework. Bayesian methods consider all parameters to be random distributed variables and allows to calculate so-called credible intervals for them (for details see for example Koop *et al.*, 2007). Moreover, this estimation treats all to-be-estimated parameters as stemming from jointly distributed random variables, that is, their estimation takes into account the uncertainty associated with all the others (see Kim and Nelson, 1999). It is not the only possibility that is available, however, this way estimation is carried out helps eliminate issues that are encountered in case of applications of the Maximum likelihood estimation in combination with the Kalman filter as briefly highlighted above).

Following Blake and Mumtaz (2012), for simulation of draws from the parameters' posterior

[44] There are two potential problem of the MLE estimation approach (for details see Kim and Nelson, 1999): 1) the estimation of likelihood functions (estimation errors can potentially accumulate, which can be a severe problem for large models (with many state and other variables) because one parameter estimation is carried out with conditioning upon other estimates) and 2) the initialization of the Kalman filter requires objectivity to be correct. While the latter can be solved easily, the former does not.

distribution the Gibbs sampler (one of *Markov chain Monte Carlo* (McMC) methods) and the algorithm suggested by Carter and Kohn (1994) are employed. In order to do that, one has to specify (see Byrne *et al.*, 2016): (*a*) the unknown parameters of the model to be estimated and (*b*) their posterior conditional distributions, subsequently allowing (*c*) the algorithm to draw samples from them.

As described above, one problem is a proper choice (specification) of priors (formulation of beliefs on prior distributions to be utilized). In this paper we use the beginning of our sample to generate the necessary information, of the same length for all countries for comparability. This choice means that a country-specific characteristics are taken into account at the start of the estimation procedure and thus, they are aimed to help alleviate problems with a fixed choice of some arbitrary values. This approach is also assumed to lead to more accurate time-varying estimates (reduced variance) because of natural shrinkage contained in the likelihood (Byrne *et al.*, 2016).

The TVP regression model allowing for specified time-variation of coefficients takes the following form (with the measurement (observation) equation being the (4.5a), and the transition equation being the (4.5a) below):

$$y_t = \aleph b_0 + \boldsymbol{\beta_t} \boldsymbol{X_t} + \epsilon_t \tag{4.5a}$$

$$\boldsymbol{\beta_t} = \omega + \boldsymbol{\Lambda} \boldsymbol{\beta_{t-1}} + \varepsilon_t \tag{4.5b}$$

where

$$\epsilon_t \sim N[0, \Xi] \ (iid), \tag{4.5c}$$

$$\varepsilon_t \sim N[0, \Theta] \ (iid). \tag{4.5d}$$

where y_t is univariate ($T \times 1$), $\boldsymbol{X_t}$ consists of $p > 2$ fiscal rule determinants (including the first lag of dependent variable), $\boldsymbol{\beta_t}$ is a $p \times 1$ matrix of coefficients, $\boldsymbol{\Lambda}$ is the $p \times p$ matrix ($\sim I_k$ identity matrix), and $E[\epsilon_t, \varepsilon_t] = 0$ (independence). When setting $\Xi = I_k$ and parameter $\omega_\epsilon = 0$), the regression coefficients evolve according to a random walk with innovations ε_t. $\aleph b_0$ represents any time invariant variable(s) and the coefficient (matrix ($k \times k$) of their coefficients) included in the model specification. In our case it is set to zero.

As Kim and Nelson (1999) or Blake and Mumtaz (2012) explain (see for details), initial values for time-varying parameters $\boldsymbol{\beta_t}$ (observable state variables), $\boldsymbol{\beta_{(0|0)}}$, and their variances ($\boldsymbol{V_{(0|0)}}$) need to be specified before the Kalman filter can be initialized. This is done alongside with selecting initial values for the variance of the measurement (observation) equation – $\boldsymbol{\Xi}$ – and the variance-covariance matrix of the transition equation – $\boldsymbol{\Theta}$. The Kalman filter derivation will not be shown but it can be found for example in Frühwirth-Schnatter (2006, Ch. 13) or in Blake and Mumtaz (2012, Ch. 3).

In order to find the initial values ($\beta_{(0|0)}$, $V_{(0|0)}$) for our TVP model, a simple parameter-

time-invariant OLS regression over a training period (TP) of five years at the beginning of our sample is run (because of a four-quarter lag the actual period is: T_{TP} = 1981q1–1984q4). The length of our training sample period is rather short, however, given our time sample it should provide some information for the estimation. This way of parameter initialization with help of a training period accords for example with Primiceri (2005) for the US economy (40 quarters for his VAR model), or more recently with Byrne *et al.* (2016) for country specific estimations. As a result, the following can be set: $\beta_{(0|0)} \equiv \beta_{OLS}$ and $V_{(0|0)} \equiv V_{OLS}$. This, however, reduces our sample period for estimation of fiscal responses to 1985q1–2015q4 (i.e. 124 quarters).

$$\beta_{OLS} = (\mathcal{B}'_{TP,t} \cdot \mathcal{B}_{TP,t})^{-1}(\mathcal{B}'_{TP,t} \cdot y_{TP,t}) \tag{4.6a}$$

$$V_{OLS} = \Omega_{TP} \otimes (\mathcal{B}'_{TP,t} \cdot \mathcal{B}_{TP,t})^{-1} \tag{4.6b}$$

where

$$\Omega_{TP} = (y_{TP,t} - \mathcal{B}_{TP,t} \cdot \beta_{OLS})'(y_{TP,t} - \mathcal{B}_{TP,t} \cdot \beta_{OLS}) \cdot (T_{TP} - r)^{-1}, \tag{4.6c}$$

where r is the number of parameters to be estimated and $\beta_{(.)}$ and $V_{(.)}$ are priors to be found.

The prior for the measurement (observation) equation is represented by inverse Gamma distribution and inverse Wishart distribution for our single equation model (in VAR specification for example the Jeffrey's or the Minnesota prior could be used). Firstly, inverse Gamma ($\beth^{-1}$) for the measurement equation, $P(\Xi) \sim \beth^{-1}\left[\Xi_{TP}, (T_{TP} - r)\right]$ with the degrees of freedom from the training sample $(T_{TP} - r)$ and the scale parameter $\Xi_{TP} = \Omega_{TP}$. The prior for the transition (updating) equation is inverse Wishart distribution: $P(\Theta) \sim IW\left[\Theta_{TP}, T_{TR}\right]$ with the training sample variance $V_{TP} = \Theta_{TP}$ (with a scaling factor, see below) and degrees of freedom of the training sample T_{TR}. Following recommendation in Blake and Mumtaz (2012), the matrix Θ_{TP} affect the variation of coefficients in our model (larger values lead to large dispersion) and since our starting period provides some information on individual variables but this information is somewhat limited, we restrict its content. Therefore, the calculated variance is re-scaled via: $\Theta_{TP} = V_{OLS} \times T_{TP} \times \nu$, where ν is the factor of proportionality. We set it to a small number $\nu = 3.5 \cdot 10^{-5}$ for all models (along the lines justifying similar treatment of variance provided in *ibid.* or Primiceri, 2005) to limit the amount of variability that is passed through. That also affects the speed of adjustment for parameters of our model.[45] Parameters (β's) are drawn from multivariate normal distribution, in accordance with the recommendation in the Bayesian literature.

Also for the initialization of the Gibbs sampler some values of priors are required – Ξ and Θ. These are set similarly to the previous case (with variability of the training sample to

[45] On the one hand, one could argue that fiscal measures and changes in fiscal policy are not very frequently adopted because of institutional dynamics. On the other hand, there have been periods of time, when fiscal policy have respond rather quickly. Therefore, alternative values of the scaling factor ν were tried, see robustness section.

be reduced): $\Xi_0 = V_{OLS}$ and $\Theta_0 = V_{OLS} \times T_0 \times \nu$. In our model we do not consider the possibility of changing volatility over time (stochastic variability) that can be added on the top in estimates of policy rules; for details see Blake and Mumtaz (2012). The reason for this decisions is driven by the length of our time series, which limits the amount of data that can be utilized for identification.

To verify that our algorithm meets the necessary conditions for convergence, two statistics were calculated. Firstly, a statistics that contains information about the necessary number of draws to achieve a given level of numerical accuracy for a particular simulation (for details see Geweke, 1992). It is the relative numerical efficiency (RNE) of the Gibbs sampler. The other (*ibid.*), is a statistics (convergence diagnostic, CD) that aims to capture behaviour of the generated sample by comparing its two sub-samples (usually at 10% and 50% of the retained Gibbs draws; the lower threshold was moved to 20% in our case, similar to application in Byrne *et al.*, 2016); for details see Blake and Mumtaz (2012). Using a suggested calculation of Raftery and Lewis (1992), we arrive at the minimum number of draws ($\sim$ 4000) for our model. We used 20000 draws and 2000 draws were stored and consequently used for inference based on visual inspection of simulated series as recommended, see above. A similar treatment followed in case of HP filtered output gap.[46] Blake and Mumtaz (2012) also recommends a visual inspection of autocorrelation functions and recursive means of the retained draws from the Gibbs sampler to detect any irregularities in the simulation exercise.[47]

5 First results

This section consists of several subsections that follow the logic of our work. Firstly, country specific fiscal responses are estimated and then shown in figures. Consequently, mean response for the EA-12 countries is calculated (and several percentiles). Thirdly, simple standard deviation of country specific responses and a harmonization (Geweke (1982) test) are presented. All these are presented for the FR I. In the robustness section, we discuss effects of reducing our set of EA countries (without Luxembourg or Greece or both, that is, EA-10), the use of our alternative output gap (HP filtered series), changes in the length of training period, and the amount of information passed from that or exclusion of years before 1999q1 for analysis (and their use only for the training period). Lastly, we present some evidence of the FR II (main results for comparison with the FR I), which is much more reduced because of space considerations.

[46] Baumeister and Benati (2013) propose as an alternative so-called inefficiency factors (IF) that are calculated as the inverse of relative numerical efficiency. Series of IF should be below twenty to indicate convergence.

[47] In this case of 'visual check' of our specification, there was 'light' problem with autocorrelation (slightly above 95% confidence interval) for some countries that could be remedied by changing the number of draws to 50000 or to 100000 with 2000 draws stored (keeping the sample size unchanged). All countries passed the CD test ($|CD| < 2$) as commonly required, however, RNE was rather low and varied across countries.

5.1 Baseline model – country specific responses

The first set of countries is represented by those labelled as with weaker 'fiscal constraints' (GIIPS countries, see examples in panels of figure (A.12) in appendix), Italian fiscal responses have been larger than zero throughout the sample period (with the exception of 1987), with peaks in quarters of 1993 and 1997 – that is, around key dates for the monetary integration process, and rather week after the full unfolding of the ESDC in the EU.[48] Also in case of Spain, one can see a spike around 1993, followed by a upward trend that brought positive fiscal responses after 1998 peaking during pre-crisis boom with a steep decline in the wake of bursting the housing bubble. A recovery after the burst of the housing bubble in 2009 has been rather slow compared with other GIIPS countries, revealing at least partially the actual depth of the crisis. Our results only partially accord with Bayesian TVP estimates of Cuerpo (2014);[49] a properly modelled fiscal responses on the quarterly frequency and the inclusion of a proxy for financial markets and adjustment for GAFS (improving the actual fiscal balances), reveals somewhat different picture of fiscal policy. Fiscal responses were largely insufficient and the boom during the first decade of the new century (massive extra revenue flows and reduction of expenditures resulting in large budget surpluses and debt reduction) arrived as late as in quarters of 2004. It resulted in a spell of quite large positive fiscal responses.

Three remaining countries in the group, show different trajectories before the ESDC, with a rather similar development after. While Ireland showed positive responses throughout the period before the ESDC followed by a steep fall, Greece only during their pre-Euro period followed by an attempt to regain fiscal control in the mid-2000 before slumping down into the current crisis. Conversely, Portugal was losing fiscal ground even in the Maastricht period, with an attempt to reverse the trend around 1997 without lasting effects that resulted in them breaching the rules of the Pact in early 2000's and fiscal consolidation thereafter (again with short-lived effects).[50] All three countries, however, managed (with smaller or more substantial efforts within their stabilization programmes) to regain fiscal ground reflected in low but positive responses from around 2013. The uncertainty of fiscal responses is also reflected in the $16^{th} - 84^{th}$ percentiles of posterior distribution that are rather wide (in 1980's and 1990's, especially in case of Portugal).

Turning now to the remaining EA countries, two sub-groups can be identified (illustration for Austria and France is in Figure (A.12) in appendix). On one hand, Belgium and Luxembourg, whose fiscal responses remained positive and relatively strong throughout the period (with a drop around 2009 and relatively large gaps between both quantiles in some periods). Other members of the group show similar patterns with small differences in timing

[48] All results were generated using Matlab. Our codes draw upon examples in Blake and Mumtaz (2012).

[49] It also supplements the finding of fiscal regimes in Ricci-Risquete *et al.* (2016) that were not so frequent when financial markets responses are considered.

[50] These findings accord with Afonso *et al.* (2011) that also find only negligible effects of the Maastricht and of the EDP. Our results show more clearly the inefficiency and short-livedness of fiscal measures in Portugal.

but Germany. Both Austria, Finland, France and the Netherlands fiscal responses show signs of weakening in late 1980's and early 1990's with drop into the negative area (in or around 1993), followed by a reversal (quite delayed in Finland). First quarter/years in the monetary union were linked to a continuous worsening (lowering) of fiscal responses similar to many GIIPS countries including a repeated return of negative responses around 2004 and repeated rebound. There are larger differences in responses in more recent years among countries in this group. While Austria showed a short-period of negative responses and return to positive values, France and the Netherlands experienced large reduction in responses and they have not returned to positive values. Finland recorded a large drop in responses (with only weak recovery after the 2004) and they have remained quite negative.[51] A particular case is Germany, whose fiscal responses, nowadays a country with one of the soundest fiscal policy in the Euro Area, are somewhat surprising. Their responses were negative until 2004 (with continuous improvements since mid-1990's) followed by positive responses until end of our sample, however, with relatively large gaps between both quantiles. While behaviour in early 1990's can be because of the reunification, the delayed reversal and uncertainty accord with early puzzling findings in Thams (2007).

In case of stand-alone EU countries (see two panels of Figure (A.12) in appendix), fiscal patterns seem to have been driven by other factors than the need to comply with EU institutional framework.[52] There are some similarities and differences in fiscal patterns among this group: while Denmark and the UK have been hit by the Great Recession with implication for financial sector (particularly hard in the UK) with implications for fiscal policy, Sweden experienced negative fiscal responses only few quarters after 1993, mainly as a result of the Nordic banking crisis. A significant improvement of fiscal accounts after 2000, can be seen in case of Denmark, while Sweden showed stability and the UK a decline before the Great Recession. Both the UK and Denmark have shown negative responses over the crisis period, however, two quickly reversed spells in Denmark and a long-lasting spell in the UK. Relative large uncertainty (distance between both quantiles) are only in case of the UK.

To summarize, our results partially confirm previous findings about effects of the Maastricht Treaty (ambiguous results) and first years of the Pact (a sort of the 'Olympic effect').[53] However, they also show a change in fiscal behaviour following the ESDC resulting in somewhat more synchronized fiscal behaviour across EA countries documented below.

[51] This specific behaviour of Finnish fiscal policy is usually explained with large stocks of assets, that is, the net position is positive (a net *creditor*).

[52] However, both Sweden and the UK have had national fiscal rules at work, at least for some period over our time span, largely determining fiscal outcomes (such as the Golden Rule in the UK until 1997, later replaced with a balanced-budget type of a fiscal rule (a five-year-long horizon), Swedish fiscal rules that have been modified several times since late 1990's, see Claeys, 2008).

[53] A discussion of this effect can be found in Fatás and Mihov (2010).

5.2 Has there been any harmonization of fiscal policies?

Since there is no indisputable test for harmonization of fiscal policies, we provide both visual presentation of our measure of harmonization and simple statistics (standard deviation, variation coefficient, correlations and a method proposed by Geweke, 1982).[54] To see whether there has been any harmonization of national fiscal policies, a set of figures is included in the following text, separately for countries with fiscal problems (GIIPS), and all the remaining EA members but Luxembourg (with rather sound fiscal policy over recent years). Showing members of a group in one figure provides a more plastic view on individual responses and their changes over time compared with separate discussion in the previous section. For the sake of comparison, a figure with stand-alone EU countries is added as well. In our point of view, there have been three important dates over the course of our sample period that are highlighted:

(*a*) the Maastricht Treaty (1992) that was at the beginning of all preparations for the Euro adoption set the well-known Maastricht convergence criteria (despite being primarily concerned with high debt levels than budget deficits in case of fiscal criteria);

(*b*) the launch of Euro (1999) since that moment initiated the need to comply with the first Stability and Growth Pact (established in 1996, however, fully at work including the excessive deficit procedure, EDP, and its sanction clauses) for EA members, and

(*c*) the full unwinding of the Great Recession in the Euro Area (second half of 2008) leading to the sovereign debt crisis and mainly, a long list of changes in fiscal policy framework.[55]

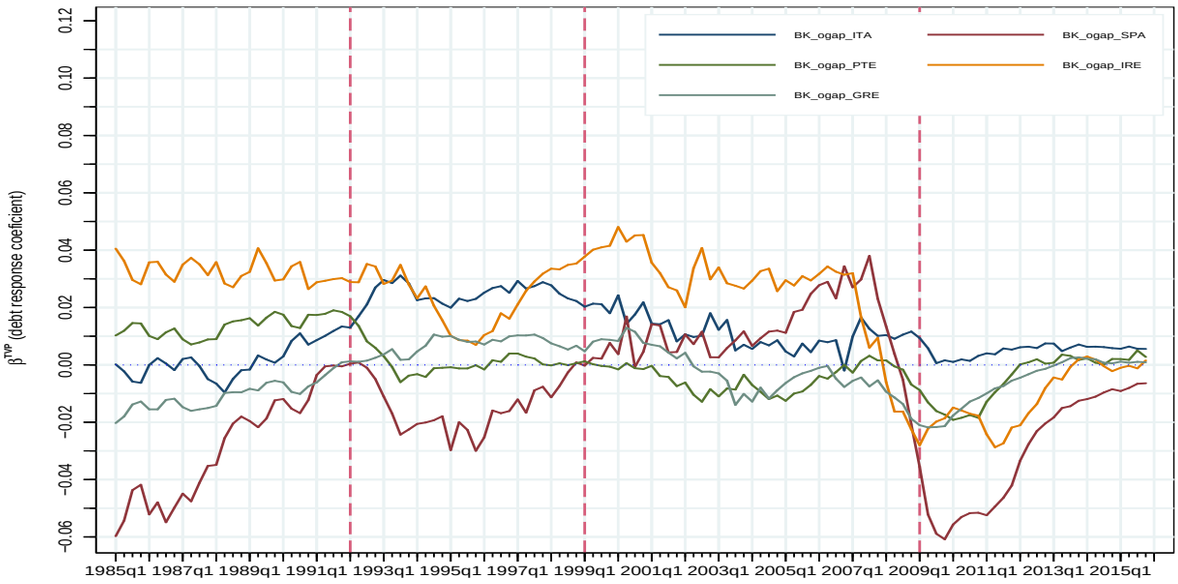
There seems to have been some harmonization in national fiscal policy of crisis affected countries since the start of the Great Recession. Quite clearly it is seen in figure (5.1) for all five crisis-affected EA countries (GIIPS). Based on our base model, the worst performing has been Spain with a quite big changes in fiscal responses following a financial and housing crisis after 2009 that is reflected in response coefficient smaller than zero ($\beta^{TVP} < 0$) indicating unsustainable policy. Nevertheless, even Spanish fiscal responses have recovered (quite strongly in fact) recently. Even without the inclusion of Greece as a country under international supervision, the resulting picture would not change much since Greece response function lies in the middle of their piers' ones. Conversely, as it is illustrated below, other EA members have not shown such a clear harmonization pattern (see figure (5.2) below). Similarly in case of stand-alone EU countries (see figure (5.3) below).

What about countries outside the Euro Area with more or less independently set monetary policy, without having had tied-up hands by enforceable fiscal rules? The following figure (5.3)

[54] Since there is no clear suggestion regarding a measure of harmonization, in case of national fiscal policies in particular, we follow Arouri *et al.* (2013) that measure harmonization in case of monetary policy (short-term interest rates of three main central banks) using the Geweke (1982)'s method.

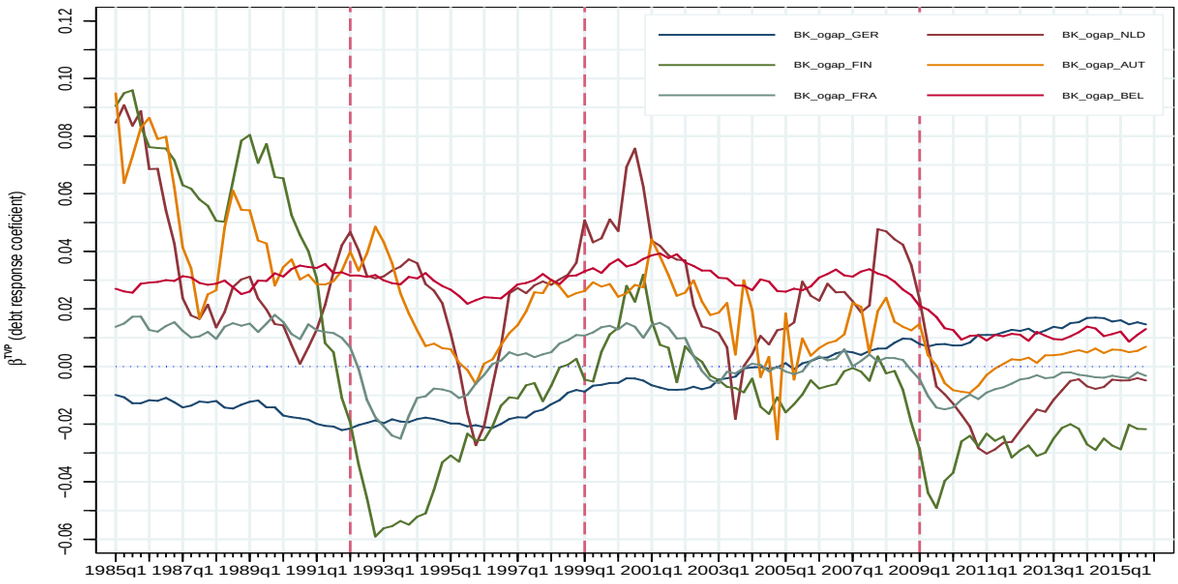
[55] There changes included both another modification on the SGP, the so-called 'Six pack', the Fiscal Pact, 'Two pack'; for overview of all changes see for example EC (2013); EC (2015) or Masten and Gnip (2016).

Figure 5.1: TVP fiscal response estimates for GIIPS countries, 1985q1–2015q4



Note: TVP responses (based on FR I). The same simulation specification across countries. Red dashed lines represent the Maastricht Treaty (1992), the launch of Euro (1999), and the Great Recession (2009). Source: own calculation.

Figure 5.2: TVP fiscal response estimates for other EA countries, 1985q1–2015q4



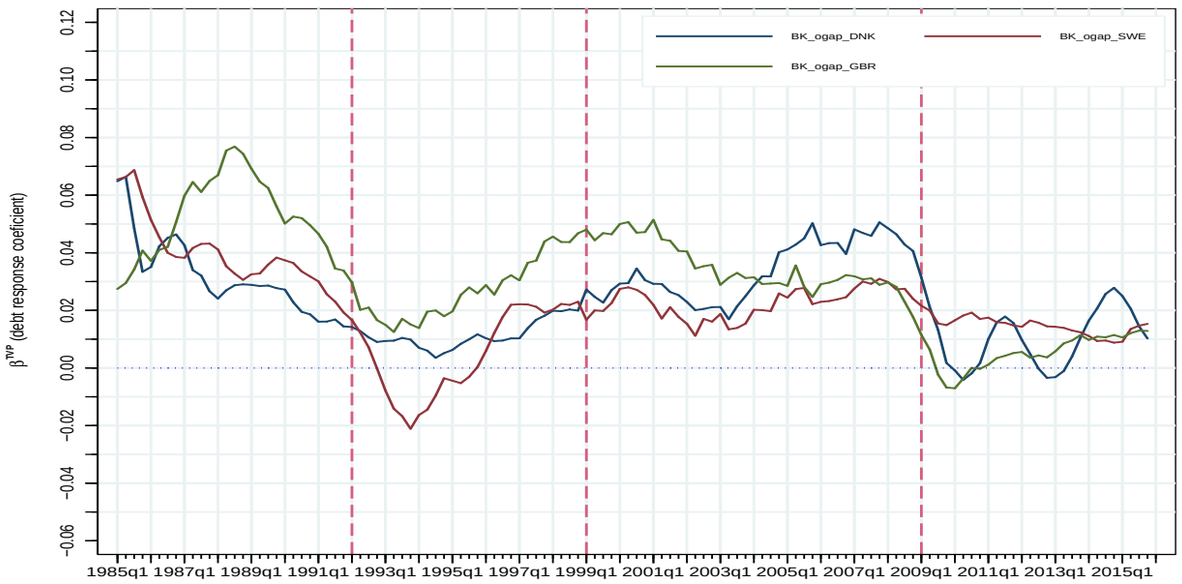
Note: TVP responses (based on FR I). The same simulation specification across countries. Luxembourg excluded. Red dashed lines represent the Maastricht Treaty (1992), the launch of Euro (1999), and the Great Recession (2009). Source: own calculation.

provides an illustration. Fiscal policy of this group of countries is more heterogeneous than in previous two cases as expected. Responses of all three countries are somewhat larger than zero with quite large positive responses in case of Denmark, slowly decreasing in case of Sweden and sluggishly coming back to the positive area after a drop for the British. Mainly British fiscal policy has been volatile in early stages because of large effects of the Great Recession

despite the fact that shown series are without support to financial institutions (GAFS) that has been substantial in case of several EU countries, in the United Kingdom as a country with the largest exposure of their financial institutions to the US ones in particular.

There has been a harmonization in case of other EA countries as well as can be seen, mainly after 2010. The largest drops of fiscal responses have been in Finland and in the Netherlands, smaller ones in France and Austria. All but one country (Finland, already discussed above), however, have shown signs of recovery and their response functions have turned positive.

Figure 5.3: TVP fiscal response estimates for stand-alone EU countries, 1985q1–2015q4



Note: TVP responses (based on FR I). The same simulation specification across countries. Red dashed lines represent the Maastricht Treaty (1992), the launch of Euro (1999), and the Great Recession (2009). Source: own calculation.

Since the country-specific evidence is rather mixed, the next figure (5.4) shows means TVP responses and quantiles of the posterior distribution calculated from country-specific fiscal responses. This figure reveals that on average, fiscal responses have been positive (except for a 'temporary' drop in quarters between 2009 and 2012) with a sluggish recovery and relative low positive responses at the end of our sample.[56] It also shows that there have been some changes in fiscal behaviour for the Euro Area over the time span: (*i*) in the second half of 1980's with an abrupt change (increase of dispersion while the mean response remained almost unchanged), before the (*ii*) signing the Maastricht Treaty and the 'Black Autumn' of the EC (1992–1993) that led to a large increase followed of the dispersion and a slow reversal), (*iii*) few quarters before and after the launch of the Euro and (*iv*) the during crisis period (around 2009; since its start there has been a visible reduction of variability of EA countries' responses that is reflected in tighter distribution – thicker map of blue-coloured lines around the mean in red). To illustrate changes in variability of country specific responses over our sample period, the

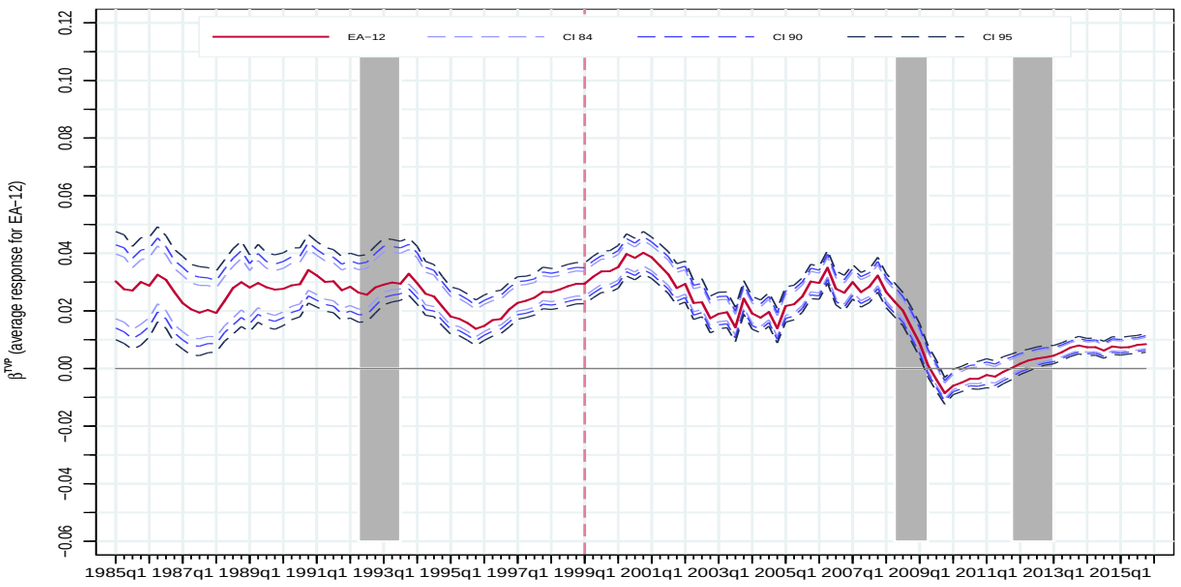
[56] A simple average of the sample period with/without the quarters of the financial crisis is approximately comparable with recent estimates using yearly fiscal series, see for example Berti *et al.* (2016).

following figure (5.5) plots cross-sectional standard deviation calculated from country-specific responses. While before the Maastricht Treaty, the calculated dispersion hovered around 0.05, there was a spike in 1991 and a large increase in quarters after 1992, that is, a period after signing and approval of the Maastricht treaty. This was reversed after 1994, when dispersion went back to pre-Maastricht levels until 1999. The pre-crisis years and quarters are a mixture or increases and decreases with many changes visible in saw-type fluctuations, pointing to more discretionary fiscal measures. More recently, after 2008, there had been a declining trend temporarily reversed around 2010 that brought dispersion to lowest levels observed since 1980's (below but close to 0.03).

5.2.1 Some measures of harmonization

Regarding statistical measures or test for harmonization, however, there is a significant limitation coming from the sample length for individual sub-periods of interest in our sample period.[57] Firstly, we present simple pairwise correlation coefficients for four sub-periods. Secondly, a measure of contemporaneous correlation proposed by Geweke (1982) is calculated (for details see section (A.2) in appendix).

Figure 5.4: TVP fiscal response estimates for EA12 countries (mean), 1985q1–2015q4

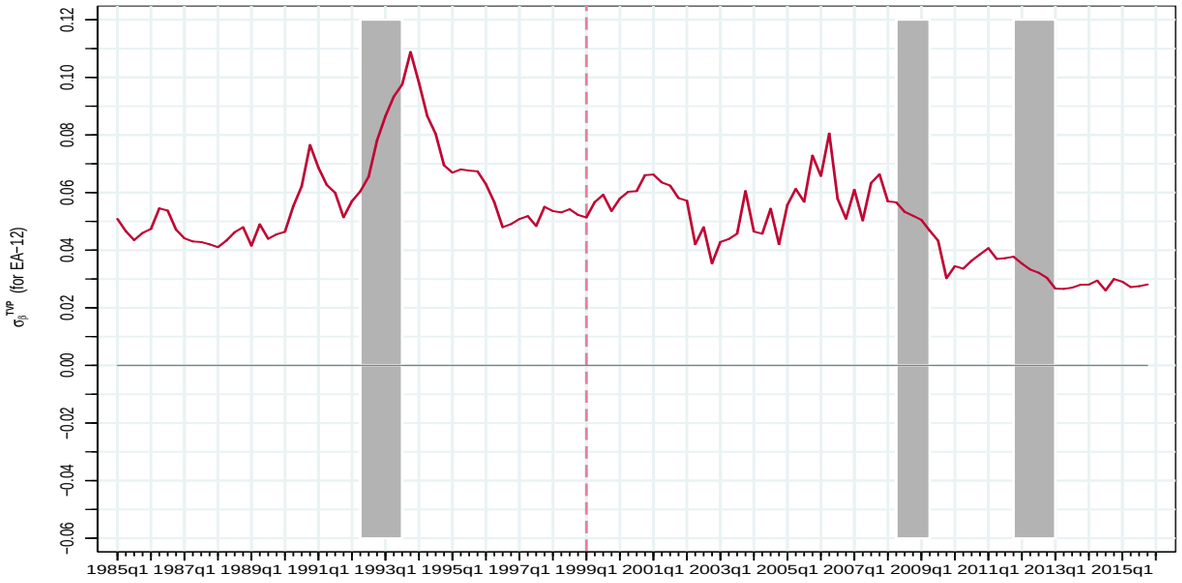


Note: unweighted EA-12 TVP responses (based on FR I). Dark areas are CEPR based recession periods for the Euro Area. Blue dashed lines (*CI XX*) represent $16^{th} - 84^{th}$, $10^{th} - 90^{th}$ and $5^{th} - 95^{th}$ quantiles of posterior distribution of TVP EA-12 responses. The red dashed line represents the launch of Euro in January 1999. Source: own calculation.

Correlation coefficients of simulated responses show increases over time and positive correlation of national fiscal policies for most of the Euro Area countries in the last sub-period (2008q3–2015q4) compared with the Maastricht period (1992q1–1998q4), however, compared

[57] For example variation coefficient suffers from very low values of mean responses in some quarters, so it is not reported.

Figure 5.5: TVP fiscal response estimates for EA12 countries (standard deviation), 1985q1–2015q4



Note: unweighted cross-sectional standard deviation of EA-12 TVP responses (based on FR I). Dark areas are CEPR based recession periods for the Euro Area. The red dashed line represents the launch of Euro in January 1999. Source: own calculation.

with the pre-crisis period (1999q1–2008q2) the picture is not so clear cut, see tables nos. (A.1)–(A.3) in appendix.[58] Looking at individual correlations of country pairs, in the pre- and post-crisis period, there are larger changes in case of Spain, Germany or Italy (more positive correlation coefficients), no the other hand, Greece or Luxembourg show signs of lower pairwise correlation, which should not be surprising given the adoption of stabilization programmes in the former and rather sound public finances in the latter, and mixed picture emerges in case of Ireland or Portugal.

Another way of capturing harmonization is to estimate contemporaneous correlations using Geweke (1982) for our group of countries. If this measure (see formula (A.3) in appendix) increases (decreases) on individual periods, the statistics provides information about the harmonization of fiscal responses in our sample of EA countries.[59] As a benchmark, model with four lags is estimated, subsequently compared with models with two, three and five lags. We also calculated the 'optimal' lag length, however, for the sake of comparison estimates of one lag length were utilized. Because of space consideration (12×12 models to be shown just for one specification), we restrict ourselves to description of main pattern that are similar across

[58] Comparison of pre- and post-crisis period can also be slightly affected by time of both periods since for post-crisis period starting as late as 2009q1, correlation coefficients for some country pairs are different (see table (A.4) in appendix). Therefore, some studies such as Baldi and Staehr (2016) working with quarterly fiscal series prefer skipping turbulent quarters in late 2008. While there were 50 positive changes of correlation coefficients in total, in the pre- and post-crisis period only 31 (36 positive changes for the alternative definition of post-crisis period in total). However, not all of them led to significant correlation coefficients or kept their significance across periods. A change is also visible in figure (5.5) showing standard deviation of EA-12 responses.

[59] The estimates were obtained using Stata package `gwke82` coded by Dicle and Levendis (2013).

models. The beginning of estimation is for 1999, that is, the first year of monetary union. For this timing, the test statistics usually takes the highest value with similar results up to 2001q4 (also significant at the 1% level). However, then estimated values of the coefficient drop and for most of the country/period pairs become insignificant. A reversal for some country/year pairs occurs in mid 2000's, when values of the FGS statistics increase and become significant again. That would be then a confirmation of trends visible in the figure 5.4 (above).

Another question remains, however, how much of the observed (shown) harmonization is because of output gap synchronization across EA countries and how much can be attributed to 'real' efforts of policy-makers. There are many ways of capturing effects of synchronization of business cycles. Commonly, two types of correlation coefficients can be calculated for GDP series: (a) simple static correlation (Pearson) for period following periods utilized when calculating correlation coefficients for harmonization and (b) dynamic correlation coefficients to see changes over time (for five-year-long periods). However, our model includes output gaps, so synchronization of business cycles across EA countries is calculated as standard deviation, following suggestions for example in Gayer (2007).

When looking at the figure A.4 in appendix showing both the estimated standard deviation of output gaps across twelve EA members and also a centered moving average (MA-13), there is an increasing trend in dispersion until 1992 (from values around 1.00 to 1.30), interrupted by a temporary decline around 1989. The trend of TVP responses was firstly without any trend, followed by a spike around 1991 and a sharp increase peaking in last quarters of 1993 (see figure 5.5 above). Subsequently, a two-step decline occurred, bringing standard deviations to 0.05 in 1996 with a slightly positive drift thereafter (up to 2001) followed by repeated increases and decreases until 2008. On average over this period, the dispersion was slightly above levels seen in the 1980's. Conversely, dispersion of output gaps kept going down until 1998 (levelling out around 0.65) with a slight increase and return to even a lower level in quarters of 2006. Since then, there was a steep increase reaching a peak in 2010 (around 1.50, the highest value over our sample period), followed by a slowly declining trend (see figure 5.5 above). During the same period, the standard deviation of TVP responses kept declining and then levelled out from 2013 onwards. Therefore, there does not seem to be a direct influence coming from dispersion of output gaps in case of dispersion of fiscal responses for the EA-12 group of countries most of the time.[60]

As it has been pointed out, the inclusion of some countries can matter for the calculation of dispersion. Therefore, similar to previous section, a check for ten EA countries (without Greece and Luxembourg) is carried out as well. Value of standard deviation calculated for this group of countries is smaller (the smallest around 2004 was below 0.50, while the crisis related spike in 2010 did not surpass previous peak from early 1990's), however, trends and turning points described above remain unchanged. The same holds true for the dispersion when HP

[60]Since results for HP filtered series are similar (changes are somewhat more pronounced because of more 'ragged' HP filtered series), they are not reported but available upon request from the author.

filtered output gaps are utilized.

5.3 Sensitivity section

In this section we present and briefly comment on various robustness checks that were carried out. Firstly, we checked the effect of excluding 'outliers', a country with very sound and very troublesome fiscal policy (Luxembourg and Greece). Secondly, we investigated whether the calculation method for output gaps (Baxter-King band pass filter) provides different results compared with the commonly used Hodrick-Prescott filter.[61] Thirdly, a set of robustness checks aimed to see effects of longer training period, when more information is allowed to affect our priors or exclusion of years before 1999q1 for analysis (and their use only for the training period). Lastly, we present some evidence on the FR II.

Since country-specific responses described in previous text showed substantial heterogeneity, it is important to explore the effect of programme countries (mainly Greece) and countries with very sound fiscal policy (such as Luxembourg). Figure (A.3) shows dispersion calculated for the EA-10 group (without Greece and Luxembourg, very similar picture is also for EA-11 without Luxembourg) that reveals rather a large effect of the latter on EA wide dispersion. The dynamics has been rather reduced and the 'global' trend has been a decline over the entire sample period. However, there are three 'reversals' visible (limited in their size though): (*i*) after 1992, (*ii*) after 2000 and (*iii*) after 2008. Nevertheless, the current level of dispersion is again, the lowest since 1980's (around 0.01 compared to 0.05) with the main decline happening in late 1980's and at the very beginning of 1990's.[62] To summarise, a harmonization of national fiscal policies in the Euro Area has occurred in several phases that have been followed by periods of reversals. It seems to be rather recent phenomenon given current levels, the lowest since late 1980's, when our sample period starts.

When the Hodrick-Prescott filter based ($\lambda = 1600$) output gaps were utilized, there was only negligible impact on our country-specific results for most of the countries. Our results – three groups of the same composition as above with HP filter – are shown in figures nos. (A.6)–(A.8) in appendix. In case of few countries there are somewhat different paths, mainly over recent quarters since both filters provided different estimates of the output gap (Finland, Germany, Ireland, Spain and the UK). In addition, calculated dispersion of EA-12 fiscal responses are shown in figures nos. (A.9)–(A.10). Similarly to country-specific responses, there are no substantial differences (responses with HP filter calculated output gap seem to be slightly

[61] Sometimes a modification of the HP filter is used, the HP band pass filter, that is, time series is adjusted twice to filter out both short and long frequencies, see Gayer (2007).

[62] Another possibility is to calculate variation coefficients provides relative dispersion (standard deviation) for our period; it is defined as $\zeta = \frac{\sigma_{(.)}}{\overline{x}_{(.)}}$, where $\sigma_{(.)}$ is the cross-sectional standard deviation for a group of EA countries (EA-12 or EA-10) and $\overline{x}_{(.)}$ is the mean for the same definition of the group. Values of variation coefficient seem more or less closely to copy changes in dispersion measured by standard deviation over the sample period. However, the problem of this characteristic is its unboundedness that is revealed during the financial crisis period, where ζ is a very large number. Therefore, we do not report its values.

more dispersed). Another alternative would be to use GDP growth rates instead of estimates output gap. However, this approximation of cyclical position is not used in the literature, so it is left as an extension of our work.

In addition, a series of robustness checks were carried out to see effects of changing the settings of Bayesian TVP estimation. Firstly, we allowed for a higher amount of variability passed through from the training period and also allowing for faster changes of parameters ($\nu = 3.5 \cdot 10^{-2}$), which did not lead to substantial changes of our base results. Secondly, the training time period af the beginning of our sample (for setting priors for parameters and their variances) was extended to five years (25 quarters, with the same or slightly lower scaling parameter ($\nu = 3.5 \cdot 10^{-4}$) to reflect somewhat larger information content) observations and all steps were repeated.[63] There were only minor differences for few countries. Since our dataset consists of reconstructed fiscal series, we decided to shorten our sample, so that it spanned only the period of full monetary unification (1999q1–2015q4) as another robustness check and allowed full/reduced information pass-through ($\nu_{full} = 1$ and $\nu_{reduced} = 3.5 \cdot 10^{-2}$). This check comes at a cost, however, since our sample size eliminated the pre-Maastricht and pre-EMU periods offering some interesting information and implications for the EMU period. Results for mean response and its standard deviation were very similar to main results for the full sample shown in the text above. That confirms the robustness of our findings.

Moreover, we tried to use the extended specification (FR II, equation (4.3), see above) taking into account potential effects of inflation and tax smoothing (but without a direct market response to changing debt level – i_{IIR}). Estimates of this micro-founded fiscal rule differ somewhat for individual countries in our sample, however, their effects on our measure of fiscal response harmonization are negligible (and for space consideration this set of results is not reported).

5.4 Is high degree of harmonization necessarily a bad thing?

A higher degree of harmonization of fiscal policy in a monetary union can be viewed as a potential problem since individual member states would behave as one, that is, as a (large) closed economy. One particular reason for concerns is the risk associated with negative fiscal spillover effects during periods of economic difficulties, which has been discussed at great lengths in the literature. In a series of papers in and around 2012 some authors (for example see Bagaria *et al.* (2012), Holland and Portes (2012) or DeLong and Summers, 2012) tried to make a theoretical point by analysing the risk of self-defeating recession spurred by fiscal tightening happening at the same time, especially when fiscal measures are applied in countries forming a monetary union. A particular attention was paid to the combination of zero-lower bound (ZLB, henceforth), interest rate transmission not working fully and/or liquidity constraints in

[63] The same increase of information pass-through works also for our base simulation exercise with minor differences for EA countries.

case of EA (or EU) countries. This on-going debate (since 2009 see the 'introductory' paper by Barell *et al.*, 2009) has highlighted several key aspects such as (see Holland and Portes, 2012): multiplication effects of fiscal measures depend not only on a (1) country and time including cyclical position and broadly defined institutions such as financial, but also on (2) a type of 'instrument' utilized (revenue or expenditure side) or (3) on composition of economic agents in the economy (i.e. *(non-)*Ricardian behaviour) and (4) links provided by movements of financial capital and flows of goods and services.

If one finds such a scenario plausible, what are the possibilities that could prevent that from occurring? To begin with, one mechanism is linked to the OCA theory, which highlights that this type of risk would be mitigated if not eliminated in case of large and effective system of transfers within a monetary union ('risk sharing'). However, that does not seem to be the case in the Euro Area (or the EU) at the moment and was one of the key points highlighted in van Rompuy *et al.* (2012) Report in late 2012, however, it was just echoing conclusions made in (EC, 1977a,b) or in Delors (1989). Moreover, a recent comparison of the US economy and their fiscal federalism and that in the EU (see D'Apice, 2015) reveals that on average estimated transfers amounted only to ¼ of percent of GDP of the EU (and equal almost to zero for the Euro Area), while being 1½ percent of GDP (over the period 1980–2005) and during the Great Recession raising to about 9% of GDP in the US. Therefore, without a reform, this mechanism cannot represent an efficient tool in policy-makers' toolkit.[64]

In addition, other possibilities have been discussed in the literature related to degrees of fiscal centralisation in a monetary union, mainly drawing upon the literature studying effects of fiscal federalisms (dating back to late 1950's or early 1970's, see a summary in Evers, 2015). These cover a wide range of alternatives spanning various levels of revenue sharing ('equalization') up to a full fiscal union, that is, the existence of a supranational fiscal institution. Few recent studies have even attempted to investigate effects of such fiscal arrangement in comparison with the current state of affairs in the Euro Area. Simulations in a stylised two-country DSGE model (Evers, 2015) reveal that simple tax revenue sharing would not be of much help if an asymmetric shock occurred. On the contrary, it would bring about large volatility of macroeconomic indicators (consumption and production). However, a fiscal union (a common fiscal authority) would meet expectations in terms of smoothing and regional income insurance (about 30% of regional income).

More recently Gadatsch *et al.* (2016) empirically investigate three possible routes of deeper integration of fiscal matters in the Euro Area similar to Evers (2015), however, in a more complex model and primarily from the German perspective. They utilize a large-scale (three-country) estimated NKE DSGE model to study effects of: (*a*) tax harmonization (social security contributions and income taxation), (*b*) public revenue equalization (per capita, such as

[64]Estimates of the importance of fiscal transfers have been declining since the pioneering studies of Sala-i-Martin and Sachs (1992) that suggest up to 40% being compensated by transfers to more conservative estimates of around 10% such as Asdrubali *et al.* (1996). Estimates for the Euro Area have been lower and less effective, see Sørensen and Yosha (1998).

in Canada, Germany or Switzerland) and (*c*) a federal authority at the supranational level. Their estimates reveal that harmonization would have negative effects on Germany economy, while equalization only on public finances. The last specification considered (union) reveals gains for Germany and costs for the remaining members of the union. Moreover, effects on risk sharing are rather negligible in any scenario. The increased harmonisation could thus be viewed as an opportunity to trigger needed changes in the current fiscal framework to get equipped with tools necessary to deal with a crisis having asymmetrical effects on EA member states. Verstegen and Meijdam (2016) propose a system of transfer payments related to economic growth, eliminating moral hazard coming from revenue/expenditure based systems. Their simulations in estimated (Bayesian) DSGE model show that there are not net winners and losers of the transfer scheme, however, the starting conditions can affect welfare effects of the transfer system.[65]

Another aspect of our analysis is worth mentioning since it relates to the fact that fiscal rules cannot be viewed as the *panacea*. They can be sometimes suboptimal as it has been known at least since the work of Kydland and Prescott (1977). They can help countries to carry out sustainable fiscal policy while preserving macroeconomic stability.[66] The process of harmonization could also pose a threat for economic growth given the very low level of 'federal budget' flows in the EU (currently flows from and to the European budget).[67] This can be the other side of the increased harmonization of national fiscal policies, especially in the zero-lower-bound environment that is echoed in Portes and Wren-Lewis (2015).[68]

The European fiscal policy framework faces several challenges at the same time now. Leaving aside problems associated with a lack of transparency or difficulties with enforcement of rules (watered down by exceptions and 'balancing' actions of the Commission), and thus efficiency, the increased harmonization of national fiscal policies has raised the question of dealing with crises without further worsening economic problems. One way how to make the current system more transparent would be the introduction of some sort of a Golden rule and a simple debt ceiling with or without automatic restriction on spending when reached (instead of a long list of exceptions and special circumstances being *a ball and chain* for the current SGP).[69] If the debt level was low enough, it could also help deal with idiosyncratic shocks without the ne-

[65]Resources should flow automatically between 'booming' and 'depressed' regions on the basis of regular GDP-based payments to a common pool. Redistribution reflects a region's steady state GDP level with respect to the common GDP; the larger the GDP gap, the more funds that region will receive, however, in zero sum for the union as a whole.

[66]As for example Fatás and Mihov (2010) highlight, the reason can be the natural diversity of opinions of national government on fiscal priorities, which can create tensions among stabilisation policies inside a monetary union.

[67]For a very recent estimate and comparison with the US federal budget see D'Apice (2015).

[68]This recent study recommends larger interconnectedness of rules of the Pact with aggregate demand (member states' cyclical situation). Moreover, in case that the probability of reaching the ZLB is larger than 50% (forecasted by a central bank), the rules would be temporarily disabled. However, such a change of the 'rules of the game' would call for another mechanism that would clearly set up ways of dealing with the consequences of the freeze and supposedly large increase in public indebtedness that would follow.

[69]Similar remarks on possible fiscal policy arrangements (the need for simplification, open access to information, etc.) has been discussed for example in Buba (2015).

cessity to introduce further fiscal mechanisms at the supranational level. Since that alternative does not seem to be plausible for many reasons, one could think of using existing institutions such as the ESM to accumulate resources ('rainy days' fund) to be used in countries affected by idiosyncratic (asymmetric) shocks. The necessary resources could come from a negligible increase of the current system of mainly output based (GNI) contributions or in a change of the system. Since policy-makers are aware of the problem and would help them to deal with crises, such solution may have a chance of being implemented rather quickly.

6 Conclusions

This paper aims to shed some light on harmonization of national fiscal policies in the Euro Area. National fiscal responses are approximated by two types of fiscal rules. One that follows macro-fiscal response literature (in line with the Bohn (1998) type of the literature) explicitly allowing for the effects of financial markets, the other resembling a Taylor rule, that is, a micro-based optimal fiscal response function (in line with a model of Kirsanova *et al.*, 2005). These rules are estimated with Bayesian time-varying parameter technique that allows to address problems of changes in the broadly defined institutional environment and thus parameter instability. In order to do that, a novel quarterly dataset of fiscal and economic determinants covering twelve EA members had to be created for the period 1980q1–2015q4. Since fiscal variables were not readily available at quarterly frequency for all countries and the time span, they were reconstructed utilizing a Bayesian decomposition method following Giannone *et al.* (2015) and Bańbura *et al.* (2015).

To summarize the findings, our results showed that the process of institutionalization of fiscal policy endorsed over the pre-Euro period led to more synchronized responses, which was partially reversed during first years of the monetary union. However, the outset the European sovereign debt crisis resulted in a new phase in the EU-wide macro-fiscal regulation that has brought the dispersion of fiscal responses to the lowest levels since the 1980's. Our results are robust both to the choice of a fiscal rule and to the method used for output gap calculation, whose dynamics shows somewhat different behaviour over the time span and cannot be viewed as the only driver of fiscal harmonization.

Moreover, our results illustrated that the level of harmonization has recently surpassed those levels seen in the beginning of the monetary integration process. This finding is of essential importance for the single monetary policy and its conduct. Nevertheless, a harmonization of fiscal responses does not imply anything about the actual shape of fiscal policy and as it was also illustrated in the accompanying figures. Mainly, when the commonly utilized concept of Bohn (1998)'s sustainability was to be applied, the mean response for EA countries is positive but rather low, when controlling for financial markets. That seems to indicate that despite interest rates being unprecedentedly low, providing an extra fiscal space, the sustainability of fiscal policy may be easily endangered by another unexpected shock leading to an economic

downturn with the need to actively use fiscal measures.

There are, naturally, many possibilities for extensions of our work. One could try to improve the way financial market spillovers are captured since our measure or a commonly used (either short-term or long-term interest rates or their combination) are far from being optimal. One could also try to estimate not only fiscal rules but also their monetary counterpart (an ECB response function) to see their changes and possible interactions over years of monetary integration and mainly the Euro period. In order to address the question of determinants driving fiscal policy outcomes, relaxing the assumption of relying on a Taylor rule specification, a Factor Augmented VAR Bayesian estimation would be needed. Another extension can be aimed to capture effects coming from policy changes, that is, to model variation of policy-makers' fiscal responses completely, following a similar exercise done for monetary policy rules (Primiceri, 2005). That is possible by employing a Bayesian TVP estimation allowing for changes in volatility over time (fiscal regimes with more or less discretionary measures), which require longer time series, however, so we left this extension for future research.

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A Appendix

A.1 Data treatment

Main steps and data sources for creating our quarterly database of fiscal and other control variables employed in this paper are summarized in this section. The main emphasis, following recent studies – Mauro *et al.* (2013) and Berti *et al.* (2016) –, was put on the consistency of reconstructed time series over the time period utilized in our study. In general, the main steps applied in case of fiscal and other variables were the following:

- Eurostat database is the primary source of fiscal quarterly series (total deficit, gross debt, interest payments, and non-interest expenditures, often available from mid-1990's to 2015); see Eurostat, 2016; Eurostat (2016a;b).

- In case that series were not available, yearly series were taken from a database published by the European Commission (*Annual macro-economic database*, AMECO henceforth, see EC, 2016b). If they were available only partially (usually public debt series but not primary balance series), the *Historical Public Finance Database* (HPFD, henceforth, see Mauro *et al.*, 2013) providing both series was preferred as the main source.
  The HPFD series were linked to AMECO series by utilizing growth rates of HPFD series to the first data point (observation) available in the AMECO database.
  GAFS series (*government support to financial institutions*) came from a Eurostat database on excessive deficit procedure (EDP, henceforth) notifications provided by individual member states (see Eurostat, 2016a). GAFS are values that represent budgetary impact of government actions to support financial institutions and/or financial markets over years of the Great Recessional and/or the European sovereign debt crisis. They are available since 2007 and as of end of 2015 only three EA countries have not reported any GAFS values (Estonia, Malta and Slovakia). GAFS series are then related to auxiliary fiscal measures (one of so-called one-off items) not stemming from the outstanding value of government debt, budgetary situation or a situation in financial markets as a result of one or both of them. GAFS are also excluded when assessing programme countries by international organisations such as the IMF.

- Once yearly series for our time period were completed (1980–2015), they were imputed into our mixed frequency database (quarterly series alongside yearly ones) to check consistency of yearly and quarterly country-period observations. There were only minimal differences between yearly values provided by the AMECO database and sums of our reconstructed series (since quarterly series reflect seasonal adjustment, minor differences ($< 0.5\%$) are to be expected because of rounding, etc.).

- Missing observations for fiscal variables were reconstructed using country-specific correlations among series (unemployment, CPI, government short-term [3M] and long-term interest rates [10Y], GDP and GDP components) by employing the Kalman filter and Bayesian approach as described in (Giannone *et al.*, 2015 and Bańbura *et al.*, 2015).

– Since quarterly output gaps were not readily available (only yearly series), they had to be calculated using the Band-pass (Baxter-King, BK filter) and the Hodrick-Prescott filter (HP filter).[i] To mitigate the issue with beginning and end of our quarterly GDP series as follows (as a robustness check year-on-year growth rates in a particular quarter were utilized). Our dataset contains quarterly GDP observations (prior 1980q1 from the same OECD *Quarterly National Accounts database*, QNA henceforth, see OECD, 2016a) that can be used to extend our sample. Moreover, OECD *Economic outlook* (EO No. 99 from June 2016, see OECD, 2016) contains forecasted quarterly GDP. Both are utilized to evaluate our exercise.
Firstly, we forecasted and backcasted up to four years (16 quarters) of GDP using a unconditional bivariate $VAR(p)$ model for log differences of GDP and differences of inflation. The lag length p selected via the Akaike information criterion (AIC henceforth), following the recommendation of Watson (2007).[ii] Since the original Watson (2007)'s approach works with time series including house permits that were not available for our sample (all countries and years), quarterly series of industrial production, inflation (and interest rates spreads) were utilized instead as a robustness check for output gaps generated using quarterly GDP and inflation (and interest rates).[iii] OECD series of industrial production were already seasonally adjusted.
To the extended GDP series filtering techniques were applied carefully selecting the specification of the BK filter and as a robustness the HP filter (see below).[iv] Then, all observations outside our sample period were excluded from further estimation. Similar results were obtained when backcasted observations were replaced with actual GDP observations and therefore, we decided to use them instead.

Alternatively, we repeated all previous steps using another way Watson (2007) suggested for reconstructing output gaps – an $AR(p)$ model for GDP without any covariates. Moreover, we also followed another approach proposed by Marcellino and Musso (2010) that lies in using GDP growth rates in an $AR(4)$ model and also with country-specific $AR(p)$ models to allow for differences across countries in our sample (some catching-up, other developed countries).
An evaluation of our forecasted/backcasted observations was carried out by comparing all results against the OECD forecast and OECD QNA database. Methods did good job in terms of relative error of predictions for the period 2016q1–2017q4. We decided to use the $VAR(p)$ predictions and keep the other version for robustness.[v]

[i] The BK filter ($BK_{12}(6, 32)$) was used as a benchmark in line with Market and Ravn (2007). Even though this study also derives a formula for optimal HP filter, our interest is not in finding an optimal business cycle for our group of countries and for the sake of comparability it is left as another robustness check for further research. The closest approximation to the widely used HP filter is $BK_{12}(2, 32)$ according to Baxter and King (1999). However, the HP filtered series were utilized only as robustness in this paper because of the objectives explained in Hamilton (2016).

[ii] The optimal lag selection starts with the 'rule-of-thumb' recommendation for the maximum number of lags as suggested by Schwert (1989) and commonly applied for lag selection.

[iii] OECD database contains quarterly and monthly series of permits issued for dwellings. For our sample they were available since 1980q1 only for six (four EA) countries, for some were not available at all.

[iv] Since for several countries the optimal lag length of the BK filter was larger than 12, 16 quarters of GDP were forecasted and backcasted and not only 12 (three years) as recommends for example Watson (2007). That allowed us to keep our sample period of the same length for all EA and stand-alone countries.

[v] Since our variables (GDP and CPI) are non-stationary, the transformation mentioned in the text were applied to both series. We also experimented with a larger bivariate VAR (with differences of unemployment rate

Secondly, output trends were calculated using the Baxter-King band pass filter that was applied to individual GDP series to find the best fit; for most of the EA countries standard specification (MA component with 12 lags and the length of cycles between 6 and 32 months) were able to provide smooth series (checked by periodogram). Only for few countries the optimal number was higher (16 lags: Greece, Ireland and Sweden). In order not to lose observations from our sample, which is usually a reason for using the HP filter, four years of actual (backcasted) data were used with this filter. The differences between both specifications of output gaps were negligible.

Thirdly, as a robustness check, we applied the HP filter with the standard value of smoothing coefficient λ recommended in the literature (equal to 1600, for example see Ravn and Uhlig, 2002). In addition, an alternative, a corrected HP filter, following Perron and Wada (2009)'s suggestion was considered with the smoothing parameter is equal to $8 \cdot 10^5$ (500 times the standard value) to capture changes in the slope of the trend and thus eliminate bias coming from attributing too little variation to the cyclical component in comparison with the trend component. However, given our sample length it did not fit the data for some countries well.

Lastly, the Christiano and Fitzgerald filter with the cycles between 6 (min) and 32 (max) quarters with the assumption that GDP follows Random walk with drift (process assumed for the underlying data generating process). Our results revealed that mainly the commonly utilized HP filter could not be viewed as optimal since it did not filter out cyclical frequencies of quarterly series while the BK filter performed quite satisfactory.

In particular, for the reconstruction of quarterly time series of primary balances and public debt, the following steps have been done:

a) Fiscal variables – both debt and primary balances (net lending/net borrowing series, B.9, with interests payable), all series were in levels in the ESA 2010 methodology – millions of units of national currency, not seasonally adjusted – provided by Eurostat and DG ECFIN (AMECO database). Because of lack of quarterly observations before 1995 (public debt) and 1999 (primary balance) for most of the Euro area countries (except for Belgium, France and Spain) and the United Kingdom, both series were reconstructed using the Historical Public Finance Database (HPFD), by applying growth rates calculated from level series;

Main challenge was the recalculation of primary balance series for Luxembourg due to missing observation at the end of 1980's (1988 and 1989). We collected information on central budget from OECD Economic Survey of Luxembourg (OECD, 1986; 1988; 1989; 1990; 1992; 1994) and calculated growth rates for budgetary out-turn and preliminary value for 1989 (no other values are available even after consultations with staff working with fiscal data in the *Banque de Luxembourg*) of net lending/net borrowing item. There rates were applied ESA 1995 series available from AMECO database. Since estimates of interest payments are unavailable as well, payments in both years were approximated with values representing linearly decaying payments between the observed endpoints (1987 and 1990). This approximation is mostly likely overestimating the actual interest payments due to the reduction of debt ratio and a fall

and interest rate spread, as suggested by Watson (2007). However, results were similar in terms of prediction errors to the simpler model that was then kept (transformations reduced correlations among variables).

of interest rates following the high-interest rate period of early 1980's (see OECD, 1990).
As a robustness, (1) we kept primary balance unchanged or missing years were replaced with linearly approximated values (between endpoints) with negligible impact on the level of primary balance and recalculated series respectively and (2) we use trend of interest payments for central and general government provided by the IMF GFS (*Government Finance Statistics*, cash data, see IMF, 2014) with basically unchanged results.
Germany was treated as West Germany before 1990 and growth rates applied to the first observation for the re-united country in 1991 using the HPFD database (separate calculations for West Germany up to 1991 and for Germany 1990–2015 in comparison with the previous approach had only negligible effect on the output gap estimate, so the previous method was preferred).

b) The underlying series for implied interest rates (IIR) were calculated using a rolling sum (four quarters) of interest payable series from Eurostat database (quarterly, mil. of national currency, not seasonally adjusted) after a seasonal adjustment with ARIMA X-13, divided by the previous quarter debt level and then complemented with AMECO database and/or the HPFD database (yearly series, for most of the EA countries before 1999).

c) Total current expenditures without interest payments were calculated from underlying series of this National account aggregate using series from Eurostat database (quarterly, mil. of national currency, not seasonally adjusted) using the exact definition provided in methodological notes to the AMECO database and then complemented with AMECO database and/or the HPFD database (yearly series, for most of the EA countries before 1999). Since they are at yearly frequency, quarters were created using the same decomposition method. Consequently, three years (twelve quarters) of observations were backcasted/forecasted via $VAR(p)$ model, where p was chosen optimal for each country in the sample (the AIC criterion). Subsequently, the BK and HP filter were applied to calculate trend deviations of current expenditures without intercept ($cgout_t$) utilized in the fiscal rule.

d) GDP and its components (General government final consumption expenditures, Private final consumption expenditures and Investments – Gross Fixed Capital Formation) – real, 2010 constant prices, seasonally adjusted, came from OECD QNA Database and OECD EO No. 99 Database. No further adjustments were necessary;

e) Price index series (consumer prices, seasonally adjusted, national definition) came from the OECD EO No. 99 database;

f) Implicit interest rates were calculated from interest payments primarily obtained from Eurostat databases (Eurostat, 2016b) and complemented with OECD EO No. 99, OECD Main Economic Indicators database (MEI henceforth, see OECD, 2016b) and with IMF IFS database (IMF, 2016) and AMECO database. Missing quarterly payments were reconstructed from yearly observations using the same Bayesian method (using correlation with other series in line with the reconstruction of fiscal series).
As a robustness, we used information about average lending rates from the WDI database

of the World Bank (see WB, 2016) and for Portugal that faced double digit interest rates at that period (as the only member of the EC) there is only negligible impact on recalculated series or fiscal series. Similarly, missing observations for early 1980's in case of Ireland were reconstructed with help of growth rates based on short-term exchequer's bills provided by the Irish statistical office (CSO, see CSO, 2016) with negligible impact on the series itself and fiscal variables;

g) Unemployment rates (Labour force survey, harmonized series – ILO definition, seasonally adjusted) were taken from OECD MEI database and from IMF IFS database;

h) Current account balances (according to the IMF BMP6 methodology) were taken from OECD EO No. 99, seasonally adjusted (ARIMA X-13) or calculated as a proxy utilizing series of exports and imports of goods and services (national account definition, annual levels, national currency, seasonally adjusted).

A.2 Geweke's synchronization test

Geweke (1982) proposes a measure that captures effects of harmonization by combining estimates from a system of country-by-country equations ($VARX(p)$) with a simple $VAR(p)$ for fixed length of lags for included countries. The first system in Geweke (1982)'s measure consists of simple $VAR(p)$ models (see (A.1) below) that provides information only about fiscal responses in one particular country, without any spillover effects coming from other members of the monetary union. The non-existence of any links is the null hypothesis, when testing harmonization of responses. This system estimated via OLS technique reads:

$$\Delta Z_t^{AUT} = \alpha_{AUT} + \sum_{p=1}^{P} I_{1,i,p} \Delta Z_{t-p}^{AUT} + \iota_t^{AUT} \tag{A.1a}$$

$$\dots \tag{A.1b}$$

$$\Delta Z_t^{SPA} = \alpha_{SPA} + \sum_{p=1}^{P} I_{12,i,p} \Delta Z_{t-p}^{SPA} + \iota_t^{SPA} \tag{A.1l}$$

where Z_t^i stands for fiscal responses in the quarter t of our sample period for all twelve Euro Area countries (that is $i = 1$ for Austria, ..., $i = 12$ for Spain), and the variable ι_t^i represents a set of residuals for all Euro Area countries. These are assumed to be *iid* with mean zero, variances σ_i^2 and not serially correlated.

The second system consists of models fiscal responses in individual Euro Area countries allowing for spillover effect, that is, this system of fiscal responses incorporates both responses of the analysed country and lagged fiscal responses of all other remaining EA countries. Therefore, this $VARX(p)$

system is estimated via SUR technique and can be written in the form of:

$$\Delta Z_t^{AUT} = \alpha'_{AUT} + \sum_{p=1}^{P} II_{2,i,p}\Delta Z_{t-p}^{BEL} + ... + \sum_{p=1}^{P} I_{12,i,p}\Delta Z_{t-p}^{SPA} + \jmath_t^{AUT} \tag{A.2a}$$

$$\dots \tag{A.2b}$$

$$\Delta Z_t^{SPA} = \alpha'_{SPA} + \sum_{p=1}^{P} II_{2,i,p}\Delta Z_{t-p}^{BEL} + ... + \sum_{p=1}^{P} I_{12,i,p}\Delta Z_{t-p}^{SPA} + \jmath_t^{SPA} \tag{A.2l}$$

where the interpretation of individual variables is the same as above, however, the individual residual terms, $\jmath_t^i$, can be contemporaneously correlated (that is they represent a link in the same quarter across the system). The length of delays in shocks transmission (P) is set equal to four quarters across the system.[vi] The set of coefficients $II_{j,i,p}$ represents how fiscal responses in a country j (Belgium if $j = 1$) affect the Austrian over quarters in (A.2a), similarly up to $j = 12$ (Spain) in (A.2l).

Once both systems have been estimated, stored estimated residual matrices containing variances and covariances can be utilized to compute the Geweke (1982)'s measure of contemporaneous feedback (FGS) for a pair of countries l and k ($l \neq k$). The statistics takes the form:

$$FGS_{l,k} = N \ln \left(\frac{\sigma_{\tau_l}^2 \times \sigma_{\tau_k}^2}{|\Upsilon|} \right), \sim \chi^2(1) \tag{A.3}$$

where N is the sample size, $\sigma_{\tau_l}^2$, $\sigma_{\tau_k}^2$ are the variances of residuals for the pair of countries (l and k) when system (A.2) is estimated, Υ is the determinant of the covariance matrix based on residuals when system (A.1) is estimated. Under the null the test statistics has χ^2 distribution with 1 degree of freedom.

A.3 Appendix – tables

[vi] When estimating the optimal number of lags for $VARX$, the Akaike information criterion (AIC) suggested two lags for many countries. Results with this number of lags are not significantly different from those shown.

Table A.1: Correlations of fiscal responses, 1992q1–1998q4

	ITA	SPA	PTE	IRE	GRE	LUX	GER	NLD	FIN	AUT	FRA	BEL
ITA	1.00											
SPA	-0.09	1.00										
PTE	0.09	-0.43*	1.00									
IRE	-0.01	0.87*	-0.40*	1.00								
GRE	0.08	-0.61*	0.48*	-0.57*	1.00							
LUX	-0.09	-0.74*	0.37	-0.86*	0.21*	1.00						
GER	0.31	0.51*	-0.30	0.55*	-0.56	-0.43*	1.00					
NLD	0.15	0.57*	-0.16	0.53*	-0.40*	-0.45*	0.83*	1.00				
FIN	-0.24	0.25	0.31	0.31	0.36	-0.55*	-0.31	-0.02	1.00			
AUT	0.23	0.76*	-0.57*	0.72*	-0.75*	-0.55*	0.81*	0.67*	-0.22	1.00		
FRA	-0.39*	0.44*	0.10	0.51*	0.12	-0.62*	-0.26	0.05	0.91*	-0.08	1.00	
BEL	0.01	0.77*	-0.43*	0.80*	-0.58*	-0.74*	0.86*	0.77*	0.06	0.83*	0.16	1.00

Note: * represents statistical significance at the 5% level. *Source:* own calculation.

Table A.2: Correlations of fiscal responses, 1999q1–2008q2

	ITA	SPA	PTE	IRE	GRE	LUX	GER	NLD	FIN	AUT	FRA	BEL
ITA	1.00											
SPA	-0.46*	1.00										
PTE	0.69*	-0.17	1.00									
IRE	0.29	-0.11	0.22	1.00								
GRE	0.72*	-0.33*	0.65*	0.53*	1.00							
LUX	0.43*	-0.02	0.75*	0.23	0.71*	1.00						
GER	-0.41*	0.70*	-0.09	-0.60*	-0.52*	-0.11	1.00					
NLD	0.57*	-0.20	0.66*	0.13	0.75*	0.60*	-0.05	1.00				
FIN	0.59*	-0.20	0.79*	0.31	0.73*	0.79*	-0.13	0.71*	1.00			
AUT	0.50*	-0.39*	0.70*	0.14	0.55*	0.58*	-0.26	0.44*	0.58*	1.00		
FRA	0.60*	-0.23	0.81*	0.38*	0.80*	0.79*	-0.30	0.75*	0.75*	0.59*	1.00	
BEL	0.66*	-0.48*	0.76*	0.38*	0.75*	0.69*	-0.45*	0.53*	0.77*	0.77*	0.73*	1.00

Note: * represents statistical significance at the 5% level. *Source:* own calculation.

Table A.3: Correlations of fiscal responses, 2008q3–2015q4

	ITA	SPA	PTE	IRE	GRE	LUX	GER	NLD	FIN	AUT	FRA	BEL
ITA	1.00											
SPA	0.64*	1.00										
PTE	0.55*	0.87*	1.00									
IRE	0.20	0.84*	0.82*	1.00								
GRE	0.18	0.71*	0.78*	0.90*	1.00							
LUX	0.16	-0.38*	-0.49*	-0.72*	-0.91*	1.00						
GER	0.16	0.78*	0.83*	0.95*	0.92*	-0.78*	1.00					
NLD	0.70*	0.51*	0.21	0.04	-0.21	0.56*	-0.05	1.00				
FIN	0.32	0.55*	0.35	0.46*	0.52*	-0.42*	0.44*	0.19	1.00			
AUT	0.79*	0.66*	0.57*	0.27	0.10	0.29	0.25	0.81*	0.01	1.00		
FRA	0.84*	0.90*	0.80*	0.61*	0.59*	-0.24	0.56*	0.58*	0.53*	0.73*	1.00	
BEL	0.67*	0.40*	0.11	-0.06	-0.24	0.53*	-0.12	0.92*	0.15	0.74*	0.55*	1.00

Note: * represents statistical significance at the 5% level. *Source:* own calculation.

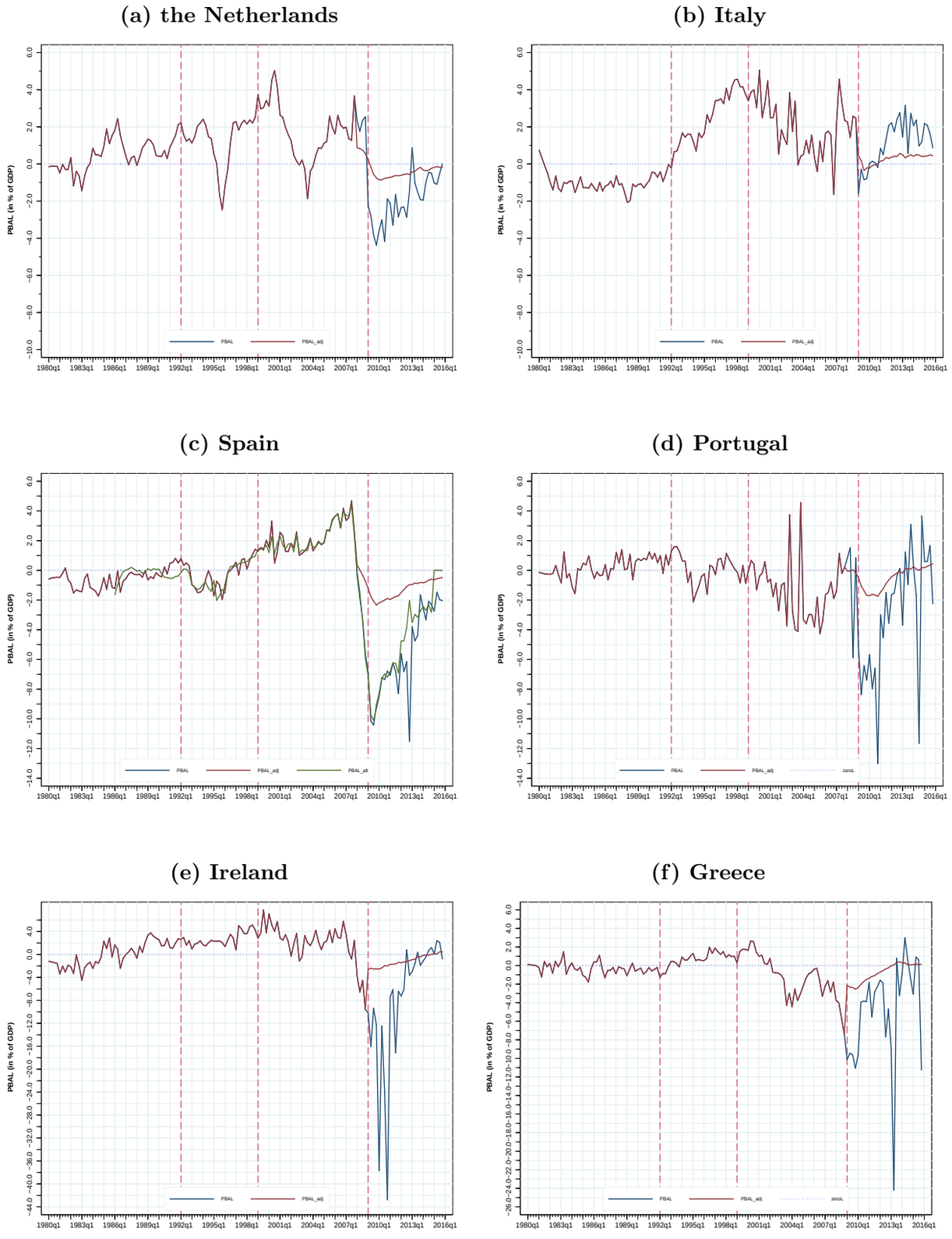
Table A.4: Correlations of fiscal responses, 2009q1–2015q4

	ITA	SPA	PTE	IRE	GRE	LUX	GER	NLD	FIN	AUT	FRA	BEL
ITA	1.00											
SPA	0.65*	1.00										
PTE	0.70*	0.91*	1.00									
IRE	0.42*	0.93*	0.83*	1.00								
GRE	0.52*	0.87*	0.83*	0.90*	1.00							
LUX	-0.27	-0.63*	-0.58*	-0.75*	-0.92*	1.00						
GER	0.45*	0.92*	0.87*	0.95*	0.91*	-0.77*	1.00					
NLD	0.51*	0.55*	0.39*	0.34	0.09	0.23	0.32	1.00				
FIN	0.19	0.51*	0.38*	0.56*	0.69*	-0.77*	0.58*	-0.10	1.00			
AUT	0.73*	0.65*	0.65*	0.42*	0.30	0.05	0.46*	0.84*	-0.15	1.00		
FRA	0.84*	0.91*	0.89*	0.77*	0.84*	-0.62*	0.79*	0.46*	0.46*	0.68*	1.00	
BEL	0.51*	0.40*	0.28	0.20	0.06	0.16	0.25	0.81*	-0.26	0.82*	0.43*	1.00

Note: * represents statistical significance at the 5% level. *Source:* own calculation.

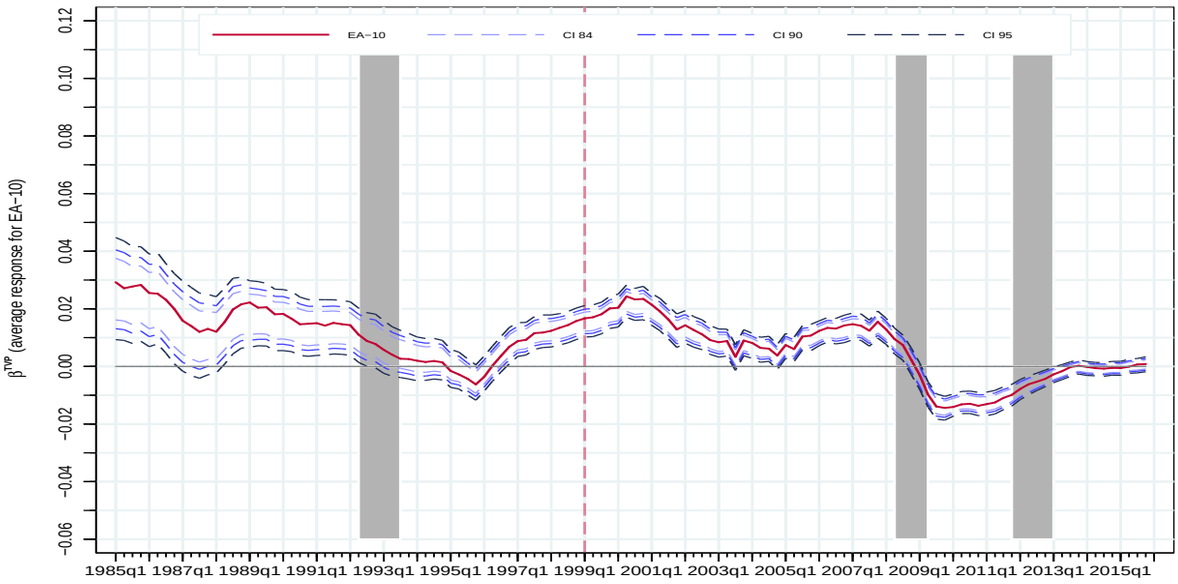
A.4 Appendix – figures

Figure A.1: Examples of primary balances – original and adjusted, 1980q1–2015q4



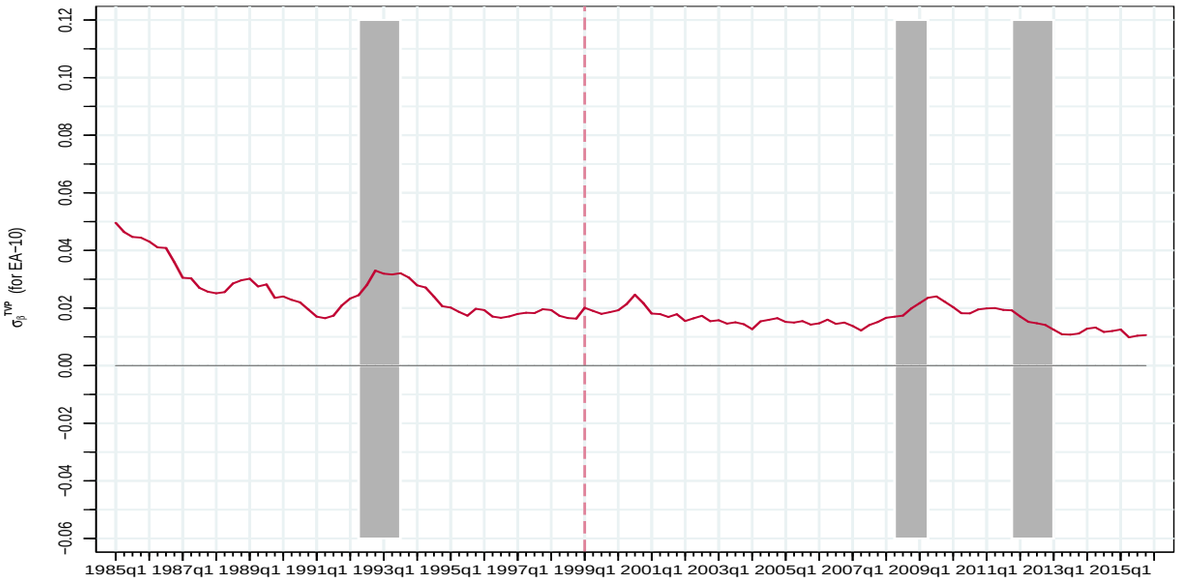
Note: GAFS series are non-zero for the Netherlands, Portugal and Spain since 2008, for Greece, Ireland and Italy since 2009. *PBAL* – officially published series, *PBAL_adj* – officially published series with adjustments for GAFS. *PBAL_alt* in case of Spain is without GAFS items (only for 2011 and 2012), and thus not fully comparable since Eurostat provides non-zero GAFS observations from 2008; TO BE CHANGED – ask Javier: the plotted series is based on an update of the dataset accompanying De Castro *et al.* (2014). Vertical axes are different for some countries. Source: own calculation and Eurostat (2016); Eurostat (2016a).

Figure A.2: TVP fiscal response estimates for EA-10 (mean), 1985q1–2015q4



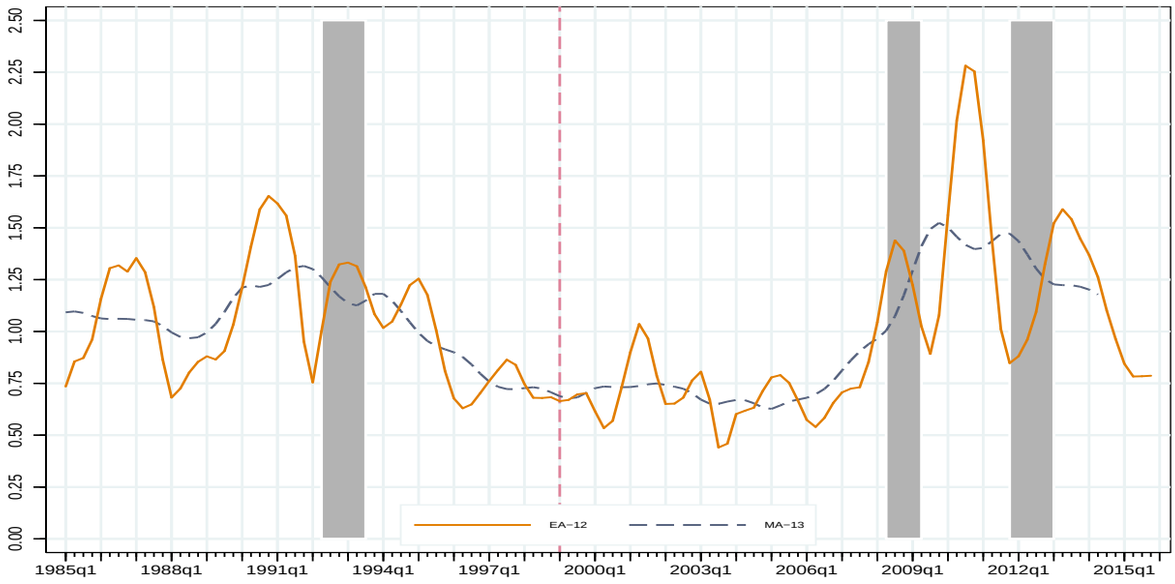
Note: unweighted EA-10 TVP responses (without Greece and Luxembourg, based on FR I). Dark areas are CEPR based recession periods for the Euro Area. Blue dashed lines ($CI\ XX$) represent $16^{th} - 84^{th}$, $10^{th} - 90^{th}$ and $5^{th} - 95^{th}$ quantiles of posterior distribution of TVP EA-10 responses. The red dashed line represents the launch of Euro in January 1999. Source: own calculation.

Figure A.3: TVP fiscal response estimates for EA-10 countries (standard deviation), 1985q1–2015q4



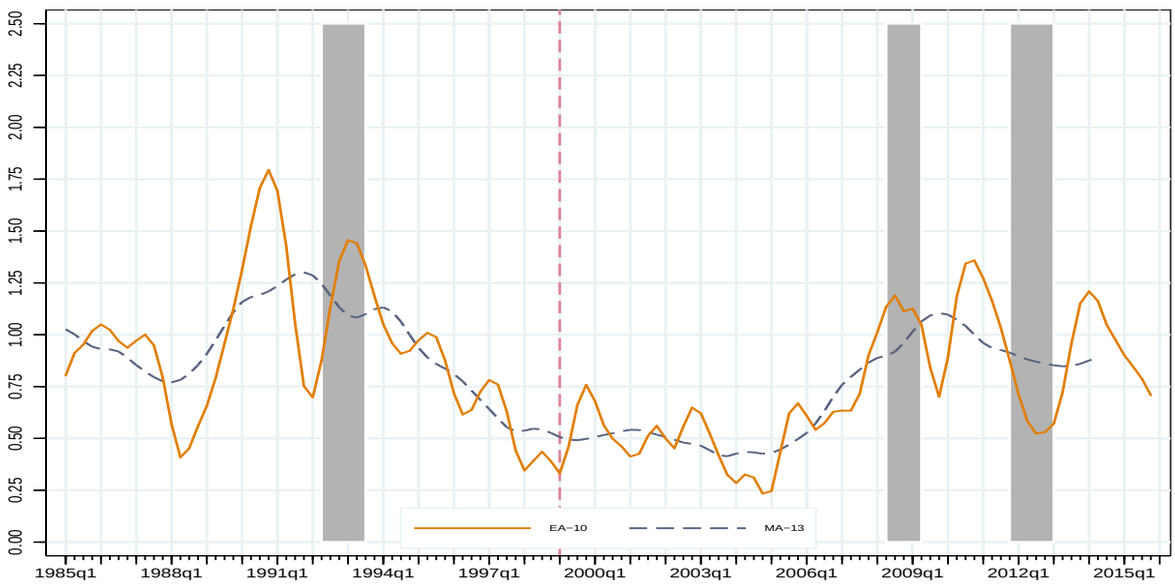
Note: unweighted cross-sectional standard deviation of EA-10 TVP responses (without Greece and Luxembourg, based on FR I). Dark areas are CEPR based recession periods for the Euro Area. The red dashed line represents the launch of Euro in January 1999. Source: own calculation.

Figure A.4: Dispersion of output gaps for EA-12 countries, 1985q1–2015q4



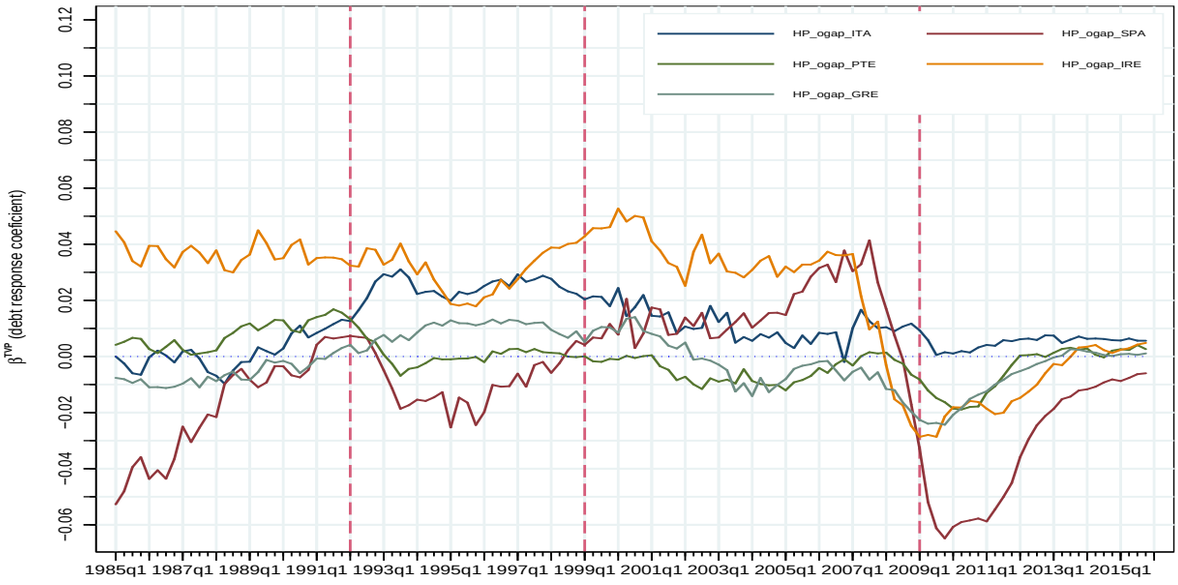
Note: unweighted cross-sectional standard deviation of EA-12 output gaps calculated with the BK filter. MA-13 stands for the centered moving average of length 13 quarters (symmetric filter). Dark areas are CEPR based recession periods for the Euro Area. The red dashed line represents the launch of Euro in January 1999. Output gaps and their dispersion is available since 1980q1. Source: own calculation.

Figure A.5: Dispersion of output gaps for EA-10 countries, 1985q1–2015q4



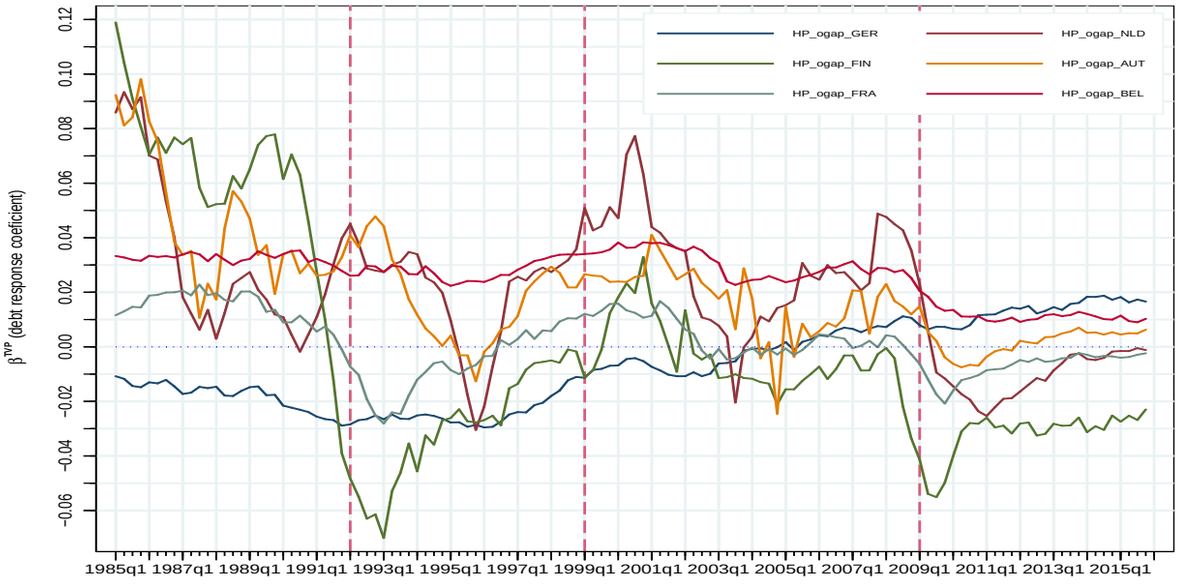
Note: unweighted cross-sectional standard deviation of EA-10 (without Greece and Luxembourg) output gaps calculated with the BK filter. MA-13 stands for the centered moving average of length 13 quarters (symmetric filter). Dark areas are CEPR based recession periods for the Euro Area. The red dashed line represents the launch of Euro in January 1999. Output gaps and their dispersion is available since 1980q1. Source: own calculation.

Figure A.6: TVP fiscal response estimates for GIIPS countries (alter. output gap), 1985q1–2015q4



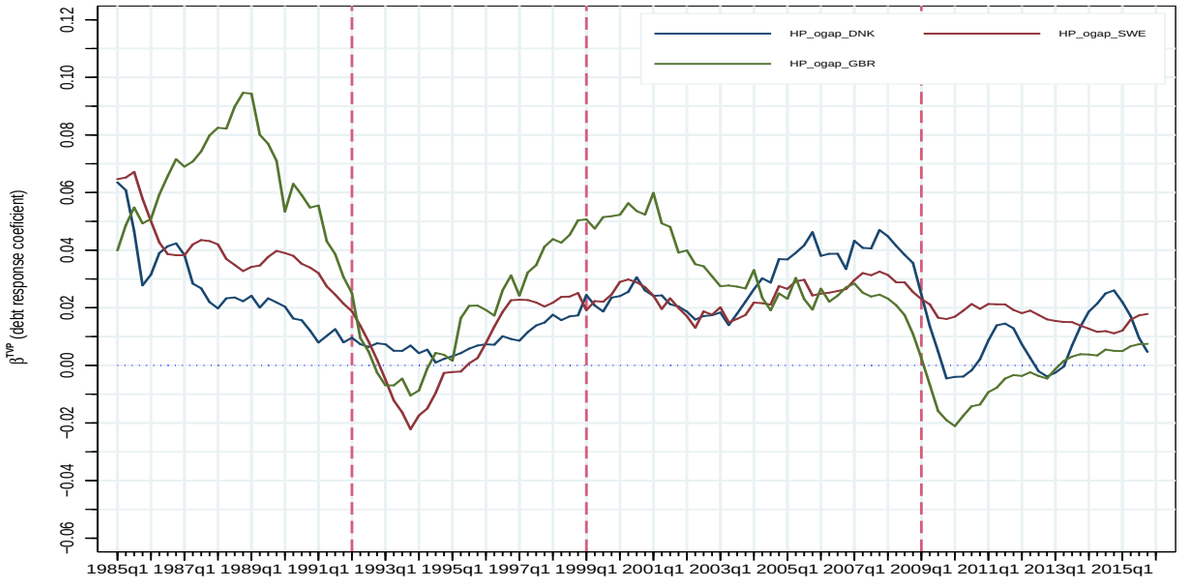
Note: TVP responses. Output gap estimated with the HP filter ($\lambda = 1600$). The same simulation specification across countries. Red dashed lines represent the Maastricht Treaty (1992), the launch of Euro (1999), and the Great Recession (2009). Source: own calculation.

Figure A.7: TVP fiscal response estimates for other EA countries (alter. output gap), 1985q1–2015q4



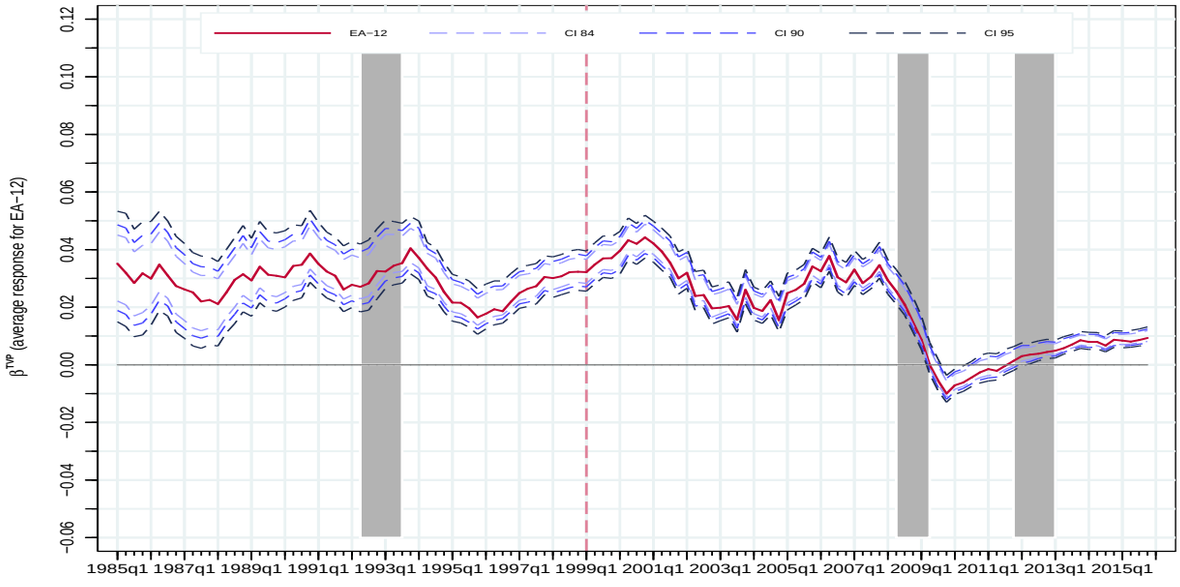
Note: TVP responses. Output gap estimated with the HP filter ($\lambda = 1600$). The same simulation specification across countries. Luxembourg excluded. Red dashed lines represent the Maastricht Treaty (1992), the launch of Euro (1999), and the Great Recession (2009). Source: own calculation.

Figure A.8: TVP fiscal response estimates for stand-alone EU countries (alter. output gap), 1985q1–2015q4



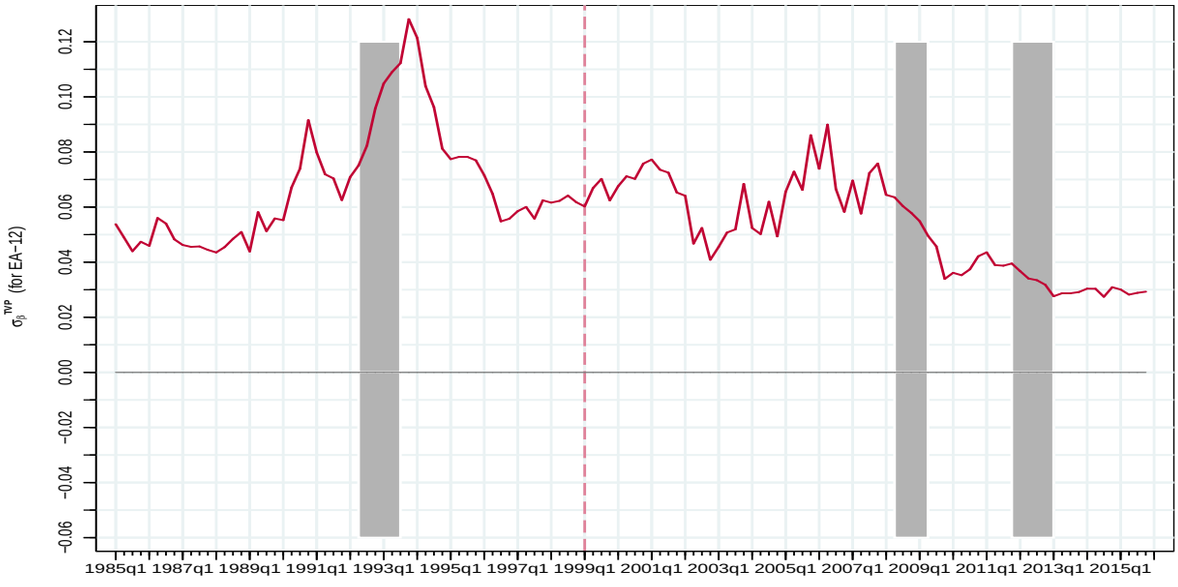
Note: TVP responses. Output gap estimated with the HP filter ($\lambda = 1600$). The same simulation specification across countries. Red dashed lines represent the Maastricht Treaty (1992), the launch of Euro (1999), and the Great Recession (2009). Source: own calculation.

Figure A.9: TVP fiscal response estimates for EA-12 (mean with alter. output gap), 1985q1–2015q4



Note: unweighted EA-12 TVP responses (based on FR I). Dark areas are CEPR based recession periods for the Euro Area. Blue dashed lines ($CI\ XX$) represent $16^{th} - 84^{th}$, $10^{th} - 90^{th}$ and $5^{th} - 95^{th}$ quantiles of posterior distribution of TVP EA-12 responses. The red dashed line represents the launch of Euro in January 1999. Output gap estimated with the HP filter ($\lambda = 1600$). Source: own calculation.

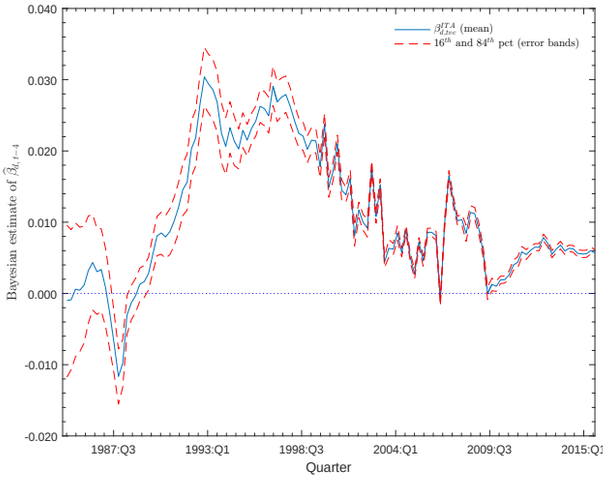
Figure A.10: TVP fiscal response estimates for EA-12 countries (standard deviation with alter. output gap), 1985q1–2015q4



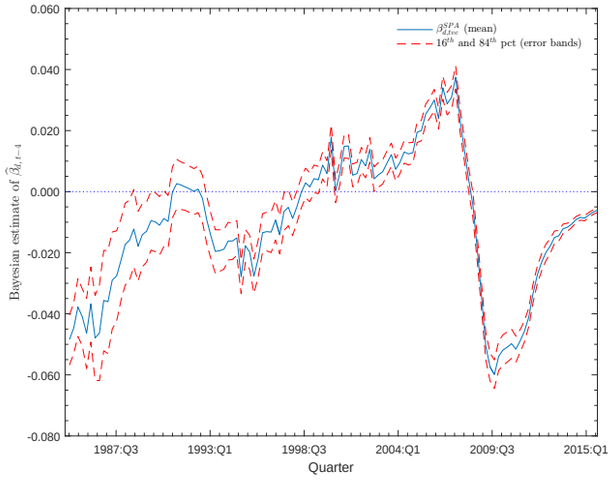
Note: unweighted cross-sectional standard deviation of EA-12 TVP responses (based on FR I). Dark areas are CEPR based recession periods for the Euro Area. The red dashed line represents the launch of Euro in January 1999. Output gap estimated with the HP filter ($\lambda = 1600$). Source: own calculation.

Figure A.11: TVP estimates for selected EU countries, 1986–2015

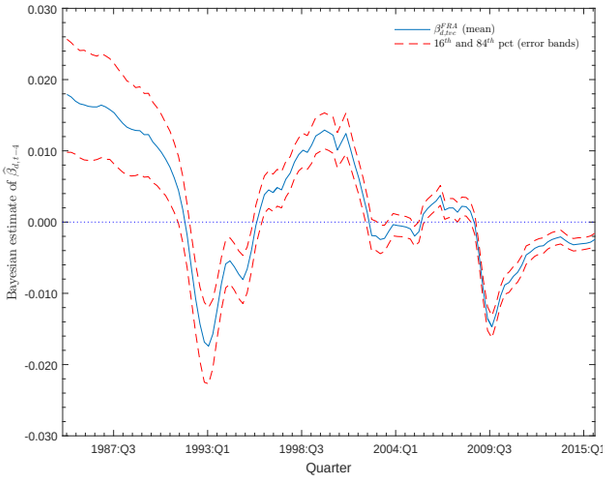
(a) Italy



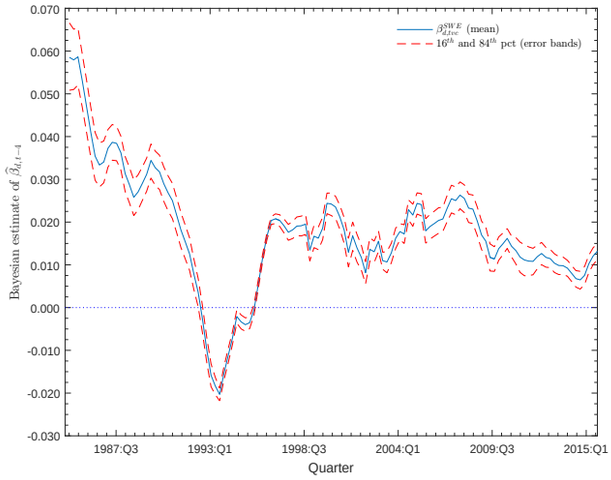
(b) Spain



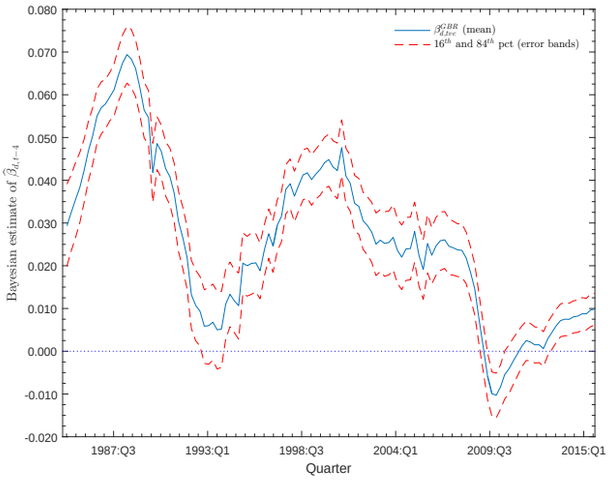
(c) France



(d) Sweden



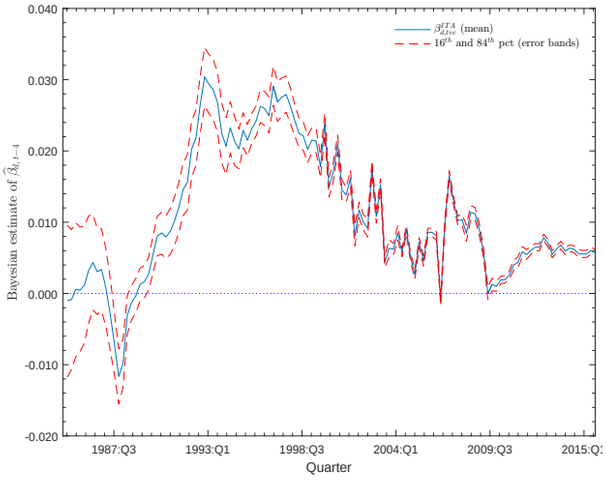
(e) the United Kingdom



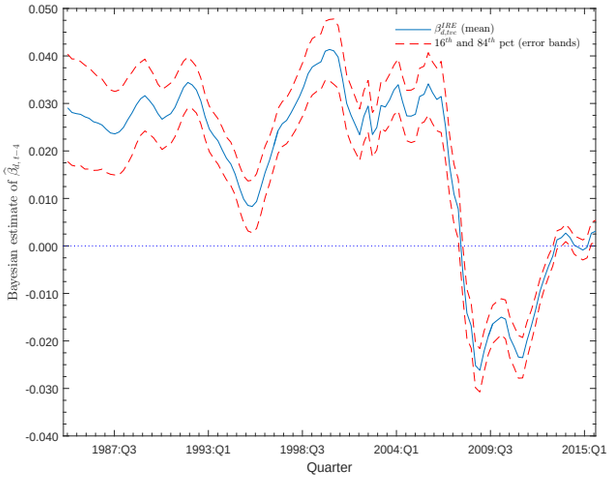
Note: TVP responses and 16-th and 84-th percentiles of the standard deviation of posterior values. Blue dotted horizontal line visible in some figures indicates zero value responses. Units on the vertical axis are country-specific. Source: own calculation.

Figure A.12: TVP estimates for GIIPS countries, 1986–2015

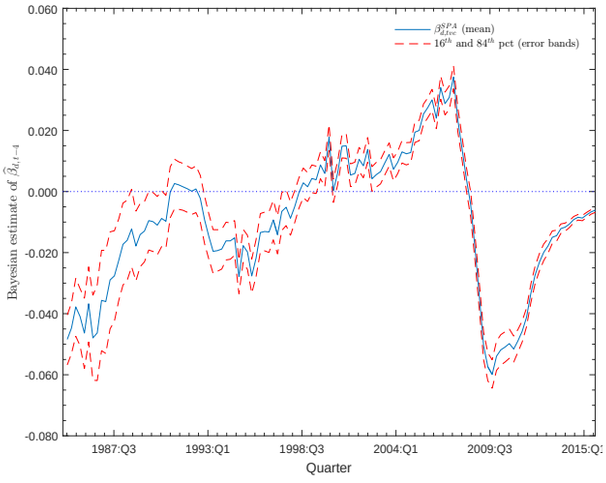
(a) Italy



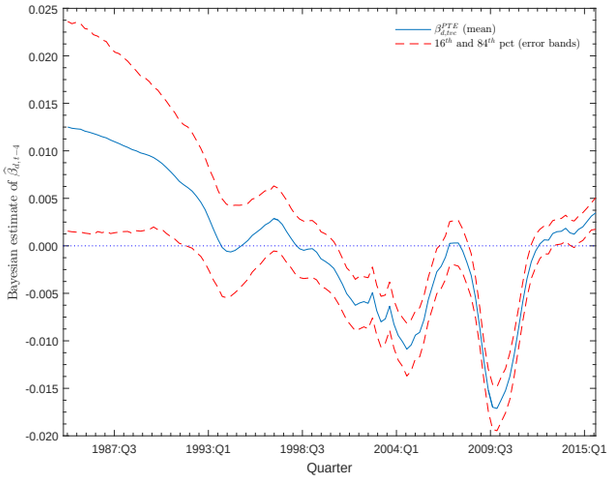
(b) Ireland



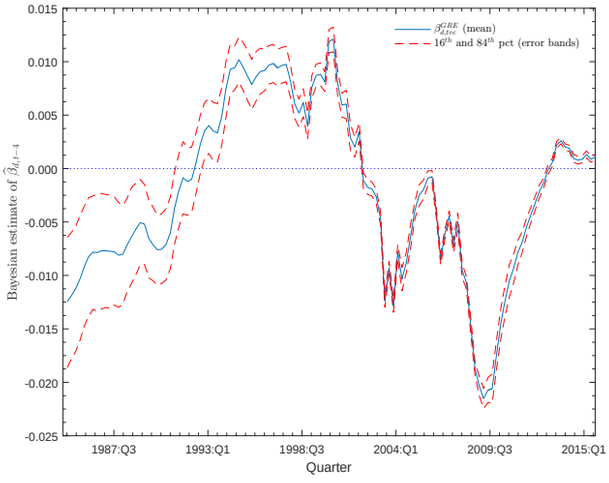
(c) Spain



(d) Portugal



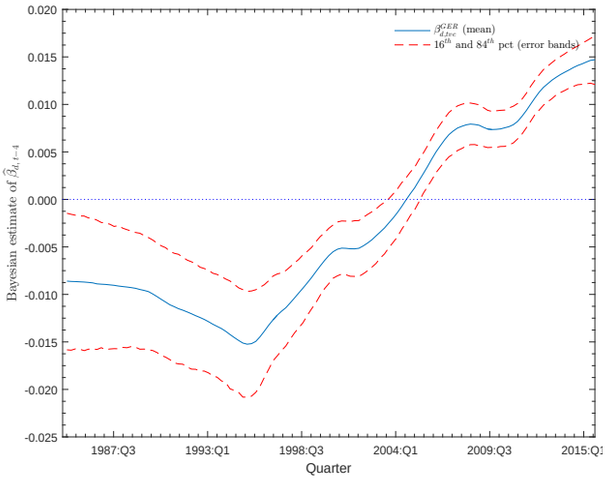
(e) Greece



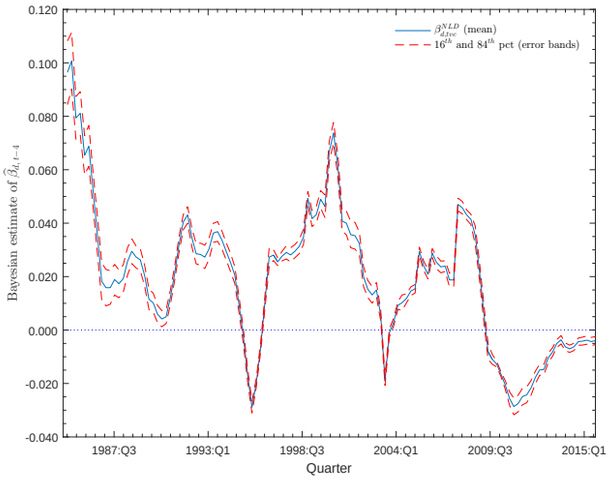
Note: TVP responses and 16-th and 84-th percentiles of the standard deviation of posterior values. Blue dotted horizontal line visible in some figures indicates zero value responses. Units on the vertical axis are country-specific. Source: own calculation.

Figure A.13: TVP estimates for other EA-12 countries, 1986–2015

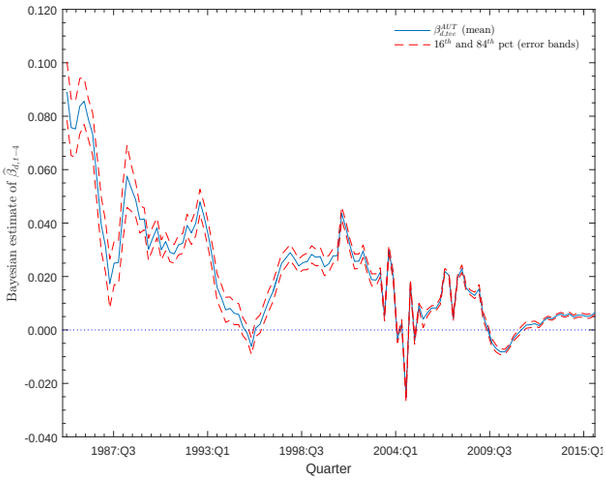
(a) Germany



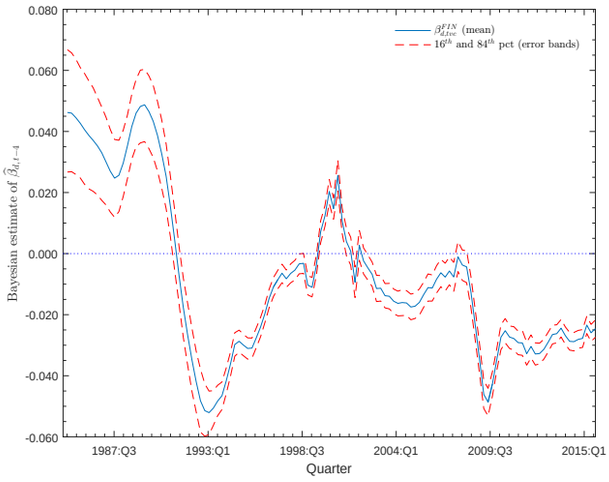
(b) the Netherlands



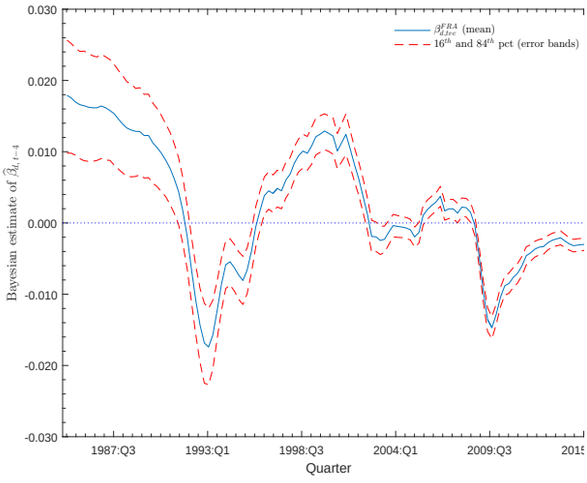
(c) Austria



(d) Finland



(e) France



(f) Belgium

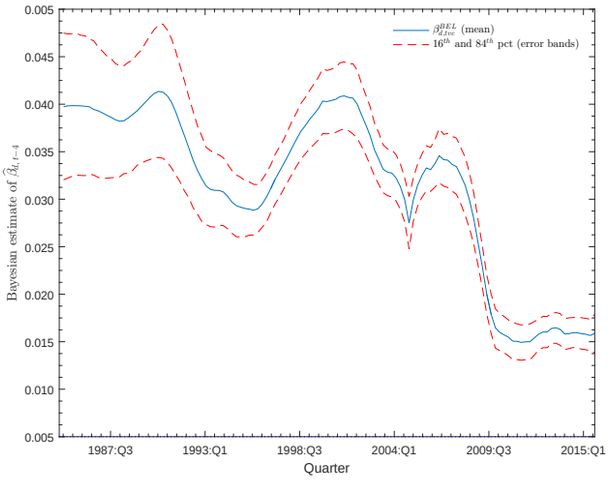
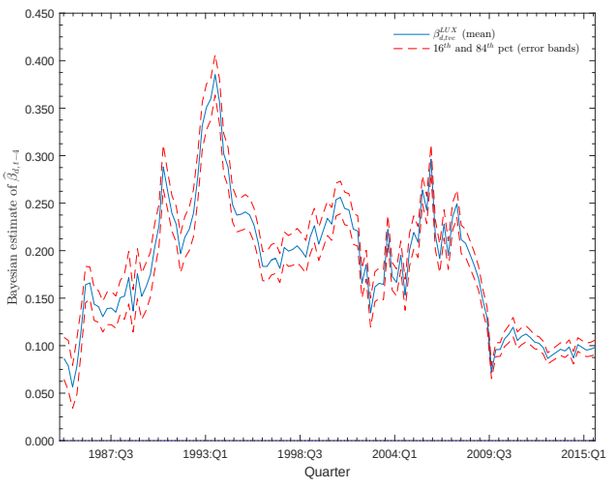


Figure A.13: TVP estimates for other EA-12 countries, 1986–2015 (*con't. from page 58)*

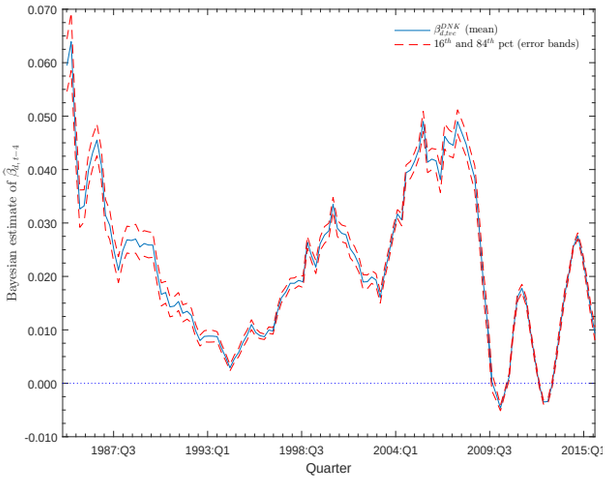
(g) Luxembourg



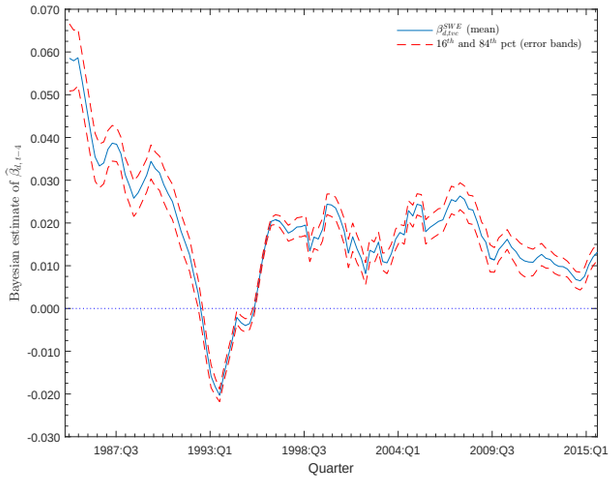
Note: TVP responses and 16-th and 84-th percentiles of the standard deviation of posterior values. Blue dotted horizontal line visible in some figures indicates zero value responses. Units on the vertical axis are country-specific. Source: own calculation.

Figure A.14: TVP estimates for stand-alone EU countries, 1986–2015

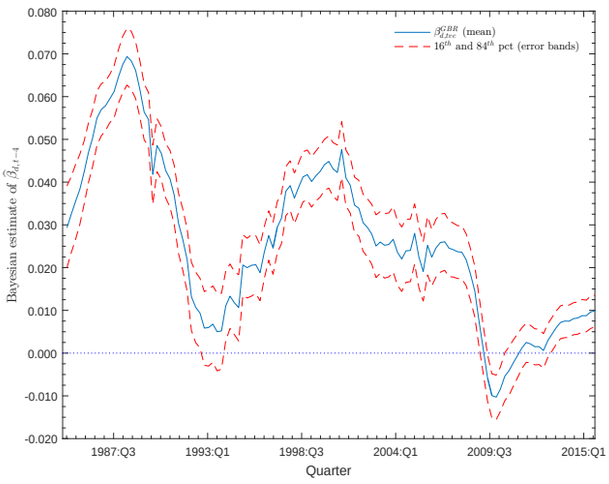
(a) Denmark



(b) Sweden



(c) the United Kingdom



Note: TVP responses and 16-th and 84-th percentiles of the standard deviation of posterior values. Blue dotted horizontal line visible in some figures indicates zero value responses. Units on the vertical axis are country-specific. Source: own calculation.