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Measuring fiscal spillovers in EMU and beyond: A Global VAR approach

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Measuring fiscal spillovers in EMU and beyond: A Global VAR approach

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Abstract

This paper identifies and measures fiscal spillovers in the EU countries empirically, using a structurally stable global vector autoregression (GVAR) model. For our purposes, the individual EU countries, as well as the most important international trading partners, are modelled with a special focus on the effects of either single-country or coordinated fiscal shocks such as increases in fiscal spending. Our aim is to look at the sign and the absolute values of fiscal spillovers in a country-wise perspective and at the time profile (impulse response) of the impacts of fiscal shocks. For this purpose, we differentiate between the spillovers of fiscal shocks in specific EMU member countries and the spillovers of "regional" shocks, i.e. area-wide shocks to fiscal policy. Fiscal policy is measured by government expenditure, government revenues or the government budget balance, all as percentages of GDP. Special attention is paid to the question of whether or not spillovers are stronger within the EMU group than within the "Rest of Europe" due to tighter financial or trade links.

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1. Introduction

It is undisputed among economists that the growing interdependence that stems from sharing a common currency and a single monetary policy legitimises a certain degree of economic policy coordination among Euro area Member States. However, empirical studies have yet offered *inconclusive evidence* with regard to the quantitative importance of different types of *economic spillovers*. In accordance, estimates of the welfare gains arising from economic policy coordination in the Euro area have varied considerably (Weyerstrass et al., 2006).

This paper identifies and measures fiscal spillovers in the EU countries empirically, using a global vector autoregression (GVAR) methodology. The GVAR modelling approach has been pioneered by Pesaran, Schuermann and Weiner (2004) and further contributions such as Dees et al. (2007). It allows consistent modelling of international interdependencies and transmission channels across countries and the evaluation of different economic policies in counterfactual analyses. In a nutshell, a GVAR model consists of a number of individual country VAR models describing the country's economy treating all variables as endogenous. These countries then are consistently linked into a single multi-country model using weights relating to the international linkages of each country with the other countries in the sample. In this way, international interdependencies can be modelled in a transparent fashion and in a way that is both consistent with the theory and consistent with the data.

The recent crisis has shown yet again how the world economies are globally interlinked, via a complex net of transmission channels. When it comes, however, to build econometric frameworks aimed at analysing such linkages, modellers are faced with what is called the "curse of dimensionality": there far too many parameters to be estimated with respect to the available observations. The GVAR, a VAR based model of the global economy, offers a solution to this problem. The basic model is composed of a large number of country specific models, comprising domestic, foreign and purely global variables. The foreign variables, however, are treated as weakly exogenous. This assumption, which is typically held when empirically tested for virtually all economies - with the notable exception of the US which is treated differently - allows estimating first the individual country models separately. Only in a second stage, country-specific models are simultaneously solved, thus allowing global interactions (Di Mauro and Pesaran, 2013).[1]

For our purposes, the individual EU countries, as well as the most important international trading partners, can be modelled with a special focus on the effects of either single-country or coordinated fiscal shocks such as increases in fiscal spending. Fiscal variables analysed in this paper cover variables such as government expenditure, government revenues or the government budget balance, all measured as percentage of GDP.

What is the motivation of this paper? Currently, policy calls for more government spending in the Euro area (of countries with some fiscal space). Monetary policy is constrained because its arsenal appears to be exhausted. Therefore fiscal policy may need to be active. If spillovers are sufficiently high, output can be stimulated across the monetary union. Potential questions that might arise in this context are, therefore: Who is benefiting fiscally from whom in the Euro area? Whose spillovers are biggest? Which ones are small (or even negative) (Georgiadis and Hollmayr, 2016)?

Our aim is to look at the sign and the absolute values of fiscal spillovers in a country-wise perspective and at the time profile (impulse response) of the impacts of fiscal shocks, i.e. of the spillovers of a German fiscal expansion on French GDP (as was the aim of, for instance, Gros

[1] A brief and coherent description and explanation of the GVAR methodology is also delivered by Canova and Ciccarelli (2013), pp. 39-41.

and Hobza, 2001, one and a half decades ago). We differentiate between fiscal shocks in individual countries and common Euro area wide shocks which in the GVAR analysis is called a "global" shock. Our analysis is extended to include European economies outside the Euro area in order to assess whether, on the one hand, core and peripheral EMU countries and, on the other hand, EMU member countries and the "Rest of Europe" react symmetrically to external fiscal shocks (Caporale and Girardi, 2011). Special attention will be paid to the question of *whether spillovers are stronger within the EMU group than within the larger EU group* due to tighter financial or trade links (Faini, 2006). Why? Economic and Monetary Union (EMU) increases the degree of economic interdependence between Euro area Member States.

Under EMU, the negative impact of interest rate increases in the wake of national fiscal expansions is often said to be limited (which is exactly what we see in our impulse responses of long-term interest rates within the euro area as a reaction to fiscal shocks in individual EMU member countries or to Euro area-wide shock. Let us take the example of Germany for illustration purposes. The authority responsible for the conduct of monetary policy is the ECB, which targets the total money supply of all the members of the Euro area, of which the German GDP is approximately slightly beyond one-fourth. Therefore, the interest rate increase following the German fiscal expansion will be proportionately lower. The German domestic demand will thus be dampened to a lower extent and the positive trade effects can well be expected to play a more pronounced role (Gros and Hobza, 2001). In the Euro area in particular, the single monetary policy, the common external exchange rate and the related absence of bilateral nominal exchange rates can thus strengthen spillover effects across Euro area countries (European Commission, 2014).

Sharing a common currency and a single monetary policy means that there is a *higher probability* that economic policies and developments, here: fiscal policies, in one Member State will spillover into the rest of the Euro area (as opposed to the "Rest of Europe"). Coordination of economic policy instruments across the Member States of a monetary union is seen by some to be justified when this kind of spillover is significant.[2] Regarding this issue, Article 99 of the Treaty imposes on the Member States to treat their economic policies as a matter of common concern and to coordinate them in Council with an eye on achieving, among others, higher non-inflationary growth and an improved standard of living (Weyerstrass et al., 2006). Other papers of the FIRSTRUN project deal with these policy issues in more detail. This paper, in contrast, is mainly dealing with the quantification of fiscal spillovers in Europe.

This paper proceeds as follows. Section 2 on fiscal spillovers in Europe and GVAR analysis provides a brief discussion of the interrelation between fiscal spillovers and fiscal policy coordination in EMU/the EU (more exhaustive deliberations have been conducted in other parts of the FIRSTRUN project) and comes up with a literature review of the theory and the quantification of fiscal spillovers. The data and variables used and the estimation approach are described in section 3. Our GVAR estimations and impulse responses are presented in section 4 combined with the results of a battery of necessary pre-tests, including some structural break and robustness checks. Section 5 sums up our results, derives some policy implications and provides an outlook for further research.

[2] Later on in this study we argue that significance of fiscal spillovers may be a necessary but by far not sufficient condition of fiscal policy coordination.

2. Fiscal spillovers in the Euro area (EU) and GVAR analysis

2.1 Cross-country spillovers and fiscal policy coordination in EMU/the EU

Basic considerations

What is the economic rationale for economic policy coordination? Economic literature suggests that the *justification for fiscal policy coordination* should be sought in the existence of economic *cross-country spillover effects*. Exogenous shocks, either induced by policy choices or driven by external factors, in one country can generate effects that spill over into other countries through multiple economic channels fed by economic interdependence (as modelled in a GVAR in this paper). Indeed a fiscal impulse in one country may impact output and prices in another country through imports, relative prices, the interest rates channel and other financial linkages. Such linkages are generally assumed to be particularly strong and relevant in the context of a monetary union, where both the monetary policy and the exchange rate are common and reflect average conditions and integration is deep (Faini, 2006).[3]

In such a context a cooperative approach, in the form of economic policy coordination, while on the one hand, reduces the discretionary use of fiscal policy by national governments, on the other hand, should increase stability across the union. Hence, strengthening the framework of fiscal rules and their enforcement seems to be fully consistent with the rationale for coordination. It should also be recalled that in the context of the monetary union, fiscal rules were conceived as a crucial tool for making sure that fiscal instability in one country does not jeopardise the stability of other countries and the common monetary policy would be adequate for all member states (Alcidi, Määttänen and Thirion, 2016).

It is quite often claimed by politicians that a common currency makes it beneficial to be also endowed with a common fiscal policy. In a monetary union, budgetary laxity in the individual Member States negatively affects the other members. If the no-bail-out clause stating that no Member State can be forced to step in for another state's liabilities is not totally credible, there are risks that individual fiscal irresponsibility impairs economic performance in the other Member States. Extremely profligate fiscal policies in some countries might harm other less profligate members via higher borrowing costs, especially if markets believe that members would have to stand in for peers that became insolvent. If this is the case, the profligate members could 'free-ride' on the backs of the others. These negative consequences of irresponsible fiscal policies could be avoided by coordinated budgetary discipline (Weyerstrass et al., 2006).

Another popular but opposing approach would be to start from a negative fiscal policy shock, particularly a country-specific shock in a big country such as Germany or a negative Euro area-wide shock, and to argue that negative fiscal spillovers imply "austerity" in the whole euro area (de Grauwe, 2009).

However, if fiscal policy can reasonably be considered to be a source of shocks, national fiscal policies which are steered independently from each other are generally preferable because they allow the possibility to *diversify macroeconomic risks* (Belke and Gros, 2009, and Belke and Gros, 2009a). We would like to argue that this view is valid at least in "normal" times but now turn closer t othe quantification of fiscal spillovers in Europe.

[3] Blanchard, Erceg and Lindé (2015) show that a fiscal expansion by the core economies of the euro area would have a large and positive impact on periphery GDP assuming that policy rates remain low for a prolonged period. Under their preferred large-scale model specification, an expansion of core government spending equal to one percent of euro area GDP would boost periphery GDP around 1 percent in a liquidity trap lasting three years, about half as large as the effect on core GDP.

Definition of spillovers

Cross-border spillovers are broadly defined as the result of a shock in one economy which is transmitted through any number of a variety of channels to another economy. This definition implies that the *qualitative and quantitative nature of spillover effects depends on several dimensions* (European Commission, 2014): the transmission channels, the type of shock and the amplification or stabilisation mechanisms operating in the originating and receiving economies.

Types of spillovers

In general, a number of different types of spillover can be distinguished in the Euro area/the EU (Weyerstrass et al., 2006):

External vs. internal spillover: External spillover which we do *not* specifically focus upon in our study originates from interactions between the Euro area and the rest of the world. In particular, developments in the US economy influence the Euro area economy significantly, especially via trade linkages and the euro/US dollar exchange rate. Prices of oil and other raw materials are determined in international markets largely beyond the control of the Euro area but having potentially strong spillover on its economies. However, we assess *internal* spillover which originates from the economic linkages between the Euro area countries.

Shock vs. policy-induced spillover: This is particularly relevant from the perspective of policy action to be assessed by the FIRSTRUN project. Policy-induced spillover implies a direct influence of policy measures (changes in government expenditure, in government revenue and in the government budget balance) undertaken on the individual country level on other individual countries. Coordination is often recommended to mitigate negative consequences of policy errors and internalises the consequences of spillover from non-coordinated policies (for an opposing view in normal times, however, see Belke and Gros, 2009, 2009a). Policy coordination may also be beneficial to address spillover produced by macroeconomic shocks hitting either all Euro area countries symmetrically (like oil price shocks) or individual countries (like the German unification). In our study, we model a symmetric "global" shock as, for instance, a simultaneous government budget cut in all EMU/EU member countries.

Direct vs. indirect spillover: In the context of the Euro area/EU, direct and indirect spillover of the different countries is present. Direct international spillover operates mainly through trade linkages. In addition, indirect spillover working through the common interest rate and the euro exchange rate is also important. As an example, an overly expansionary fiscal policy by one country may result in higher interest rates, influencing all other Euro area Member States. Furthermore, fiscal policy measures may induce exchange rate reactions affecting all members of a monetary union. The empirical GVAR and the dynamic analysis using impulse response function is able to include direct as well as indirect channels of transmission. However, the GVAR approach is not capable of a clean distinction between the two.

Positive vs. negative spillover: In the case of a positive spillover, individual policies reinforce each other. In the case of negative spillovers, policy measures are mutually inconsistent and in conflict with each other. Obviously, this difference has implications for the design of coordination. In the presence of negative spillovers, there is a stronger need for monitoring, corrective mechanisms, and sanctions in case of noncompliance. While there is often a clear theoretical notion why a certain spillover is likely to be positive or negative, empirical estimations of spillovers may not always confirm theoretical priors. The interactions of spillovers, and in some cases (but not in the GVAR exercise in this study) also non-linearities and the complexity of dynamics may lead to more indeterminate outcomes concerning sign, size and the timing of spillover.

Factors amplifying or mitigating spillovers

Various conditions relative to market structures and policy regimes can either amplify or mitigate spillover effects. For example, a high *degree of trade openness* facilitates the propagation of shocks across highly integrated economies. *Nominal and real rigidities* also play an important role in determining the amplitude and persistence of spillover effects, affecting the adjustment to shocks (European Commission, 2014).

The magnitude of financial spillovers depends on several factors, such as the *degree of international portfolio diversification, the degree of prevailing risk aversion, the size and activity of multinational banks, access to funding, the degree of financial market integration and the nature of financial market regulations* (European Commission, 2014). What is more, a key role is played by the prevailing *governance structure* and *fiscal regime* (continuity, in particular the existence or absence of supranational risk sharing mechanisms) and by the monetary policy regime (European Commission, 2014). Some even mention *distance* and *common language* in this context (Bankowski, 2016, Georgiadis and Hollmayr (2016), Slide 10: Determinants of spillovers).

Finally, *monetary policy* plays a role as well (Elekdag and Muir, 2014, Gadatsch, Hauzenberger and Stähler, 2016): In't Veld (2016) describes model simulations that broadly confirm the view that at the current juncture, with monetary policy constrained by the zero interest rate floor, a debt-financed increase in government investment in surplus countries will have positive GDP spillovers to the rest of the Euro area. If monetary policy cannot be accommodating, GDP spillovers may be small, but when policy rates are held constant for two years, spillovers can be significant (In't Veld, 2016). Bundesbank (2016) and Cook and Devereux (2016) assess the role of monetary policy for fiscal spillovers in the context of a currency union.[4]

2.2 Literature review: theory and quantification of fiscal spillovers

2.2.1 Fiscal spillovers and transmission channels

A fiscal policy change in one country may influence other countries via *multiple channels*, which are treated extensively in the economic literature. The main channels discussed in the literature are the *demand channel* (also referred to as the trade channel), the *competitiveness channel* (also referred to as the terms of trade channel) and the *financial markets channel*. (Alcidi, Määttänen and Thirion, 2016). See Weyerstrass et al. (2006) for a detailed discussion. All transmission channels are contained in the GVAR through estimated cointegration vectors within the GVAR estimated by us (for details see section 3).

The *demand channel* is the one that has been emphasised the most (In't Veld, 2016). By affecting domestic demand, fiscal policy actions are very likely to affect the demand for imported goods, which realises as a change in export demand in countries that are trade partners. This channel is commonly related to budgetary policies. For instance, through the demand channel, a fiscal stimulus in one country may stimulate aggregate demand in other countries (Alcidi,

[4] The impact of many of these "conditioning" interaction variables on the fiscal spillovers could best be investigated in a panel analysis but not in a basic GVAR of the Dees et al. (2007)-type used in our study (Georgiadis and Hollmayr, 2016). Fahri and Werning (2012), Cook and Devereux (2016), and Fujiwara and Ueda (2013) have analysed fiscal spillovers in a liquidity trap. However, they utilise theoretical models but do not employ Global VARs.

Määttänen and Thirion, 2016, Bundesbank, 2016, European Commission, 2014, and Weyerstrass et al., 2006, who speak of the "output channel" in this context). This is in a nutshell what Elekdag and Muir (2014) and Hebous and Zimmermann (2013) refer to as "positive spillover effects through trade": a fiscal expansion stimulates domestic activities, pressuring the exchange rate to appreciate and the domestic interest rate to increase. In a currency union, however, the exchange rate between members is fixed and the interest rate is ultimately determined at the union level. Hence, domestic money under circulation increases, further stimulating domestic output. The increase in domestic output leads to an increase in imports, boosting the income of the trading partners.

The *competitiveness channel* represents the second potential channel of fiscal spillovers. Its first variant is the *interest rate and exchange rate channel*. In the Euro area, fiscal policies can (at least potentially, if the ECB does not accommodate) induce changes in the short-term interest rates and exchange rate of the euro, leading to interest rate and exchange rate spillover through the "interest rate channel" and the "exchange rate channel". This spillover within the Euro area gives support for the standard "beggar-thy-neighbour" argument for policy coordination which makes possible the internalisation of the negative spillover from fiscal policies through these channels. It is also important to realise here that Euro area member countries are likely to differ in the spillover they experience from changes in the common short-term interest rate and the euro exchange rate (Bundesbank, 2016, Elekdag and Muir, 2014, In't Veld, 2016 and Weyerstrass et al., 2006).

A fiscal stimulus is also eventually affecting the terms of trade by *increasing inflation* in the source country, which serves as an example of the competitiveness channel. Hebous and Zimmermann (2013) and Weyerstrass et al. (2006) call this the "spillover effects through the real exchange rate": the euro is floating with respect to the rest of the world. If the fiscal expansion in a (large) member economy causes an appreciation of the real exchange rate of the Euro, as the Mundell-Fleming model predicts, the expansionary effects of a fiscal expansion will be dampened in the wake of worsening trade balances.

The *competitiveness channel* may be an issue in the case of so-called structural fiscal policies as well. Given distortionary taxation, all fiscal policy decisions are probably impacting on relative prices and, as a consequence, the terms of trade to a certain extent (Ferrero, 2009). Fiscal policies may as well target the terms of trade directly. That is the case, in particular, with a so-called fiscal devaluation, i.e. a policy that consists of increasing VAT and reducing payroll taxes (Alcidi et al., 2016). Other structural fiscal policies, such as those aiming to increase labour supply, may also have spillover effects via the competitiveness channel (Alcidi, Määttänen and Thirion, 2016, European Commission, 2014).

The *financial market channel* may be related to several mechanisms. Interest rates in different market segments and the policy rates are the typical transmission mechanisms. For one thing, excessive government borrowing in an individual country can increase the risk-premium of government debt in other member countries of a monetary union. This may happen because of a lack of commitment to a no bail-out rule, which implies that member countries are to some extent liable for the sovereign debt of all other member countries. Even if the no bail-out rule is credible, risk premia may increase in other countries because of a risk of financial contagion. In particular, increased sovereign default risk may spill over to other countries via weakened financial intermediation. Especially when fiscal expansion is debt-financed and public debt is already high, substantial financial market spillovers can thus emerge. To some extent at least, these concerns apply to private debt as well. Excessive private debts have often become part of public debt during a financial crisis (Alcidi, Määttänen and Thirion, 2016, Caporale and Girardi, 2011, European Commission, 2014).

The working mechanism of the previous channels are usually demonstrated in the GVAR literature in a *multi-country Mundell-Fleming model* with a fixed exchange rate peg between members and perfect capital mobility (Hebous and Zimmermann, 2013 European Commission, 2014).

Different forms of financial market integration are also a source of cross-country spillover effects. In the Euro area, where financial integration has resulted in cross-border banking exposure, foreign claims of the banks may work as transmission channels of fiscal policy shocks and in some cases even as amplifiers of shocks (Alcidi, Määttänen and Thirion, 2016, Caporale and Girardi, 2011, European Commission, 2014).

Another issue is the possibility of *self-fulfilling government debt crises and the role of the central bank* (in particular, the ECB) as a lender of last resort in government bond markets. See De Grauwe (2011) for a detailed discussion on this issue. Related to this, Aguiar et al. (2015) emphasise that there is a fiscal externality in the sense that a (small) member country ignores the impact of its borrowing decisions on inflation expectations via the credibility of the central bank's inflation target (Alcidi, Määttänen and Thirion, 2016).

Quantifying fiscal spillover effects

As discussed above, from a theoretical point of view, the case for coordination rests on the existence of fiscal policy spillovers on cross-border output together with some type of market imperfections. In reality, it is crucial to identify the nature, the sign and the magnitude of the crossborder spillover associated with fiscal policy, paying attention to the state of the economy and the underlying market frictions. However, quantifying cross-border spillovers in a robust fashion remains a key practical challenge and existing studies do not provide an unambiguous answer on the matter. This section aims at breaking down the literature into its relevant pieces in order to identify cases in which spillovers are sizeable or not (for a much larger survey on the non-GVAR literature see Alcidi, Määttänen and Thirion, 2016).

In't Veld (2016) describes model simulations that broadly confirm the view that at the current juncture, with monetary policy constrained by the zero interest rate floor, a *debt-financed increase in government investment* in surplus countries will have *positive GDP spillovers* to the rest of the Euro area. If monetary policy cannot be accommodating, GDP spillovers may be small, but when policy rates are held constant for two years, spillovers can be significant. An increase in (productive) spending in Germany and the Netherlands can boost GDP in these countries and also have significant positive spillovers on the rest of EA GDP, while the effects on current accounts are likely to be small. Effects can be even larger when investment is directed to the most productive projects. With low borrowing cost at present, the increase in government debt for surplus countries will be modest, while there could be an improvement in debt ratios in the rest of the Euro area. Similar results are derived by Bundesbank (2016).

Given the backdrop of pressing infrastructure needs, Elekdag and Muir (2014) argue that higher German public investment would not only stimulate domestic demand in the near term and reduce the current account surplus but would also raise output over the longer-run as well as generate *beneficial regional spillovers*. While time-to-build delays can weaken the impact of the stimulus in the short-run, the expansionary effects of higher public investment are substantially strengthened through an accommodative monetary policy stance - as is typical during periods of economic slack. The current low-interest rate environment presents a window of opportunity to finance higher public investment at historically favorable rates.

The studies by In't Veld (2016), Elekdag and Muir (2014) and Bundesbank (2016) share one common implication: Spillover effects of public investment expenditure in surplus countries

are negligible as far as monetary policy reaction is rule-based. If the monetary policy stance before the fiscal stimulus was appropriate, the new situation would necessitate an increase in the policy rates (or a less intensive use of unconventional monetary policy measures) (Bundesbank, 2016).

In their seminal study, Weyerstrass et al. (2006) assess the nature of economic interdependence under European Economic and Monetary Union. Its main contribution is to provide plausible estimates of the sign and size of economic *spillover from budgetary consolidation* and/or structural reforms in a large Member State or in the EMU as a whole. A combination of empirical methods is employed in this study. Vector autoregression analysis is used to explore the interplay between government borrowing, public debt and short- and long-term interest rates. Panel data techniques are applied to investigate the link between structural reform and economic performance. Structural models are used to estimate the *cross-country spillover from budgetary consolidation* and structural reforms and the interaction between these policies (Weyerstrass et al., 2006).

Their analysis of short-run budgetary spillover in the aggregate Euro area suggests that a reduction in the budget deficit results in a small but positive effect on output. This result suggests the prevalence of *positive non-Keynesian effects of fiscal consolidation* (a result which we will not be able to corroborate in section 4). Crowding in effects and positive supply-side effects from fiscal consolidations are the most intuitive explanations for this finding. A fiscal consolidation in the Euro area only *weakly affects short-term interest rates and inflation* (a result which we will come up with in section 4 as well, at least with regard to inflation). The disaggregated analysis reveals that in most cases there are significant positive direct output and inflation spillover effects from the rest of the Euro area. Moreover, Member States display substantial differences in the spillover from fiscal consolidations in the Euro area (as confirmed by our results for the effect of a "global" shock in section 4 later on). These differences can be explained by diverging trade links, the size of the economies, and initial fiscal conditions (Weyerstrass et al., 2006).

The analysis of long-term budgetary spillover in the Euro area finds that, with the exception of highly indebted countries, rising government debt in one Member State has a weak impact on long-term interest rates. Aggregate Euro area responses, on the contrary, are stronger than for the individual Member States. This means that rising debt levels in the Euro area as a whole will "crowd out" private investment through higher long-term interest rates. This provides a strong argument for economic policy coordination in the Euro area since a coordinated budgetary consolidation by the Member States will yield lower long-term interest rates (Weyerstrass et al., 2006).

Taking the Weyerstrass et al. (2006) study as a starting point, we now turn to the results of further empirical studies which try to quantify fiscal spillover effects.

Fiscal spillovers: evidence from Global VARs

The GVAR (Pesaran et al., 2004, Dees et al., 2007) was developed for the purpose of capturing spillovers in multi-country analyses, where a particular structure on the strength of interdependencies is imposed. Each country-specific VAR is augmented with a foreign factor, calculated as a weighted average of foreign variables according to economic or financial bilateral links. The GVAR is a large constrained VAR, where restrictions arise as a result of the weights imposed on foreign variables, as well as from the exogeneity of each foreign factor with respect to the long-run parameters of the corresponding domestic VAR (Bicu and Lieb, 2015). Since the GVAR is designed to be used in applications with a large cross-sectional dimension, these

exogeneity assumptions can be interpreted as no long-run feedback from any individual country (except the dominant unit) to the dynamics of the foreign factor.

While the GVAR has some appealing features, a series of concerns have been raised regarding the factorisation of the joint density for the domestic and foreign variables (see Ericsson, 2011). Furthermore, imposing weak exogeneity restrictions and estimating each country-specific VAR independently may not be justified for our empirical analysis, given that we include a small number of countries that are strongly interconnected. The implications of the underlying restrictions for the dynamics of the system and for the transmission of shocks across countries are difficult to assess (Bicu and Lieb, 2015).

Although the model is based on the restrictive assumption that foreign variables are weak exogenous in the long-run, this assumption can be tested in order to assess whether the assumption is justified. Despite its restrictions, we believe that the GVAR approach delivers an adequate solution to cope with the curse of dimensionality which is always present if dynamics within and across a large number of countries are examined.

So far, papers using GVAR for studying spillovers of national fiscal shocks and of coordinated fiscal policies are still *scarce*. Hebous and Zimmermann (2013), Ricci-Risquete and Ramajo-Hernández (2014) and Dragomirescu-Gaina and Philippas (2015), Caporale and Girardi (2011), Nickel and Vansteenkiste (2013) and Georgiadis and Hollmayr (2016) employ GVAR approaches with rich model specifications in order to analyse spillovers stemming from shocking Euro area fiscal variables. They conclude by underlying the need for fiscal coordination due to greater economic consequences of an area-wide fiscal shock compared to country-specific shocks.

Hebous and Zimmermann (2013) estimate spillover effects of a fiscal shock in one member country in the Euro area on the output of the remaining members, employing the Global Vector Autoregression (GVAR) model of Dees, di Mauro, Pesaran, and Smith (2007) and Pesaran, Schuermann and Weiner (2004). Closely following the seminal GVAR paper by Dees et al. (2007), they compare the impacts of a *domestic* fiscal shock with those of a similar size[5] *area-wide* shock expressed as a weighted average of the fiscal shocks across all member countries. This is exactly the way in which we also specify fiscal policy shocks in section 4. According to their estimates, the impact of a Euro area-wide fiscal shock on output of a member country turns out to be positive and larger than the spillover of a domestic fiscal shock. In a nutshell, their policy conclusions run as follows. If each Euro area member country contributes to the Euro area-wide shock in accordance with the size of this country, this is less costly from the perspective of a Euro area member country and also more effective or at least not less effective than a domestic fiscal shock. This indicates the importance of coordinated fiscal actions. Seen on the whole, thus, the results by Hebous and Zimmermann (2013) indicate there are considerable differences in countries' reactions to fiscal actions depending on whether these are internationally coordinated or not.

Ricci-Risquete and Ramajo-Hernández (2014) empirically assess the economic consequences of shocks to fiscal variables in the EU countries from the domestic and global perspective. For this purpose, they specify and estimate a GVAR for 14 countries of the former EU15 and the United States, employing quarterly macroeconomic, monetary and fiscal data from 1978 to 2009. Unlike other GVAR models with fiscal variables, they consider total public receipts and total public expenditure separately – a way of modelling which we also apply in our study (in addition to including the government balance as Hebous and Zimmermann, 2012, 2013, do). What is more, they model not only the Euro area economies but, beyond that, all countries of

[5] This implies that the simulated area-wide fiscal shock does not correspond to a Euro area-wide fiscal shock which consists of shocking each country-specific fiscal variable with one standard deviation.

the former EU15 (except Luxembourg) and the United States. However, in our study we even reach beyond Ricci-Risquete and Ramajo-Hernández (2014) and include European countries which are neither members of the EMU nor the EU ("Rest of Europe"). The simulation results of Ricci-Risquete and Ramajo-Hernández (2014) reveal that the responses of real GDP to a negative (positive) domestic/global shock to total public expenditure (total public receipts) are negative (positive) for the countries under investigation. The impacts of domestic fiscal shocks are larger in the country of origin of the fiscal shock, whereas their spillover effects are limited (contrary to the majority of our results). This is something we will visualise in section 4 based on so-called heatmaps. The impacts of global shocks show a significant degree of similarity in, as the authors express it, "the cyclical behaviour of the European economies". As policy recommendations, they suggest "boosting the slow process of coordination of fiscal actions in the EU in order to avoid unwanted economic consequences".

Dragomirescu-Gaina and Philippas (2015) estimate a global vector autoregressive (global VAR or GVAR) model in the spirit of Dees et al. (2007) and draw policy implications based on impulse response functions and variance decomposition methods. They take advantage of a particular feature of the GVAR modelling framework that allows us to distinguish whether the dynamics of the public sectors in Europe is subject or not to some common unobserved factors, which might stem from elements not included in the model or not identifiable in the available data (e.g. policy compromises, consensus reached in Brussels etc.). This type of identification differentiates their paper from other studies employing similar empirical methodologies or addressing related topics.

An innovative study, although not published yet and only available by presentation slides, is Georgiadis and Hollmayr (2016). They estimate a Mixed-Cross-Section Global VAR (MCS-GVAR) to quantify "of all fiscal spillovers within the Euro area" for the time period 1999Q1 to 2009Q4. Different from our study, their empirical GVAR model includes an additional panel component (as a, as we think, promising avenue for further research in the area of GVAR-modelling of fiscal spillovers). The included variables are: GDP, inflation (CPI), government spending, short-term interest rates, the oil price, the real exchange rate. The countries they include are: Austria, Belgium, Finland, France, Germany, Ireland, Italy, Netherlands, Portugal, Spain (and 46 countries outside of Euro Area). According to their results, spillovers are heterogeneous and rather small (eg. from Germany). Openness and higher order spillovers are main determinants for spillovers. The fiscal position and the current account of the receiving country play a role, too. However, the authors are faced with the following restrictions: there are no non-linearities, there is no crisis-period, and there are not more endogenous country variables in the GVAR possible.[6]

The following studies are less close to ours, because the still use GVAR models to model fiscal spillovers but do not look at spillovers of changes in the government budgets. Instead, they look at the international linkages government bond yields and somewhat indirectly draw some conclusions regarding the necessity of fiscal policy coordination in the Euro area or Europe in general.

Caporale and Girardi (2011) empirically assess the dynamic impacts of fiscal imbalances in a specific EMU member state on the borrowing costs of its partner countries. They estimate a Global VAR employing quarterly data for the EMU period. The results suggest that euro-denominated government yields are strongly correlated with each other. But financial markets turn out to be capable of discriminating among different issuers. The authors conclude that fiscal imbalances in Italy and in other economies in the Euro area periphery should thus be closely monitored by their EMU counterparts and the European institutions.

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[6] Georgiadis and Hollmayr (2016) is discussed by Bankowski (2016).

A related study by Nickel and Vansteenkiste (2013), whose focus is broader than the European focus of the other studies sketched above, investigates the international spillover effects of fiscal shocks. The authors investigate the effect of fiscal spending shocks on financial variables such as equity prices, government bond yields and corporate bond yields. For this purpose, they utilise the GVAR) methodology for 8 countries, employing quarterly data for the sample period 1980Q1-2008Q4. According to their empirical results, fiscal shocks induce significant domestic and international spillover effects on financial variables. For instance, a shock to government consumption in a large country with risk-free government bonds leads to an increase in equity prices and government bond yields on the domestically and the international level. On the contrary, in case of peripheral countries, a shock to government consumption causes an increase in domestic government bond yields, while it lowers yields in large neighboring countries with risk-free government bonds. Equity prices in peripheral countries decline when fiscal spending increases. Finally, a shock to government bond yields spills over to the domestic and international corporate bond markets, especially if the shock is originating in a large country.

A somewhat more indirect approach is taken by Canova (2013). He develops an extension to existing GVAR models to capture time-varying interdependence between financial variables related to fiscal policy. He measures fiscal spillovers by modelling the time-varying pattern of co-movements among spreads. His starting point is that government bond spreads in the Euro area reveal a time-varying pattern of co-movement which represents a serious challenge for econometric modelling and forecasting. As expressed by the author: "(t)his pattern of the data is not captured by the standard specification that model spreads as persistent processes reverting to a time-varying mean determined by two factors: a local factor, driven by fiscal fundamentals and growth, and a global world factor, driven by the market's appetite for risk. This paper argues that a third factor, expectations of exchange rate devaluation, gained traction during the crises. This factor is well captured via an estimated GVAR which models the interdependence among spreads by making each country's spread function of global European spreads. Global spreads capture the exposure of each country's spread to other spreads in the Euro area in terms of the time-varying 'distance' between their fiscal fundamentals." Interestingly enough, the new specification developed in this paper dominates the standard one in modelling the time-varying pattern of co-movements among spreads and the response of Euro area spreads to the Greek debt crisis.

2.2.2 Magnitude and time profile of fiscal spillovers

The size and the sign of intra-EMU spillovers of fiscal policies cannot be accurately determined since they are susceptible to a considerable number of *uncertainties* (Caporale and Girardi, 2011). First, the results of theoretical considerations do not provide a firm indication of the extent of spillovers. The trade linkages, which are a channel of positive transmission of increased government spending across the borders, are counteracted by the functioning of capital market linkages that incorporate an influence of the Euro area-wide interest rate and common currency exchange rate. As a result, the two effects usually work in *opposite directions* which diminish the absolute size of the spillovers and creates uncertainty regarding the sign of the eventual effect (Caporale and Girardi, 2011, Gros and Hobza, 2001).

Second, many *particular circumstances* pertaining to the fiscal expansion will have an impact on the direction and magnitude of spillover effects. As Laxton et al. (1998) argue "there is no such thing as a pure fiscal shock". The short-run impacct of fiscal policies are strongly influenced by the stance of *monetary policy* followed by the central bank (which is commonly only indirectly modelled in the standard GVAR through its impact on the long-term interest rate) by the particular way in which the fiscal policy is conducted and also by the mode in which it is financed.

Third, one could argue, that *under EMU the spillovers would grow stronger* as the interactions between countries become more intensive (see above). For example, it is often expected that the role of intra-EMU trade will further increase as a consequence of declining of contract costs (Belke and Gros, 1999). However, it is difficult to assess whether the change will be significant enough to override the impact of interest rate movements. In the case of fiscal expansion, which takes place through government spending, the increase in the intensity of trade links may reduce the negative impact of higher interest rates and thus even reduce the absolute size of the spillover effects. This indicates that the size of spillovers may even decline (Gros and Hobza, 2001).

The fourth type of uncertainty arises from the *structure of the models* themselves which will necessarily influence the results of estimates. As shown, the results of simulations vary significantly which can be attributed to different preferences that the modellers had when building the models. The most obvious difference can be spotted in the case of the Marmotte model (run by CEPII, Paris), which lacks short-term Keynesian dynamics. This leads to inefficiency of domestic fiscal policy and a different pattern of spillovers compared to the other models (Gros and Hobza, 2001).

Nevertheless, we will give it a try in spite of these uncertainties, without forgetting about important lessons from an *early* literature survey. The considerable variability of simulation results between the models relating to the size and, at times, also the sign of spillovers makes it impossible to determine the real impact of economic policies undertaken in one country on the economic variables of the others. This makes the coordination very complicated if not unfeasible as the policy-makers do not know the 'true' model according to which they could coordinate their economic policies. As some studies indicate (Mooslechner and Schuerz, 1999) a bad choice of the model can even have welfare-decreasing consequences. Moreover, the currently used models are calibrated with the use of historical data for the last couple of decades. If some structural characteristics of economies change as a result of the functioning of the monetary union, the outcomes of the model simulations may be considerably different from the reality (Gros and Hobza, 2001).

A large number of economic studies are concerned with the impact of the exchange rate regime on the cross-border externalities. A simple comparison of the spillover effects under the predecessor of the monetary union – the EMS – may be useful in the discussion regarding the need for economic policy coordination in EMU as it indicates that the spillovers might, in fact, be lower under EMU than they used to be under the system of fixed exchange rates (Gros and Hobza, 2001).

The recent empirical results of large-scale macro-econometric models *do not seem to provide conclusive evidence* concerning the nature of the cross-border spillovers of fiscal policies in EMU. In general, their absolute size is indeed rather small. However, when one disaggregates the average figures, an extremely colourful picture appears. The absolute size of spillovers varies widely among countries. And so does their sign. Therefore, it seems improbable that the EMU members would take up the cross-border externalities as a serious argument for the further development of fiscal policy coordination. It is also unlikely that the countries could agree on a concrete mechanism that would be advantageous for all (Gros and Hobza, 2001).

In the following, we check whether a full-fledged GVAR model is delivering a somewhat clearer picture on the quantitative importance of fiscal spillovers in Europe.

3. Data and empirical approach

3.1 Variables and data sources

We define fiscal spillover as an influence of fiscal policy measures undertaken in an individual country (source country) on another (recipient country) country. By fiscal policy, we mean government policies that influence aggregate economic outcomes - in particular private borrowing and savings, consumption, labour supply and investment - via taxes or government spending (Alcidi, Määttänen and Thirion, 2016).

A key feature of our GVAR model is the calculation of foreign variables for each country in the sample using a weighting matrix which captures international linkages across the countries in the sample. Like most existing studies we use trade data to calculate this matrix. It can of course not be excluded that the used variables are not appropriate proxies for the respective channels of fiscal policy transmission (Gros and Hobza, 2001). It seems that the QUEST model gives priority to the trade flows, whereas in the NiGEM capital markets play a more important role (Gros and Hobza, 2001).

As a measure of economic activity, we closely follow the common approach in the fiscal spillover GVAR literature to use GDP in constant prices. In this regard, we primarily use quarterly and seasonally adjusted data from the IMF IFS database[7]. Data is available for the following countries: Australia, Canada, France, Germany, Netherlands, Spain, the UK and the US. We complement our sample with OECD[8] data for the following countries: Austria, Belgium, Czech Republic, Denmark, Finland, Greece, Hungary, Italy, Norway, Poland, Portugal, and Sweden. For China and Ireland, we use seasonally adjusted data published by Oxford Economics[9].

As a measure of price developments, we use the GDP deflator. For the following countries, we use seasonally adjusted data from the IMF IFS database[10]: Australia, Canada, France, Germany, Italy, Japan, the Netherlands, Spain, Switzerland, the UK and the US. Because seasonally adjusted data is not available for all countries under observation, we use data from the OECD[11] for the remaining countries expect China. For China, we have to use the Consumer Price Index published by the OECD which we adjusted seasonally by using the X-12 procedure illustrated by Smith and Galesi (2014).

The 10-year interest yield is employed as a variable measuring the costs of fiscal lending as well as a monetary variable in our framework. Corresponding data is obtained from Thomson Reuters Datastream. Due to limited availability, 10-year interest rates for China, Czech Republic, Hungary, and Poland are not included.

As fiscal variables, we use nominal *fiscal expenditure* and *fiscal revenue* as percent of nominal GDP as a percentage of nominal GDP. Both variables are obtained from Oxford Economics. With respect to seasonality, we find evidence for the time series of the Czech Republic, Germany, Hungary, the Netherlands, Portugal, Switzerland, the UK and the US. Again, the procedure by Smith and Galesi (2014) is used to eliminate seasonal effects from the time series. Additionally, we use the cyclically adjusted government primary balance, as a percentage of potential GDP. The variable is obtained from OECD economic database.[12] Because only annual data is available for this variable, cubic spline interpolation is used to obtain quarterly data.

[7] Concept: GDP, real index, quarterly, seasonally adjusted, base year (2010=100).
[8] Concept: GDP, VIXOBSA, Volume Index, OECD reference year (=2010), seasonally adjusted.
[9] Datastream code: China: CHXGDSA.D, Ireland: IRXGDPR.D.
[10] Concept: GDP, Deflator, Seasonally adjusted, Index.
[11] Concept: DOBSA, Deflator, OECD reference year (=2010), seasonally adjusted.
[12] Variable code: NLGXQA.

Additionally, we include nominal and real effective exchange rate indices published by the Bank of international Settlements (BIS) in our basic specifications. According to the BIS, the (broad) indices comprise of 61 countries and are calculated as geometric weighted averages of the bilateral exchange rate. In the case of real indices, the nominal indices are adjusted by relative consumer prices.

Regarding transformations of the variables, we follow Dees et al. (2007) and take all variables except the interest rate and the fiscal variables as a percentage of GDP in logarithms. Whereas we do not transform the latter, we transform the (annualized) interest rate measure into quarterly measures following the procedure of Smith and Galesi (2014).

In order to build country-specific foreign variables, we need data to construct bilateral weights. We use trade data published by the IMF Direction of Trade Statistics database. For the aggregation of the country-specific VAR, we use the average of national GDP in purchasing power parity terms in current international dollars between 2009 and 2012. The corresponding data is published by the World Bank[13].

Our estimation period ranges from 1995Q1 to 2015Q4. We do not include earlier observations in order to avoid the modelling of too many structural breaks (due to German reunification etc.). The countries contained in our analysis are: Austria, Australia, Belgium, Canada, China, the Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, the Netherlands, Norway, Poland, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the (weakly exogenous) United States.[14] These countries were carefully selected: according to the latest statistics, in 2015, they accounted for roughly 45% of global GDP measured in purchasing power parity (PPP) terms. We did not take into account further economies that belong to the EU27 because data availability is limited to a short period, or statistical quality does not comply with required standards.[15]

3.2 The global vector autoregressive (GVAR) framework

In order to determine international spillover of national fiscal policy, we use the GVAR framework as presented by Dees, di Mauro, Pesaran, and Smith (2007) and Pesaran, Schuermann, and Weiner (2004). The model combines the estimation of country-specific VECM models which include national as well as foreign variables. Due to the curse of dimensionality and the face that GVARs can include a large number of countries, it is not possible to include every single foreign variable into every country-specific VECM model. Therefore, foreign "star" variables are individually generated for every country-specific VECM model as weighted averages of the other country's variables. Furthermore, the GVAR allows to include global variables as well as deterministic components.[16]

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[13] Concept: NY.GDP.MKTP.PP.CD.

[14] For the Czech Republic, Poland and Hungary interest rates are available not earlier than from 1997 on. And for Greece, the interest time series is not directly interpretable in the "programme" period and sometimes even before for obvious reasons. Hence, we include these countries without the interest rate as it is common practice in GVAR modelling exercises. See Smith and Galesi (2014).

[15] It would have been also interesting to look at the impact of the formal EMU entry of the Baltics and Slovenia on the magnitude, the sign and the time profile of fiscal spillovers. However, this would have increased the calculation effort, whereas these countries are at the same time economically nearly insignificant in the GVAR context.

[16] See Dees et al. (2007) for a more comprehensive derivation of the GVAR model. For a variety of concise derivations in the context of fiscal spillovers see Dragomirescu-Gaina and Philippas (2015), pp. 52-55, Caporale and Girardi (2011), pp. 4-8, Nickel and Vansteenkiste (2011), Niehof (2014), pp. 6-10, Koukouritakis, Papadopoulos and Yannopoulos (2015), pp. 3-5, Ricci-Risquete and Ramajo-Hernández (2014), pp. 1593-1595, Hebous and Zimmermann (2012), pp. 5-6 including the interpretation of fiscal shocks in Hebous and Zimmermann (2012), pp. 6-8.

Following Dees et al. (2007), we assume that our model includes $N + 1$ countries which are indexed by $i = 0,1,2, \dots, N$. Setting the lag order for domestic and foreign variables to two, we obtain the VARX* (2,2) model:

$$x_{it} = a_{io} + a_{i1}t + \Theta_{i1}x_{i,t-1} + \Theta_{i2}x_{i,t-2} + \Lambda_{i0}x_{it}^{*} + \Lambda_{i1}x_{it-1}^{*} + \Lambda_{i2}x_{it-2}^{*} + u_{it} \qquad (1)$$

where x_{it}: k_i x 1 vector of domestic variables; Θ_{il}: $k_i \; x \; k_i$ matrix of lagged coefficients x_{it}^{*}: k_i^{*} x 1 vector of foreign variables; Λ_{il}: $k_i \; x \; k_i^{*}$ matrix of coefficients associated with the foreign variables; u_{it}: $k_i \; x \; 1$ vector of idiosyncratic shocks; $x_{it}^{*} = \sum_{j=0}^{N} w_{ij} \, x_{jt}$; $w_{ii} = 0$.

As shown above, the country-specific foreign variables are based on weights which are supposed to reflect the relative importance of economic developments in country j for country i.

The VARX*(2,2) can be written in its error correction form (VECMX*(2,2)) as follows:

$$\Delta x_{it} = c_{i0} + \delta_i ECM_{i,t-1} + \Lambda_{i0}\Delta x_{it}^{*} + \Lambda_{i1}\Delta x_{it-1}^{*} + u_{it} \qquad (2)$$

Where $z_{it} = (x_{it}, x_{it}^{*})'$ and $ECM_{i,t-1}$ representing the error correction terms corresponding to the r_i cointegration relationships of the i^{th} country model. The framework allows for the possibility of cointegration both within x_{it} and between x_{it} and x_{it}^{*}, and consequently across x_{it} and x_{jt} for $i \neq j$.

Regarding the estimation of the country-specific VARX* models, the main assumption is the weak exogeneity of x_{it}^{*} with respect to the model's long-run properties presented above. As depicted by Dees et al. (2007), x_{it}^{*} assumed to be „long-run forcing" for x_{it} implying that the error correction terms of the country-specific VECMX* models do not significantly enter the models of x_{it}^{*}. This aspect is closely connected to the assumption that the idiosyncratic shocks of the country-specific models should only be weakly correlated cross-sectionally. Therefore, it is assumed that $Cov(x_{it}^{*}, u_{it}) \rightarrow 0 \; with \; N \rightarrow \infty$. We follow the approach of Dees et al. (2005) to test the assumption of weak exogeneity of the foreign variables by 1) testing the joint significance of the estimated error correction terms in auxiliary equations for the country-specific foreign variables x_{it}^{*} and 2) by examining the average pairwise cross-section correlations between VECMX* residuals and the domestic variables of the other countries. Economically, the weak exogeneity assumption is closely linked assumption that all countries are small relative to size of the whole group of countries and therefore the world.

Once the individual country models are estimated separately, which is possible because of the weak exogeneity assumption discussed above, the GVAR model is solved simultaneously. After the estimation of the VECMX* models, the cointegration rank is obtained and the corresponding VARX* models are recovered. Based on the VARX*(p_i, q_i) model and assuming that $p_i = q_i$ for reasons of simplicity:

$$A_{i0}z_{it} = a_{i0} + a_{i1}t + A_{i1}z_{it-1} + \cdots + A_{ip}z_{it-p} \qquad (3)$$

Where $z_{it} = (x_{it}, x_{it}^{*})'$; $A_{i0} = (I_{ki}, -\Lambda_{i0})$ and $A_{ij} = \left(\Theta_{ij}, A_{ij}\right)$ for $j = 1, \dots, p_i$

Using the matrix containing the weights w_{ij} for the construction of the country-specific foreign variables (also called "link matrix") W_i, we obtain:

$$z_{it} = W_i x_t \qquad (4)$$

Where $x_t = (x_{0t}', x_{1t}', \dots, x_{Nt}')'$ contains all endogenous variables of the entire system and W_i is a $(k_i \; x \; k_i^{*}) * k$ matrix and $k = \sum_{i=0}^{N} k_i$.

In this regard, the link matrix allows the country-specific models to be written in terms of the global variable vector x_t. After inserting the new expression for z_{it}, the individual models are stacked to obtain the model for x_t:

$$G_0 x_t = a_o + a_1 t + G_1 x_{t-1} + \cdots + G_p x_{t-p} + u_t \tag{5}$$

where $G_0 = (A_{00}W_0, A_{10}W_1, \dots, A_{N0}W_N)'$; $G_j = \left(A_{0j}W_0, A_{1j}W_1, \dots, A_{Nj}W_N\right)'$ for $j = 1, \dots, p$ $a_0 = (a_{00}, a_{10}, \dots, a_{N0})'$; $a_1 = (a_{01}, a_{11}, \dots, a_{N1})'$; $u_t = (a_{00}, a_{10}, \dots, a_{N0})'$ and $p = \max(\max p_i, \max q_i)$.

Because all variables are now combined in one system, we can analyse the effects of a shock to a domestic variable in country i on other domestic variables as well as domestic variables of other countries. After multiplying the equation by G_o^{-1} whose elements contain only the known link matrices and the estimated parameters of the country-by-country estimations, we obtain the GVAR(p) model:

$$x_t = b_0 + b_1 t + F_1 x_{t-1} + \cdots + F_p x_{t-p} + e_t, \tag{6}$$

where $b_0 = G_o^{-1}a_0, b_1 = G_0^{-1}a_1, F_j = G_0^{-1}, j = 1, \dots, p$; $e_t = G_0^{-1}u_t$.

As pointed out by Nickel and Vansteenkiste (2013), the GVAR models *interactions among the economies via three interrelated channels*, thereby allowing for a sufficient degree of interlinkages between the countries under observation to model the effect of national and regional shocks on the global economy:

1) Contemporaneous effects of x_{it}^* on x_{it}
2) Dependencies of x_{it} on the lagged values of x_{it}^*
3) Contemporaneous cross-country dependencies between the error terms

In order to analyse the international dynamics and economic relationships, we focus on impulse responses which summarize the dynamics of all endogenous variables following a shock to a specific variable. There is an unfinished debate on the identification of a structural fiscal shock which captures only discretionary fiscal actions (Perotti, 2007). But with regard to cross-border externalities, fiscal spillovers stemming from a budget deficit in one country would occur anyway, i.e. whether the cause is only discretion or a combination of discretion, automatic responses, and other effects. Therefore, we stick to identifying generalised impulse response functions. These impulse responses, though broadly interpretable, are informative and capture overall spillover effects (Hebous and Zimmermann, 2013)

In this study, we thus use generalised impulse response functions (GIRF) as used by the large majority of GVAR studies (see, for instance, Dees et al., 2007). According to the difficulties of formalizing an identification structure, GIRFs do not need an ordering of the variables and countries as it is invariant to the ordering. However, one needs to be cautious when interpreting the effect of shocks using GIRFs as they allow for correlation of the error terms. The GIRF represent the impact of a one-standard-error shock at time t to the l^{th} equation of the GVAR representation on the j^{th} variable at time $t + n$. The GIRF is computed as follows:

$$GIRF(x_t; u_{lt}; n) = \frac{б_j' A_n G_0^{-1} \Sigma_u б_l}{\sqrt{б_j' \Sigma_u б_l}}, n = 0,1,2, \dots; l, j = 1,2, \dots, k \tag{7}$$

where $б_l$ is a selection vector with unity as the l^{th} equation in the case of the country-specific shock indicating which equations is supposed to be shocked.

Regarding the aggregation, the GVAR distinguishes between the domestic, regional and the global level. In the GVAR framework, regions can be constructed which contain several countries while the global level contains every country in the model. Regarding our research topic, this feature allows us to analyse how regional shocks affect individual countries as well as other regions and also how a region is affected by domestic, regional and global shocks. In this regard, a regional shock equals a domestic shock in every country which is part of that region, weighted by its share of the total regional PPP-GDP.

3.3 Shocks considered

In section 4, we estimate a GVAR model for 20 countries, among them 16 European, 14 EU and 11 EMU member countries, and Canada, Japan, Australia and the (weakly exogenous) United States in the spirit of Ricci-Risquete and Ramajo-Hernández (2014), using macroeconomic, monetary and fiscal data from 1995Q1 to 2015Q4.

Our study contributes to the literature by several ways. Firstly, as already mentioned in section 2, papers using GVAR for studying coordinated fiscal policies are still scarce. We have mentioned in section 2 that there are only three studies available in the field which are directly comparable to ours. Secondly, unlike other GVAR models with fiscal variables, we do not primarily consider a synthetic indicator of the stance of public finances, as the public budget balance in Hebous and Zimmermann (2013). Instead, we are shocking total government expenditure and total government revenue separately. Thirdly, we model not merely the Euro area economies, but also member countries of the EU which are not EMU members and EFTA members and the "rest of the world" like Australia, China, Japan and the (weakly exogenous) the United States. Hence, we are - in contrast to the prevailing fiscal spillover literature - able to differentiate between fiscal spillovers to European countries within the EMU and to the "Rest of Europe". Fourthly, we present results of the simulations concerning the effects of shocks to total government revenue and total government expenditure in both the country of origin of the shock and its trading partners (as, up to now, only Ricci-Risquete and Ramajo-Hernández, 2014 did in the context of the GVAR methodology). The importance of jointly model both public revenue and public expenditure has often been discussed in the literature and is straightforward (Blanchard and Perotti, 2002).[17]

What kind of shocks to we investigate in the following? We are shocking a single country's fiscal policies (Germany, France) and, secondly, investigate so-called "global" fiscal policy shocks.

To be more specific, we employ the GIRFs in order to analyze the dynamic effects of the following simulations *on a group of countries*: (1) a one standard error negative shock to German total public expenditure, (2) a one standard error negative shock to French total public expenditure, (3) a one standard error positive shock to German total public revenue, (4) a one standard error positive shock to French total public revenue, (5) a one standard error negative "global" shock to total public expenditure and (6) a one standard error positive "global" shock to total public revenue. Since each economy is potentially related to the others, these simulations will determine the degree of international spillovers.

What does „on a group of countries" mean in this context?

(1) Fiscal shock "Change in Government Expenditure" in Germany, effects on EA (except Germany) and on remaining Europe.

[17] Blanchard and Perotti (2002): "Both government expenditure and taxation affect GDP: since the two are presumably not independent, to estimate the effects of one, it is also necessary to include the other. Hence, we focus on two-variable breakdowns of the budget, consisting of an expenditure and a revenue variable."

(2) Fiscal shock "Change in Government Revenue" in Germany, effects on EA (except Germany) and on remaining Europe
(3) Fiscal shock "Change in Government Expenditure" in France, effects on EA (except France) and on remaining Europe
(4) Fiscal shock "Change in Government Revenue" in France, effects on EA (except France) and on remaining Europe.

We thus estimate the effects of a shock to one-country total government expenditure or revenue in real terms *on a group of relevant economies*.

In view of the significant level of integration among the European countries, it appears useful to us to also analyse the *impact of a "global" shock* (see cases (5) and (6) above). Its origin is not focused on a particular economy, but can simultaneously occur in every country of a predefined region or every country of the entire sample. As pointed out by Dees et al. (2007), a "global" shock can be defined as a weighted average of a shock to the same variable for all investigated countries, using as weights some indicator that reflects their relative importance in the world economy as a whole (in our case, GDP in purchasing power parity terms).[18] In other words, a "global" shock can be understood as a disturbance with a magnitude similar to that of a domestic shock, to which each country contributes a percentage based on the size of its economy (Hebous and Zimmermann, 2013). Or expressed differently: "For a regional shock say to equity, eq has PPP-GDP weights that sum to one corresponding to the equity shocks of each of the countries that belong to the selected region, and zeros elsewhere." (Smith and Galesi, 2014).

A central focus of our analysis is on impulse responses following a Euro area-wide budget deficit or surplus ("austerity", "fiscal compact"). This area-wide shock (the "global shock") is recovered as a weighted average of the variable-specific shocks across all countries (Hebous and Zimmermann, 2013). The weights in the area-wide shock are calculated as the ratio of the GDP of a member country to the total GDP of the Euro area.

Assessing "global" shocks is legitimate in countries where public sector balances are characterized by co-movement with other countries (e.g. due to policy compromises reached in Brussels or policy reactions to a global shock) and thus a more integrated and possibly coordinated stance with respect to fiscal policies can be observed. However, the "global shock" is defined with respect to the European/EU/EMU region only, thus excluding the United States and other non-European countries (Dragomirescu-Gaina and Philippas, 2015)

Hebous and Zimmermann (2013) and Ricci-Risquete and Ramajo-Hernández (2014) argue that *area-wide fiscal shocks have larger economic consequences than domestic fiscal shocks* and thus motivate the need for better policy coordination. This is a pattern we also find in our estimations of fiscal spillovers in a GVAR model.

4. Empirical Results

4.1 Unit Root Tests

Although the GVAR methodology can be applied to stationary and/or integrated variables, here we follow PSW and assume that the variables included in the country-specific models are integrated of order one (or I(1)). This allows us to distinguish between short-run and long-run relations and interpret the long-run relations as cointegrating (Dees et al., 2007). Therefore, we

[18] See Dees et al. (2007), pp. 26ff., and Dees et al. (2010), pp. 17ff., for a detailed derivation of the "global" shock which we apply as a "regional" shock in our fiscal spillover GVAR..

begin by examining the integration properties of the individual series under consideration. In view of the widely accepted poor power performance of traditional Dickey–Fuller (DF) tests, we report unit root t-statistics based on weighted symmetric estimation of ADF type regressions introduced by Park and Fuller (1995).

Table 1. *Results of unit root tests*

Levels (Critical value at 5% level: -3,24)										
	Aus	Aust	Bel	Can	Den	Fin	Fra	Ger	Gre	Ire
rgdp	-2,011	-2,121	-1,389	-1,797	-1,604	-1,651	-1,822	-1,428	-1,863	-3,133
defl	-0,556	-2,510	-1,564	-2,399	-1,369	-1,965	-0,599	-1,213	-0,164	-2,076
Ltir	-1,438	-2,463	-2,117	-3,143	-2,595	-1,116	-2,131	-2,928	-1,603	-2,379
Exp		-3,000	-2,438		-1,564	-0,806	-1,822	-2,543	-2,751	-2,636
Rev		-2,124	-2,223		**-3,993**	-1,495	-2,235	-2,046	-1,925	-1,945
	Ita	Jap	Net	Nor	Por	Spa	Swe	Swi	UK	US
rgdp	-2,167	-1,401	-3,298	-1,964	-2,235	-1,821	-2,004	-2,591	-1,662	-2,269
defl	-0,879	-0,839	-0,399	-1,673	-1,543	1,044	-2,680	-1,605	-0,164	-0,636
Ltir	-2,009	-0,597	-2,656	-2,913	-2,572	-1,746	-1,926	-2,802	-2,619	**-3,623**
Exp	-1,171		-1,420	-2,550	-1,171	**-4,436**	-1,409	-1,139	-1,713	-1,085
Rev	-1,721		-3,109	-2,353	**-3,912**	-2,644	-2,507	-1,092	-3,212	-2,882
First Differences (Critical value at 5% level: -2,55)										
	Aus	Aust	Bel	Can	Den	Fin	Fra	Ger	Gre	Ire
Δrgdp	-3,280	-3,942	-5,186	-4,965	-5,086	-3,357	-3,866	-5,137	**-2,308**	-3,872
Δdefl	-3,753	-2,709	-4,711	-6,595	-7,060	-4,425	-2,960	-6,432	**-1,799**	**-1,715**
ΔLtir	-4,094	-6,679	-5,424	-3,951	-6,840	-3,789	-6,503	-7,175	-5,875	-4,954
Δexp		-5,195	-9,035		-4,123	-4,275	-4,277	-4,801	-10,538	-4,062
Δrev		-6,853	-4,606		-6,280	-4,621	-3,680	-10,189	-8,039	-7,704
	Ita	Jap	Net	Nor	Por	Spa	Swe	Swi	UK	US
Δrgdp	-3,664	-6,128	-4,011	**-2,453**	-3,669	**-2,327**	-4,945	-4,650	-4,461	-4,003
Δdefl	**-2,013**	-3,433	-6,227	-5,118	**-2,210**	-2,868	-2,825	-2,650	**-2,153**	-3,724
Δltir	**-2,456**	-5,330	-6,640	-5,156	-4,397	**-2,469**	-4,764	-5,364	-6,933	-5,093
Δexp	-3,928		**-2,457**	-4,553	-8,899	-5,022	-3,879	-4,695	-6,029	-2,604
Δrev	-5,925		-9,348	-7,289	-9,261	-8,218	-2,857	-3,808	-9,266	-5,202

Notes: For Unit Root Tests using data in levels numbers in bold indicate significance at the 5% level. Regarding Unit Root Tests using data in first difference, bold numbers indicate that the H0 is non-rejected at the 5% level. The selection of the optimal lag numbers is in each case based on the Akaike information criterion (AIC)

Regarding the order of integration, the GVAR can include variables which are I(0) and I(1). However, the inclusion of variables which contain a higher order of integration violates the assumption of the GVAR and might lead to severe bias. Our unit root test results presented in Table 1 indicate evidence of I(2) variables. With respect to the national real GDP variables (Rgdp), we find borderline evidence of I(2) variables for Greece, Norway and Spain. The corresponding test statistics are not significant at the 5%, but 10% level. Because it is not feasible to use first differences of rgdp for the countries mentioned and levels of rgdp for the remaining countries, we performed additional tests by performing the Phillips-Perron test which rejects the H0 for the three national variables at the 5% level. Keeping in mind that structural disturbances like the sharp decline in real GDP during the financial crisis in 2008 can influence the results of unit root tests towards a too high integration order, GDP is used in levels as we assume that all national variables are I(1).

For the GDP deflator (defl), we find even larger evidence of I(2) dynamics the domestic variables of Greece, Ireland, Italy, Portugal and the UK. Performing additional tests using the Phillips-Perron tests generates similar results. We follow Dees et al. (2005) and use the first difference of the price variable for every country in our sample. The GDP deflator in first differences equals its percentage change and therefore the inflation rate (Δdefl).

For the remaining interest rate variable (ltir) and the fiscal expenditure and revenue (exp, rev), we find very small evidence of I(2) variables. Therefore, the variables mentioned are included in levels.

4.2 Specification and estimation of the country-specific models

The specification of each country-specific VARX* and VECMX* model is based on an appropriate choice of the lag lengths for the domestic and foreign variables as well as the cointegration rank.

Due to data availability, we started the empirical analysis by setting a lag length of two for the endogenous variables (p_i) and one for the weakly exogenous variables (q_i). However, due to severe residual autocorrelation for some countries (especially in the European periphery) for these lag lengths, we increased the maximum to 4 respectively 2 lags. In Table 2, we present the lag length used in the estimation process which is based on the results of residual autocorrelation tests[19] and also on the Schwarz-Bayesian information criterion.

Table 2. *Lag lengths of the country-specific models*

	p_i	q_i		p_i	q_i
AUSTRALIA	2	1	ITALY	4	1
AUSTRIA	2	1	JAPAN	2	1
BELGIUM	2	1	NETHERLANDS	3	1
CANADA	3	1	NORWAY	3	1
DENMARK	3	1	PORTUGAL	2	1
FINLAND	2	2	SPAIN	2	1
FRANCE	3	2	SWEDEN	2	1
GERMANY	2	2	SWITZERLAND	1	1
GREECE	3	1	UNITED KINGDOM	2	1
IRELAND	2	1	UNITED STATES	3	1

Notes: p_i denotes the number of lags for the endogenous variables in the model of country i. q_i denotes the number of lags for the (assumed) weakly exogenous (foreign) variables.

Regarding the possibility of cointegrating relations, the rank for each country is chosen based on Johansen's trace and maximal eigenvalue statistics as set out in Pesaran, Shin and Smith (2000). Additionally, we use the eigenvalues and the persistence profiles (PPs) which refer to the time profiles of the effects of system or variable-specific shocks on the cointegrating relations in the GVAR model. Therefore, the PPs are used in order to observe the convergence behaviour of the assumed number of cointegrating relations in the country models.

[19] The F-version of the Lagrange Multiplier (LM) statistic is used.

Table 3. *Cointegration rank of the country-specific models*

	r_i		r_i
AUSTRALIA	1	ITALY	2
AUSTRIA	1	JAPAN	1
BELGIUM	1	NETHERLANDS	2
CANADA	1	NORWAY	0
DENMARK	1	PORTUGAL	2
FINLAND	2	SPAIN	1
FRANCE	2	SWEDEN	2
GERMANY	2	SWITZERLAND	2
GREECE	2	UNITED KINGDOM	2
IRELAND	1	UNITED STATES	1

Note: r_i denotes the cointegration rank in the model of country i.

As mentioned in section 3.2, the main assumption of the GVAR is the weak exogeneity of the country-specific foreign variables. In order to check this assumption, we followed Dees et al. (2005) and tested for weak exogeneity by running an axillary regression and observing average pairwise cross-section correlations. The auxiliary regressions examine the joint significance of the estimated error corrections terms for the country-specific foreign variables. The appropriate lag length is based on the empirical realisations of the Schwarz-Bayes criterion and the results of the residual autocorrelation tests.

Our results reveal a dominant role of the US economy in our model – especially with regard to the development of the interest rate variable. This does not come at a surprise because the US PPP-GDP share is about 40% of the sum of all countries in our model. Both tests indicate that the assumption of weak exogeneity of the foreign variables might be violated of the US model. Therefore, we exclude the foreign variables from the US model except for rgdp. Regarding rgdp, we find no evidence of a violation of the weak exogeneity assumption. For Germany, we find large evidence that the foreign RGDP variable is not weakly exogenous. Although Germany's weight is significantly smaller than that of the US, it might be more important for developments of RGDP because we focus almost entirely on European Countries. Therefore, we exclude the foreign variable of RGDP from the German model.[20]

In order to generate the following impulse response function, we simulated the model by using bootstrap procedures. We simulate the model for 2000 to obtain median estimates as well as the confidence intervals. Because of the large number of endogenous variables ($> T$) and data limitations of our sample, we performed shrinkage on the correlation matrix for point and bootstrap estimates as well as data generation.

4.3 Global VAR estimations

The basic GVAR model is subject to the critique that the shocks cannot be given a simple economic interpretation as demand, supply or monetary policy shocks (Smith, 2013).

[20] Detailed results of our tests of weak exogeneity are available on request.

4.3.1 Estimation of Generalised Impulse response functions

To study the dynamic properties of the global model and to assess the time profile of the effects of shocks to foreign variables on the euro area economy, we investigate the implications of six different external shocks: (1) a one standard error negative shock to German total public expenditure, (2) a one standard error negative shock to French total public expenditure, (3) a one standard error positive shock to German total public revenue, (4) a one standard error positive shock to French total public revenue, (5) a one standard error negative "regional" shock to total public expenditure and (6) a one standard error positive "regional" shock to total public revenue. Note that we treat with "regional" shocks here but that the fiscal spillover GVAR literature often speaks of "global" shocks in this context (Dragomirescu-Gaina and Philippas, 2015, Ricci-Risquete and Ramajo-Hernández, 2015, and Hebous and Zimmermann, 2013).

Specifically, we analyse the *effects of various shocks to fiscal variables* on the economic dynamics of the 15 Member States of the EU paying particular attention to the differences between countries which are a member of the euro area and those which are only part of the EU.

In the following, we make use of the Generalized Impulse Response Function (GIRF), proposed by Koop et al. (1996), and developed further in Pesaran and Shin (1998) for vector error-correcting models. The GIRF is an alternative to the Orthogonalized Impulse Responses (OIR) of Sims (1980). The OIR approach requires the impulse responses to be computed with respect to a set of orthogonalized shocks, while the GIR approach considers shocks to individual errors and integrates out the effects of the other shocks using the observed distribution of all the shocks without any orthogonalization. Unlike the OIR, the GIRF is invariant to the ordering of the variables and the countries in the GVAR model, which is clearly an important consideration. Even if a suitable ordering of the variables in a given country model can be arrived at from economic theory or general a priori reasoning, it is not clear how to order countries in the application of the OIR to the GVAR model (Dees et al., 2007).

Of course, there are some problems interpreting our results as an assessment of the macroeconomic effects of 'fiscal shocks' (Ricci-Risquete and Ramajo-Hernández, 2015). We recognize such a problem, but given the difficulties in identifying structural shocks in a GVAR model (sign-restriction or narrative identification schemes are not undisputed, and the number of exclusion restrictions and/or the ordering of the variables and the countries in the specification would entail many controversial assumptions.[21] Hence, we decided to summarize the dynamic of the macroeconomic variables in the system following a domestic or area-wide shock through GIRFs. These functions contain not only information about the effects of discretionary fiscal actions, but also information about automatic stabilizers and other effects. Anyway, the GIRFs are informative about the overall macroeconomic effects of the fiscal policy, showing the dynamics of the transmission of shocks in the fiscal variables of one country to itself and also to the other countries in the EMU/EU (Ricci-Risquete and Ramajo-Hernández, 2015).

In the absence of strong a priori beliefs on the ordering of the variables and/or countries in the GVAR model, the GIRFs provide useful information with respect to changes in real GDP and inflation. Although the approach is silent as to the reasons behind the changes, the GIRFs can be quite informative about the dynamics of the transmission of shocks from a specific euro area member country or of a "regional" area-wide shock to the euro area/the EU (Dees et al., 2007).

In the discussion of the results, we focus only *on the first two years* following the shock. This seems a reasonable time horizon over which the model presents credible results (Dees et al., 2007). However, in Figures 1 to 6 we provide results over a longer period, partly as visual aids

[21] Caldara and Kamps (2008, 2012) compare different identification approaches in that respect.

for the analysis of the model's convergence properties. The figures display the bootstrap estimates of the GIRFs and their associated 80% confidence bounds. They show that the GIRFs become stable reasonably quickly, suggesting that our model is stable.

In detail, in each of Figures 1 to 6, we present the bootstrap mean estimates of the GIRFs for the real GDP for all countries as well as the regions of the Euro Area and the Rest of Europe. In This regard, the latter country group is supposed to represent countries which are part of affiliated with the EU but not part of the Euro Area. Furthermore, we present GIRFs for the effects on regional inflation and for the inflation dynamics for the country where the shock originated. Impulses are presented over a time horizon of 28 quarters. The dynamic responses are calculated by a standard bootstrap procedure with 2000 replications. The horizontal axis shows the time horizon, whereas the vertical axis measures the response of each variable (in percentage change) for each country

4.3.1.1. Shock to German government total expenditure

Consider first the GIRFs for a one standard error negative shock to German government total expenditure. This shock is equivalent to a fall of around 0.7 percentage points in German government total expenditure per quarter. The negative German government total expenditure shock is accompanied by a decline in real GDP of around 0.7% after four quarters and by 0.8% after 8 quarters (see Figure 1).

The transmission of the shock to Euro area real GDP takes place rather quickly and the effects of the shock are, in a textbook fashion, generally statistically significant in the short-run. The shape of the impulse responses generally resembles those in comparable GVAR studies as those of Dees et al. (2007) and of Ricci-Risquete and Ramajo-Hernández (2015).

Regarding fiscal spillovers to specific countries, the Netherlands, but also Finland and Ireland, and somewhat surprisingly, also Sweden are among the mostly affected EMU member countries. Note that fiscal spillovers to Finland, Ireland, the Netherlands and Sweden are at least as large or even larger than the domestic effect in Germany. In contrast, Southern European EMU member countries are on average less affected than their Northern counterpart. This is, in particular, valid for Italy and Greece.

Real output in the Euro area (except Germany) is negatively affected by the adverse fiscal shock in Germany. In other words, we do *not* find evidence in favour of *the expansionary fiscal contraction hypothesis* (Giavazzi and Pagano, 1990, De Castro (2006, and Kameda, 2012). The same is valid for the "Rest of Europe", although to a much lesser extent (i.e., about half as much). This may mirror the (amplifying) effect of a common monetary policy in the Euro area. One important outlier in this regard is Switzerland (and partly also Sweden) which is significantly affected by the German fiscal shock. On the opposite, the United Kingdom is affected much less than the remaining "Rest of Europe".

Not surprisingly, the effect of the fiscal shock on the originating country, Germany, is comparably large, a common finding in the fiscal spillover GVAR literature.

Seen on the whole, thus, the trade channel seems to play an important role in the transmission of a German fiscal shock. It seems to even dominate the competitiveness and the financial channel, as can be seen from the impulse responses for inflation and interest rates.

Inflation in the Euro area and in the "Rest of Europe" tends to decrease although the magnitude of the reaction remains limited and non-significant (as is well known from other GVAR studies such as Dees et al., 2007 and other empirical approaches to fiscal spillovers such as Weyerstrass et al., 2006).

Our empirical results are remarkably close to those gained by Georgiadis and Hollmayr (2016) based on a Mixed-Cross-Section Global VAR (MCS GVAR) and a smaller sample period than ours (1999Q1-2009Q4), except that fiscal spillovers are higher according to our estimations for Ireland and the Netherlands and significantly lower for the United Kingdom.[22] We interpret this an additional indication of the robustness of our empirical results (Figure 7). We also take the idea of a spillover "heatmap" on board and, present a "heatmap" as an illustration of our results for the example of a public expenditure shock in Germany (Figure 8).

We have chosen to present two maps, one of them showing the estimated magnitude of spillovers of a fiscal shock in Germany (defined as the absolute mean estimates GIRFS, 4th quarter) in other European countries (Figure 8a).[23] The other one displays the difference of mean estimates to German country effect, i.e. the relative strength of fiscal spillovers relative to the effect in the originating country, i.e. Germany, itself (Figure 8b). The larger the relative country effect is, the bigger the fiscal spillover will be in times when the originating country goes for a larger fiscal policy shock ("leverage") and the higher the incentive would be to think of fiscal policy coordination to prevent such "risks".

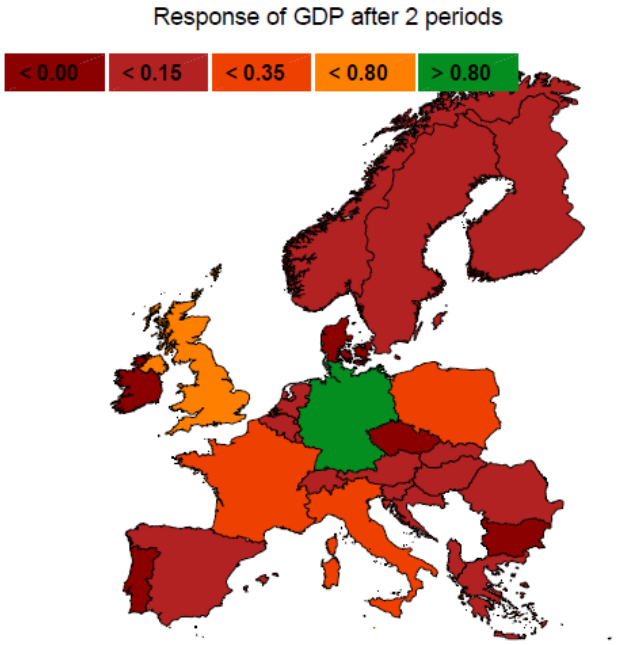
Regarding the absolute mean estimates of the responses (GIRFs) to a domestic fiscal expenditure shock in Germany (Figure 8a), the fiscal spillovers to Ireland, Sweden, Norway are the biggest. The second largest impact is on Dutch, Danish and Austrian GDP (heavily relying on the "distance" argument propagated in section 2). The United Kingdom, Spain, Portugal and Italy display the third largest fiscal spillover effects. Somewhat surprisingly, Switzerland also belongs to this group. However, the significance of the effects of a German public expenditure cut on Switzerland is one of the highest in the country sample. In a sense, this is a textbook style empirical outcome and corroborates the importance of the trade channel vis-à-vis the financial market channel (see section 2).

When the relative strength of fiscal spillovers relative to the effect in the originating country, Germany is tabulated (Figure 8b), only one country is changing the categories: Spain. The fiscal spillovers to Spain are larger relative to the domestic effects of a German fiscal shock than in absolute values. Hence, the "risk" of fiscal contagion in "non-normal times" (i.e. cases of large fiscal shocks in big EMU member countries is relatively high for Spain).

[22] See their Slide 9: "Spillover Reactions after a German Government Spending Shock".

[23] We select the fourth quarter because, as a stylised fact, fiscal shocks are (fully) transmitted with a certain time lag over time. This can be seen clearly in Figure 1.

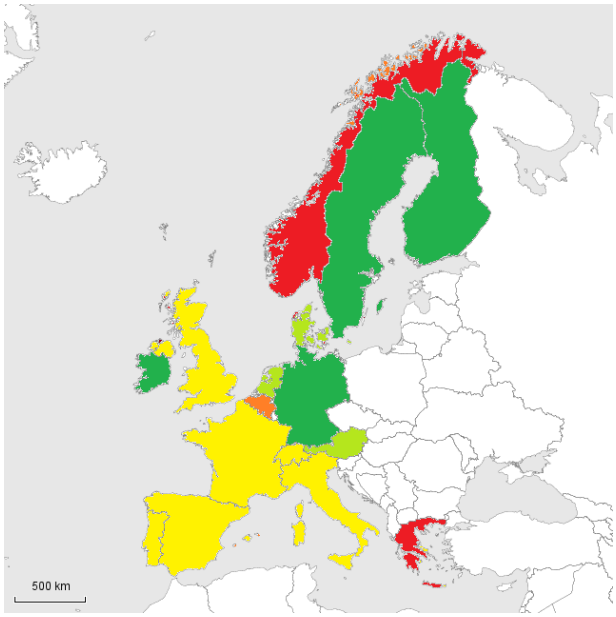
Figure 7. *Spillover reactions after a German government spending shock (Georgiadis/Hollmayer)*



Source: Georgiadis and Hollmayr (2016), Slide 9.

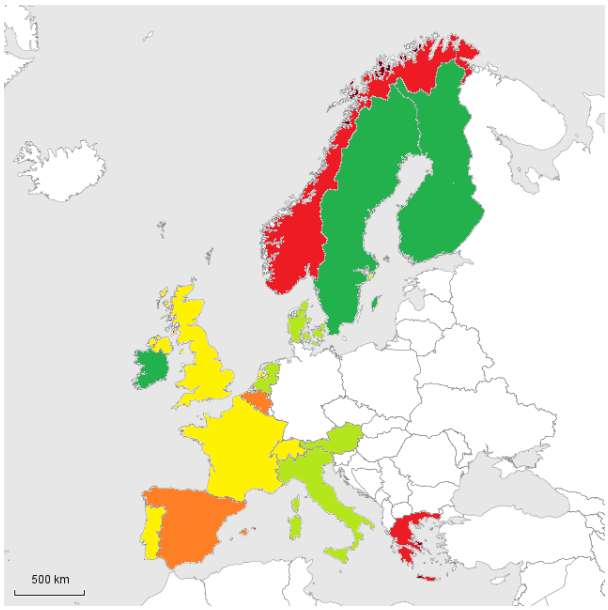
Figure 8. *Spillover Reactions after a German Government Spending Shock*

8a. *Absolute mean estimates of impulse responses (GIRFs), 4th quarter*



Notes: Spillover effects, Green<0.8, Bright green<0.5, Yellow<0.4, Orange<0.3, Red <0.25. Units are percent change in real GDP.

8b. *Relative mean estimates of impulse responses (GIRFs), 4th quarter (difference of mean estimates to German country effect)*



Notes: Difference of spillover effect in the destination country to domestic effect in Germany , Green >-0.1, Bright green >-0.2, Yellow >-0.25, Orange >-0.30, Red <-0.35%. Units are: change in real GDP relative to %-change in real GDP in Germany.

4.3.1.2. Shock to French government total expenditure

Figure 2 presents the GIRFs of a *negative* one standard error shock to French government total expenditure. A one standard error positive shock corresponds to 0.4 percentage points of the French fiscal expenditure variable. It results in a decrease of 0.2 percentage points decrease per quarter in real GDP.

The pattern of the results turns out to be rather similar to the German fiscal shock. The magnitudes of the impulse responses clearly differ from those for the German fiscal shock; they appear much smaller. However, they are not necessarily directly comparable due to the country-specific realisation of the standard errors of the fiscal shocks.

Concerning fiscal spillovers to specific countries, the effects on Southern EMU member countries such as Spain and Portugal area more pronounced than in the case of a German fiscal shock. The fiscal spillover to Germany is one of the largest.

Real output in the Euro area is negatively affected by the adverse fiscal shock in France. The same is valid for the country group called “Rest of Europe”, although to a lesser extent (i.e., again about half as much). This again is evidence of the (amplifying) effect of a common monetary policy in the Euro area.

Again, the effect of the fiscal shock on the originating country, France, is rather large.

4.3.1.3. Shock to German total public revenue

The GIRFs results of a positive one standard error shock to German total public revenue are displayed in Figure 3.

The mean estimates go into the expected direction. However, the results do in most cases not turn out to be significant, as can be seen at the rather wide confidence bands. One exception in this respect is Switzerland with its strong trade ties to Germany.

As already stated, the responses of the analyzed variables to the simulated shocks are usually not statistically significant as emerged from the graphs with 80 % confidence (a phenomenon well-known from the general GVAR literature, see Dees et al. , 2007, pp. 21-26, and particularly from the fiscal spillover GVAR literature (Dragomirescu-Gaina and Philippas, 2015, pp. 64f., and Ricci-Risquete and Ramajo-Hernández, 2015, pp. 1603-1614). This lack of efficiency in the estimates may be due to the relatively small size of the available overall sample, which forces us to restrict the dynamic specification of the model (Ricci-Risquete and Ramajo-Hernández, 2015, p. 1603). Taking this as a starting point, Ricci-Risquete and Ramajo-Hernández (2015), p. 65, Georgidas and Hollmayr, 2016, slide 8, Hebous and Zimmermann (2013), pp. 115f. and 118, and Nickel and Vansteenkiste (2013), pp. 187f., even *leave out the confidence intervals* from their visual presentation of the impulse responses (GIRFs). In any case, this fact does not detract from an economic interest of our application (as in Galesi and Sgherri 2009, p. 12).

On the one hand, it lets us know to what extent the dynamics of the variables among countries are synchronized, following a fiscal (total public revenue) shock. On the other hand, it enables us to assess to what extent the spillover effects across economies are important, following a shock. In short, we use our GVAR model not so much to quantify but rather to qualify the economic performance of the analyzed countries.

4.3.1.4. Shock to French total public revenue

Consider now the GIRFs for a one standard error negative shock to French total public revenue which are displayed in Figure 4.

The revenue shock needs more time to become effective than the fiscal expenditure shock, as expected from theory. Whereas an expenditure shock feeds through directly through the economy, the fiscal revenue shock affects the economy, as a first step, indirectly through changes in available income. However, the expected negative effect materialises for all countries and regions. The effects are significant throughout – which should be emphasised with an eye on our brief discussion in section 4.4.1.3 about the meaning of insignificance in the fiscal spillover GVAR context.[24]

The North-South divide is less strongly visible than in the case of a fiscal expenditure shock. Portugal and Italy are again comparably less affected, but fiscal spillovers to Greece and Spain are stronger than those induced by a French fiscal expenditure cut.

Again, as in the case of a fiscal expenditure shock, fiscal spillovers are stronger for the EMU than for the "Rest of Europe".

4.3.1.5. "Regional" shock to total public expenditure

Consider first the GIRFs for a one standard error negative "regional" shock to total public expenditure in Figure 5.

Figure 5 displays by far the strongest effects in terms of the magnitudes of fiscal spillovers (this may, however, partly be traced back to our definition of the "regional" standard deviation with

[24] The fact that fiscal spillovers of a German public receipts shock are insignificant as opposed to a French shock of the French realisation of the same variable may hint at some specifities such as a high volatility of the German fiscal total receipts time series.

a 27 percent share of Germany). What is more, the significance is higher than in the cases of Figures 1 to 4 and in many cases spreads all over the sample period. This strong result is also gained by Hebous and Zimmermann (2013) and Ricci-Risquete and Ramajo-Hernández (2014) who also argue that area-wide fiscal shocks defined in the specific GVAR way have larger economic consequences than domestic fiscal shocks (see section 3). Apart from that, the effects of "regional shocks" reveal a remarkable degree of similarity in the cyclical pattern of the fiscal spillovers of the European economies.

Finally, the effects of the negative "regional" fiscal shock on real GDP are negative in all considered economies during the period. They are negative in all major economies on impact, but they differ in magnitude and, partly, also significance the following quarters. Again, we do not find evidence in favour of the expansionary fiscal contraction hypothesis.

The fiscal spillovers of a Euro area-wide fiscal shock are stronger within the EMU than in the "Rest of Europe". This represents again indirect evidence of the (amplifying) effect of a common monetary policy in the Euro area.

In the case of the "regional" government expenditure shock, the results are very similar, in terms of the sign and the significance, to those of a shock to German government expenditure discussed above (significance even higher). This result confirms the predominant role of the German economy in the public expenditure developments across countries.

Inflation in the Euro area falls slightly but significantly initially as a reaction to the "regional" Euro area fiscal shock. Fiscal spillovers to inflation are thus "deeper in the short run than in the long run" (Ricci-Risquete and Ramajo-Hernández, 2015, p. 1612). This stands in contrast to the fiscal spillovers to the "Rest of Europe" whose inflation is not affected by the "regional" fiscal shock. Seen on the whole, thus, the relatively weak reaction of inflation to fiscal spillovers is comparable to evidence gained on approaches different from GVAR such as Weyerstrass et al. (2006).

These findings are in line with the results recently obtained by Dragomirescu-Gaina and Philippas (2015), Hebous and Zimmermann (2013) and Ricci-Risquete and Ramajo-Hernández (2014). These authors argue that fiscal area-wide shocks have larger economic consequences than fiscal domestic shocks in order to motivate the need for better policy coordination.

4.3.1.6. "Regional" shock to total public revenue

Let us finally turn to the GIRFs for a one standard error positive "regional" shock to total public revenue (Figure 6).

Here, we have to deal with the same problem as in the case of the German fiscal shock to total public revenue (which does not come as a surprise given the 27 percent country-weight of Germany in terms of PPP-GDP). The sign of the fiscal spillovers turn out to be negative overall, as theoretically expected. However, there is a lack of significance throughout. One exception is again Switzerland.

Again, the effects of "regional shocks" on real GDP reveal a remarkable degree of similarity in the cyclical behaviour of the European economies.

4.3.1.7 Impulse response analysis: conclusions regarding fiscal spillovers to real GDP

To summarise, the time development of the overall spillovers in the EMU follows a similar pattern and the absolute values of spillovers, generally clearly below 1 percent of real GDP, remain at levels that seem to be under the threshold of policymakers' attention. In this regard, we corroborate the conclusions by Gros and Hobza (2001).

However, a slightly different picture can be obtained when one considers the relative importance of spillovers, measured as a size of a spillover effect divided by the size of the domestic effect of the fiscal shock.

These results indicate that a fiscal expansion in one country can have a consequence on cross-border externalities whose size may at times even exceed the domestic change in GDP (as is the case, for instance, in section 4.4.1.1 for the fiscal spillovers to Finland, Ireland, the Netherlands and Sweden vis-à-vis the domestic effect of a cut in German public expenditure). This fact is of no big significance, in the current situation, which is characterised by a very low absolute size of spillovers. However, if the domestic fiscal policy multiplier under any circumstances at a certain time increased, the absolute size of spillovers could grow considerably (Auerbach and Gorodnichenko, 2015, and Gros and Hobza, 2001).

In general, the results of our dynamic GVAR analysis confirm the theoretically-based hypothesis that the absolute size of short-run cross-border externalities is in most of the cases rather low. The two basic transmission channels working through trade and capital markets (note, that long-term interest rates are contained in all our GVAR specifications) maybe cancel each other out to a large extent. Any increase in German government spending equivalent to 1% of baseline GDP thus leads to a fiscal spillover in the remaining Euro area (without Germany) of (0.0021/0,7) = approximately 0,3% of real Gdp after 8 quarters. Spillovers of such a magnitude hardly pose any important threat to European economies and it is disputable whether they would call for a more extensive cooperation framework. In that respect, we closely follow the conclusions by Gros and Hobza (2001) reached about 15 years ago based on a much older macroeconomic data set.

The relative size of spillovers is considerably higher given the rather small impact of the fiscal policies on domestic economies themselves. This indicates that a relatively large part of the shock passes through into the rest of Euro area. If under any circumstance, the domestic impact of fiscal policies increased, the size of the shocks could increase correspondingly.

It also seems that there is *not a linear* relationship between the average spillovers in the Euro area and the economic weight of country/ies undertaking the fiscal expansion. When the expansion takes place in more countries, the higher absolute size of individual spillovers in the remaining eurozone members is outweighed by their lower weight and thus the absolute size of an average spillover remains smaller than it could be(Gros and Hobza, 2001).

The results indicate that the size and the time profile of fiscal spillover effects are strongly dependent on the form that the fiscal expansion takes. As demonstrated above, the cross-border externalities turned slightly larger and, above all, positive when fiscal expansion through a reduction in government expenditure was considered (contrary to what was assumed by Gros and Hobza, 2001).

In our impulse response analysis, we differentiated between spillover effects of a fiscal shock in one country and spillovers when more countries undertake fiscal contraction simultaneously. At least for fiscal expenditure shocks, we were able to show that *fiscal spillovers are much stronger in the case of an area-wide shock.*

Another research question was whether *EMU is increasing the magnitude of the fiscal spillovers*. As stated above, various studies on international economic cooperation indicate a very important role of the exchange rate regime for the size and sign of potential spillovers. In the discussion regarding the need for policy coordination under EMU, it is usually assumed that the introduction of the Euro has increased the size of the spillovers, at least as compared to the EMS regime (Gros and Hobza, 2001, and Roeger and In't Veld, 1997). This is exactly what is mirrored by our results: *spillovers of fiscal shocks originating in EMU countries are much larger for EMU destinations than for destinations located in the "Rest of the EU".*

4.3.1.8 Impulse response analysis: fiscal spillovers to interest rates

Let us finally look briefly at the impulse responses of the long-term interest rates to the different fiscal shocks displayed in Figures 1 to 6. In each of the figures the interest responses of the Euro area, the "Rest of Europe" and North America (are displayed.[25] In our estimates we leave out the long-term interest rate for Greece because its gyrations are in significant sub-time periods (Troika programmes, see Alcidi et al., 2016) not market-based and could not be dealt with and corrected within our estimated GVAR model. Other studies in field are proceeding similarly (see, for instance, Ricci-Risquete and Ramajo-Hernández ,2015), p. 1596).

Regarding the interpretation of the GIRFs of the long-term interest rates to the German and French shocks, we would expect that a reduction of fiscal spending or an increase in taxation decreases interest rates due to a reaction of real GDP as indicated by the GIRFs. Additionally, a restrictive fiscal policy shock might decrease the government bond yield via the risk premia if the general perception of debt sustainability improves. However, we believe that the relevance of the second argument is limited to France and especially for Germany.

Because the results are roughly similar across the country-specific shocks, we focus on the shock to German fiscal expenditure in the following. As a response to the German fiscal expenditure shock, we find no significant effect on the Euro Area interest rate.[26] For the two remaining regions "Rest of Europe" and "North America"[27], we observe small, but significant (annual) interest rate reductions between 4 to 8 basis points.[28] Concerning the Euro area fiscal expenditure shock, we find a strong(er) negative effect on the Euro Area interest rate which is highly uncertain as indicated by large confidence bands. For the Rest of Europe and North America, we find a significant reduction of annual yields up to 16 basis points. Regarding the Euro area fiscal revenue shock, we find no significant effects on the interest rates.

Comparing our results with theory, our results for the Euro area (weighted) interest rate appears puzzling as we would have expected a stronger and more significant decrease in yields due to strong responses of real GDP in a majority of countries. We would like to tentatively argue that these results may be connected to the sovereign debt crisis and observable co-movements of variables. Especially between 2009 and 2012, we have observed that a decrease in real GDP was (timely) connected with an actually increased in sovereign yield for the so-called GIIPS-states. These dynamics might be responsible for the very high estimate uncertainty and the lower than expected interest rate responses. The inclusion of an additional variable measuring sovereign risk might help to account for these effects. Due to data limitations regarding the size of T and the different research focus of this paper, we did not include such a variable in this model.

4.4.2 Robustness checks

An important fact that one needs to keep in mind is the strong influence of assumptions under which the GVAR analysis is run on the empirical results. These concern the way in which the

[25] The aggregation is conducted by taking the median estimate for a country times its share at the PPP GDP of the regions. This is then aggregated across all countries of the respective region.
[26] The Euro Area long-term interest rate is measured as average of the Euro countries weighted by the country's PPP-GDP share of the total Euro Area PPP-GDP.
[27] The region "North America" contains the United States and Canada.
[28] As we closely follow the approach of Dees et al. (2007) regarding the transformation of interest rate variables, the long-term interest rate responses have a quarterly dimension. A response of -0.0004 equals a reduction of four basis points of the quarterly yield. In order to obtain annual yield effects, the responses have to be multiplied by 4.

fiscal expansion is executed and financed, the economic importance of the country/ies undertaking the expansion, the strategy followed by the monetary authorities, etc. A change in one of the assumptions can generate significantly different results. Therefore, in order to assess the robustness of the findings described above, alternative scenarios should be considered taking into account the *impact of different conditions* under which the fiscal expansion is executed on the size of cross-border externalities (Gros and Hobza, 2001).

In most of the simulations used in Gros and Hobza (2001) but also in other studies it is assumed that the fiscal contraction comes through a decrease in government spending. But this is not the only way such a contraction can be undertaken. An obvious alternative is an increase in government revenue, an alternative we fully take into account in our study. And indeed, under the current strict surveillance of the Growth and Stability Pact (SGP) over the budgetary policies of the Euro area member countries, it seems that an increase in taxes is, for political economy reasons, a much more plausible scenario of fiscal contraction than cutting government expenditure as could be seen in the EMU programme countries (Alcidi et al., 2016). Thus, we also have considered in our above estimations *how robust* are the conclusions concerning spillover effects taking into account *different origins of the fiscal contraction*.

We also test for *structural breaks* in the spirit of Dees et al., 2007), pp. 14ff. Unfortunately, despite a great deal of recent research in this area of GVARs, there is little known about how best to model breaks. However, the fact that country-specific models within the GVAR framework are specified conditional on foreign variables should help in alleviating the structural problem somewhat. And also the structure of the GVAR suggests that the VARX* models that underlie the GVAR might be more robust to the possibility of structural breaks as compared to reduced-form single-equation models (Dees et al. 2007, p. 14)).

The results of our structural break tests are displayed in Table 4.[29] Overall, not surprisingly there is evidence of structural instability of an extent usually found in estimated GVARs, but this seems to be mainly confined to error variances and does not seem to adversely affect the coefficient estimates (Dees et al., 2007, p. 32). We apply several tests and there are not more than six potential structural breaks indicated for around 90 equations we estimate. Moreover, the tests do not even convey an unambiguous picture in cases where some indication of a break is indicated. With this good result, our study ranges at the lower bound of GVAR estimations available in the literature.[30]

Anyway, we deal with the problem of possibly changing error variances by using robust standard errors when investigating the impact effects of the foreign variables, and base our analysis of impulse responses on the bootstrap means and confidence bounds rather than the point estimates to be on the safe side (Dees et al., 2007, p. 32). Seen on the whole, thus, we feel legitimised to interpret our estimated GVAR model as structurally stable and a suitable workhorse to estimate fiscal spillovers.

[29] The table is compiled in a way comparable with Table 6 in Dees et al. (2005).

[30] Dees et al. (2005), for instance, come up with stronger evidence of structural breaks than us (quite naturally because they use a longer estimation period) and still feel highly legitimised to use their estimated GVAR as their workhorse.

Table 4. *Number of rejections of the null of parameter constancy per variable across the country-specific models (5 percent level)*

Tests	Domestic variables					
	RGDP	ΔDefl	LTIR	Exp	Rev	
PK_{sub}	3	2	1	1	0	7 (7,5%)
PK_{msq}	4	1	0	1	0	6 (6,4%)
robust-Nyblom	2	2	1	1	1	6 (6,4%)
robust-QLR	2	2	0	1	1	6 (6,4%)
robust-MW	3	3	0	0	2	8 (8,6%)
robust-APW	2	2	0	1	0	5 (5,3%)

Notes: The test statistics PKsup and PKmsq are based on the cumulative sums of OLS residuals, N is the Nyblom test for time-varying parameters and QLR, MW and APW are the sequential Wald statistics for a single break at an unknown change point. The prefix robust denotes the heteroskedasticity robust version of the tests. All tests are implemented at the 5% significance level.

Our tests for structural breaks also make much sense because structural breaks would make it necessary to change and to differentiate between the underlying sub-period of analysis. Auerbach and Gorodnichenko (2015) and others agree that spillover effects are limited in normal times but can be sizable during recessions, which is related to the zero lower bound (ZLB) consideration (Georgiadis and Hollmayr, 2016, Bankowski, 2016).

As indicated in section 3.1., we also employed the cyclically adjusted government primary balance, as percentage of potential GDP as the fiscal variable to be shocked. Although this variable set does allow for separate expenditure and revenue shocks, the reduction in variables generates an increase in the degrees of freedom. Regarding the results, we find similar responses of real GDP to a German and Euro area shock. Although the inflation responses are slightly stronger, we find almost identical interest rate responses indicating that the weak interest rate responses are also present when a different fiscal variable is used. However, these results have to be interpreted with caution as autocorrelation in the fiscal equations is present across countries. This does not come as a surprise due to the interpolation of the data.

5. Conclusions and outlook

We start our GVAR analysis from the insight that the existence of large externalities from decentralised policy actions provides a rationale for centralising the decision-making of a certain policy area (Alcidi, Määttänen and Thirion, 2016). A necessary but not sufficient condition for this is a thorough quantification of the fiscal spillovers in Europe.

To contribute to this debate, we identified and measured fiscal spillovers in the EU countries empirically, using a regional vector autoregression (GVAR) methodology. For our purposes, the individual EU countries as well as the most important international trading partners were modelled with a special focus on the effects of either single-country or coordinated fiscal shocks such as increases in fiscal spending. Our aim was to look at the sign and the absolute values of fiscal spillovers in a country-wise perspective and at the time profile (impulse response) of the impacts of fiscal shocks. For this purpose, we differentiated between the spillovers of fiscal shocks in specific EMU countries and the spillovers of "regional" shocks, i.e. area-wide shocks to fiscal policy. Fiscal policy is measured by government expenditure, government revenues or the government budget balance, all as percentages of GDP. Special attention was paid to the question of whether or not spillovers are stronger within the EMU group than within the larger "Rest of Europe" group due to tighter financial or trade links.

The purpose of this paper thus was to study the economic consequences of shocks to fiscal variables in the EU countries from a domestic and a global perspective. We tried to shed light on questions of what the consequences are of a fiscal policy measure implemented in a Member State on the rest of the EMU/EU and/or on the ”Rest of Europe”. Our study serves as an input for other parts of the FIRSTRUN project which are supposed to answer the question whether EU countries should coordinate their fiscal policies and how fiscal policy contributes to growth and employment? With that objective in mind and following the seminal papers of Pesaran et al. (2004) and Dees et al. (2007), we specified the “Global VAR” methodology and built a GVAR model application for Euro area economies, but also member countries of the EU which are not EMU members and EFTA members and the “rest of the world” like Australia, China, Japan and the (weakly exogenous) United States. In this regard, we used quarterly macroeconomic, monetary and fiscal series from the first quarter of 1995 to the fourth quarter of 2015.

We emphasised that the key to the GVAR methodology is the inclusion of a specific set of foreign variables in each of the individual country models in order to treat those common factors that have an effect on different economies. Although the GVAR methodology can be applied in many diverse situations, we focused on both short- and long-term implications of a set of fiscal shocks emanating from single Euro area member countries or Euro area-wide (i.e. “regional”) fiscal shocks. Specifically, we provided impact effects related to changes in total government expenditure and in total government revenue and presented time profiles of these perturbations using generalized impulse response functions.

This paper thus contributes to the literature in several ways. Firstly, as already mentioned in section 2, papers using GVAR for studying coordinated fiscal policies are still scarce. Secondly, unlike other GVAR models with fiscal variables, in our research (1) we consider not a synthetic indicator of the situation of public finances, as the budget balance, but total government revenue and total government expenditure separately. Thirdly, we model not only the Euro area economies but the countries of the so-called “Rest of Europe” and some non-European countries such as the (weakly exogenous) the United States. Hence, we are - in contrast to the prevailing fiscal spillover literature - able to differentiate between fiscal spillovers to European countries within the EMU and to the “Rest of Europe”.Fourthly, we present results of the simulations concerning the effects of shocks to total government revenue and total government expenditure in both the country of origin of the shock and its trading partners in the context of the GVAR methodology (as conducted before only by Ricci-Risquete and Ramajo-Hernández, 2015, in a different country and region setting).

Our work can of course be *extended in a number of directions*. Our fiscal shock identification strategy may need more fine-tuning. Moreover, our findings are based on a non-structural model. Future research could focus on the structural identification of shocks within a global model of the world economy to gain a deeper economic understanding of fiscal linkages (Caporale and Girardi, 2011). We may also incorporate non-linearities and attach even more importance to the idiosyncrasies of the crisis-period itself (zero lower bound of the policy rate, explicit modelling of the central banks). In addition, we could try to incorporate more endogenous country variables in the GVAR. However, these endeavours were limited in the context of this paper by our efforts to guarantee a sufficient number of degrees of freedom. Finally, one could experiment with financial instead of trade weights in the link matrix.

Another interesting avenue would be to model the institutional conditions of the fiscal spillover effects explicitly (Georgiadis and Hollmayr, 2016). However, the GVAR structure employed in this paper would not be adequate to tackle this issue properly. Instead, one may think of using a Mixed-Cross-Section Global VAR (MCS-GVAR) for this purpose. Finally, one could think of modelling the ECB as a separate entity which would be a superior way to incorporate the euro area-wide interest rate.

References

Alcidi, C., Määttänen, N., Thirion, G. (2016): *Cross-country spillover effects and fiscal policy coordination in EMU*, Centre for European Policy Studies (CEPS), Brussels.

Alcidi, C., Belke, A:; Giovannini; A., Gros, D. (2016): Macroeconomic Adjustment Programmes in the Euro Area: An Overall Assessment, *International Economics and Economic Policy* 13/3, 345-358.

Auerbach, A., Gorodnichenko, Y. (2015): *How Powerful Are Fiscal Multipliers in Recessions*?, NBER Reporter 2, Research Summary.

Bankowski, K. (2016): Discussion of Georgiadis, G., Hollmayr, J. (2016), *Fiscal spillovers in EU - Size, sign and determinants*, ECB and Deutsche Bundesbank, Latvijas Banka Workshop on public finances within the framework of the European Central Bank Working Group on Public Finances, Riga, June 21.

Belke, A., Gros, D. (1999): Estimating the Costs and Benefits of EMU: The Impact of External Shocks on Labour Markets, *Weltwirtschaftliches Archiv* 135/1, 1-48.

Belke, A., Gros, D. (2009): Is a unified macroeconomic policy necessarily better for a common currency area?, *European Journal of Political Economy* 25, 98-101.

Belke, A., Gros, D. (2009a): On the benefits of fiscal policy coordination in a currency union: a note, *Empirica* 36(1), 45-49.

Bicu, A., Lieb, L. (2015): *Cross-border effects of fiscal policy in the Eurozone*, Research Memorandum, RM/15/019, Maastricht University.

Blanchard, O.J, Perotti, R. (2002) An empirical characterization of the dynamic effects of changes in government spending and taxes on output, Quarterly Journal of Economics, 117(4), 1329–1368

Blanchard, O.J., Erceg, C., Lindé, J. (2015): Jump starting the Euro area recovery: Would a rise in core fiscal spending help the periphery?, in: NBER Macroeconomics Annual 2016, Volume 31, Martin Eichenbaum and Jonathan A. Parker, editors.

Bundesbank (2016): *Zu den internationalen Ausstrahlwirkungen einer Ausweitung der öffentlichen Investitionen in Deutschland*, Monatsberichte, Frankfurt/Main, August, 13-17.

Caldara, D., Kamps, C. (2008): *What are the effects of fiscal policy shocks?AVAR-based comparative analysis*, ECB Working Paper Series No 877, European Central Bank, Frankfurt/Main, March.

Caldara, D., Kamps, C. (2012): *The analytics of SVARs: a unified framework to measure fiscal multipliers*, Finance and Economics Discussion Series 2012–2020, Board of Governors of the Federal Reserve System, Washington/DC

Canova, F. (2013): Modelling and forecasting government bond spreads in the Euro area: A GVAR model, Journal of Econometrics 177/2, 343–356.

Canova, F., Ciccarelli, M. (2013): Panel VAR models: a survey, *Advances in Econometrics* 31, forthcoming.

Canova, F., Ciccarelli, M. and Dallari, P. (2013): *Spillover of fiscal shocks in the Euro area*, preliminary draft, European Central Bank, Frankfurt/Main.

Caporale, G., Girardi, A. (2011): *Fiscal spillovers in the Euro area*, DIW Discussion Papers 1164, German Institute for Economic Research, Berlin.

Cook, D., Devereux, M.B. (2016): Fiscal Policy in a Currency Union at the Zero Lower Bound, The HKUST-Keio-HKIMR Conference on Exchange Rates and Macroeconomics, The Hongkong Univesity of Science and Technology, March 17 - 18th.

De Castro, F. (2006: The macroeconomic effects of fiscal policy in Spain, *Applied Economics* 38, 913–924.

Dees, S., Di Mauro, F., Pesaran, M.H., Smith, V. (2007): Exploring the international linkages of the Euro area: a global VAR analysis, *Journal of Applied Econometrics* 22, 1-38.

Dees, S., Pesaran, M.H., Smith, L.V., Smith, R.P. (2005): *Exploring the international linkages of the Euro area – A Global VAR analysis*, ECB Working Paper Series 568, European Central Bank, Frankfurt/Main.

Dees, S., Pesaran, M.H., Smith, L.V., Smith, R.P. (2010): *Supply, demand and monetary policy shocks in a multi-country New Keynesian model*, ECB Working Paper 1238, European Central Bank, Frankfurt/Main.

De Grauwe, P. (2009): To coordinate or not to coordinate, VoxEU.org, 24 September.

Di Mauro, F., Pesaran, H.E. (ed.): *The GVAR Handbook*, Oxford

Dragomirescu-Gaina, C., Philippas, D. (2015): Strategic interactions of fiscal policies in Europe: A global VAR perspective, *Journal of International Money and Finance* 59, 49-76.

Ericsson, N.R. (2011): *Improving Global Vector Autoregressions,* Division of International Finance, Board of Governors of the Federal Reserve System, Washington /DC.

Elekdag, S., Muir, D. (2014): *Das public Kapital: How much would higher German public investment help Germany and the Euro Area?,* IMF Working Paper WP/ 14/ 227, International Monetary Fund, Washington/DC.

European Commission (2014): *Quarterly report on the Euro area* 13(4), Brussels.

Faini, R. (2006): Fiscal policy and interest rates in Europe, *Economic Policy* 21(47), 443-489.

Fahri, E., Werning, I. (2012): *Fiscal multipliers: liquidity traps and currency unions*, Manuscript, Harvard University.

Ferrero, A. (2009): Fiscal and Monetary Rules for a Currency Union, *Journal of International Economics* 77, 1-10.

Fujiwari, I., Ueda, K. (2013): The fiscal multiplier and spillover in a global liquidity trap, *Journal of Economic Dynamics and Control* 37, 1264-1283.

Gadatsch,N., Hauzenberger, K. Stähler, N. (2016): Fiscal policy during the crisis: A look on Germany and the Euro area with GEAR, *Economic Modelling* 52, 997-1016.

Galesi, A. and S. Sgherri (2009): *Regional financial spillovers across Europe: A global VAR analysis*, IMF Working Paper 09/23, International Monetary Fund, Washington/DC.

Georgiadis, G., Hollmayr, J. (2016): *Fiscal spillovers in the EU - Size, sign and determinants*, ECB and Deutsche Bundesbank, Latvijas Banka Workshop on public finances within the framework of the European Central Bank Working Group on Public Finances, Riga, June 21.

Giavazzi, F.,Pagano, M. (1990): *Can severe fiscal contractions be expansionary? Tales of two small European countries*, NBER Macroeconomics Annual, 5, 75–111.

Gros, D., and Hobza, A. (2001): *Fiscal policy spillovers in the Euro area: Where are they?*, CEPS Working Document, No.176, Brussels.

Hebous, S., Zimmermann, T. (2012): Estimating the effects of coordinated fiscal actions in the Euro area, CESifo Working Papers 3912, Munich.

Hebous, S., Zimmermann, T. (2013): Estimating the effects of coordinated fiscal actions in the Euro area, *European Economic Review* 58, 110-121.

In't Veld, J. (2016): *Public investment stimulus in surplus countries and their Euro area spillovers*, Economic Brief 016, Directorate-General for Economic and Financial Affairs, European Commission, Brussels.

Kameda, K. (2012) Estimating non-Keynesian effects for Japan, *Asian Economic Policy Review* 7(2), 227-243.

Koop, G., Pesaran, M.H., Potter, S.M. 1996. Impulse response analysis in nonlinear multivariate models, *Journal of Econometrics* 74, 119-147.

Koukouritakis, M., Papadopoulos, A.P. Yannopoulos, A. (2015): Linkages between the Eurozone and the South-Eastern European countries: A global VAR analysis, *Economic Modelling* 48, 129-154.

Laxton, D., Isard, P., Faruqee, H., Prasad, E., Turtelboom, B. (1998): *MULTIMOD Mark III: The core dynamic and steady-state models*, IMF Occasional Paper 164, International Monetary Fund, Washington/DC.

Nickel, C., Vansteenkiste, I. (2013): *The international spillover of fiscal spending on financial variables*, in: di Mauro, F., Pesaran, H.E. (ed.), The GVAR Handbook, Oxford, 182-192.

Niehof, B. (20014): *Spillover effects in government bond spreads: Evidence from a GVAR model*, Joint Discussion Paper Series in Economics, No. 57-2014, Marburg.

Park, H.J., Fuller, W.A. (1995): Alternative Estimators and Unit Root Tests for the Autoregressive Process, *Journal of Time Series Analysis* 16, 415-429.

Perotti, R. (2007): *In search of the transmission mechanism of fiscal policy*, NBER Macroeconomic Manual 2007, Vol. 22, 169-226.

Pesaran, M.H., Shin, Y. (1998): Generalised impulse response analysis in linear multivariate models, *Economics Letters* 58, 17-29.

Pesaran, M.H., Schuermann, T., Weiner, S.M. (2004): Modelling regional interdependencies using a global error-correcting macroeconometric model, *Journal of Business and Economic Statistics* 22(2), 129-162.

Ricci-Risquete, A., Ramajo-Hernández, J. (2015): Macroeconomic effects of fiscal policy in the European Union: a GVAR model, *Empirical Economics* 48, 1587-1617.

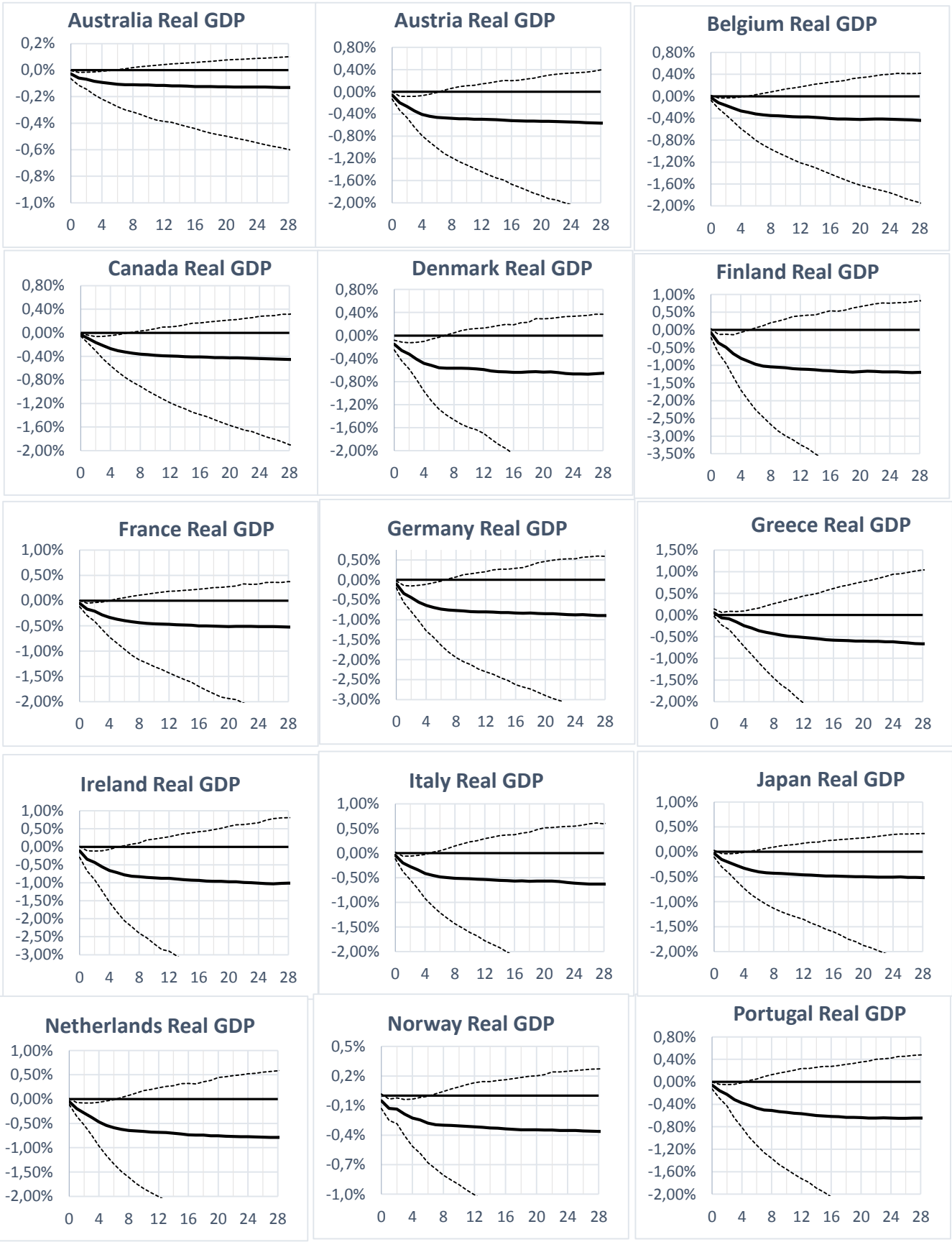
Roeger, Werner, In't Veld, J. (1997), *QUEST II: A Multi-Country business cycle and growth model*, Economic Paper 123, DG Economic and Financial Affairs, European Commission.

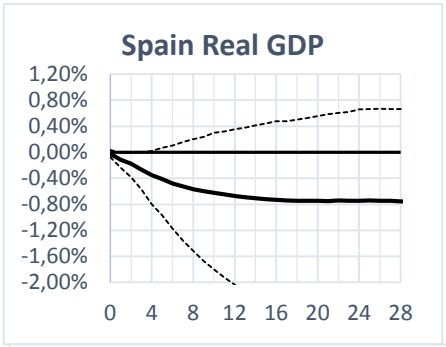
Smith, R.P. (2013): *The GVAR approach to structural modelling*, in: di Mauro, F., Pesaran, H.E. (ed.), The GVAR Handbook, Oxford, 56-69.

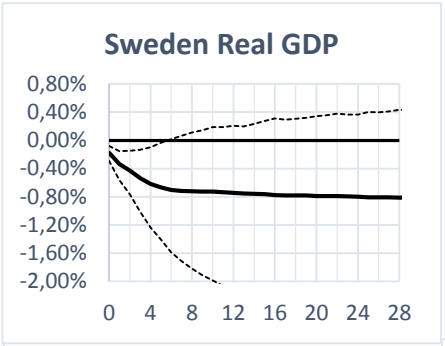
Smith, V., Galesi, A. (2014): *GVAR toolbox 2.0 – User guide*, August.

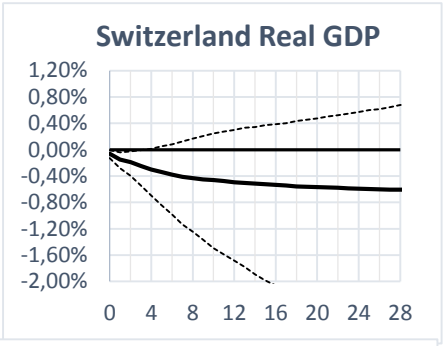
Weyerstrass, K., Johannes Jaenicke, J., Reinhard Neck, R., Haber, G. van Aarle, B., Schoors, K.. Niko Gobbin, N., Claeys, P. (2006): *Economic spillover and policy coordination in the Euro Area*, European Economy, Economic Papers Number 246, European Commission, Brussels, March.

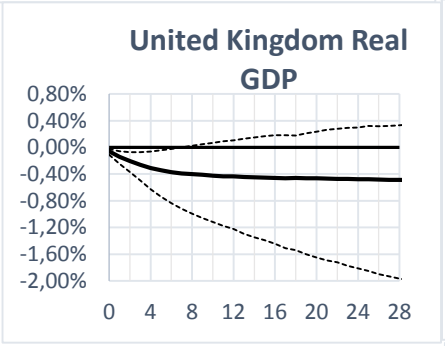
Figure 1. *Generalized impulse responses of a negative unit (1 s.e.) shock to German government total expenditure (bootstrap mean estimates with 80% bootstrap error bounds)*




Spain Real GDP
1,20%
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28


Sweden Real GDP
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28


Switzerland Real GDP
1,20%
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28


United Kingdom Real GDP
0,80%
0,40%
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-1,60%
-2,00%
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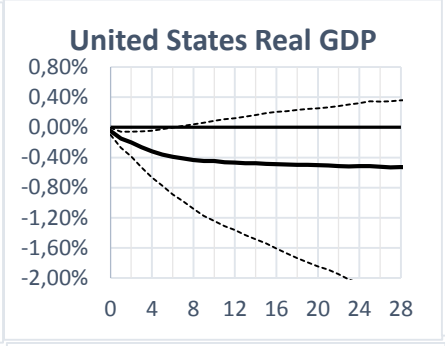
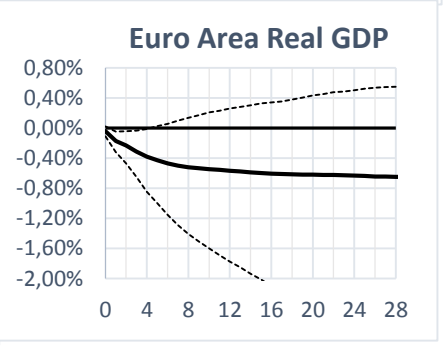
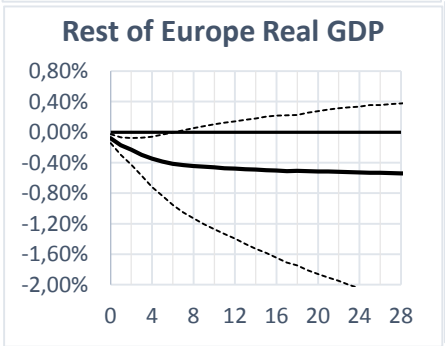
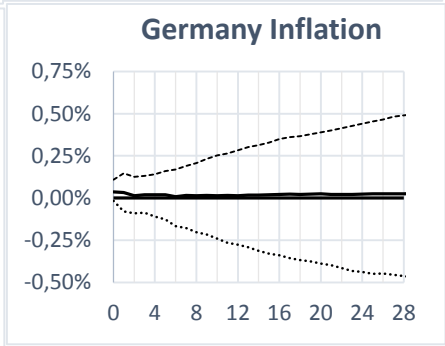
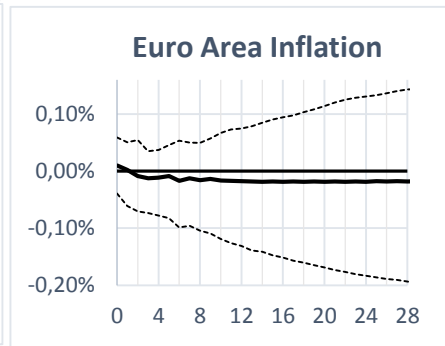
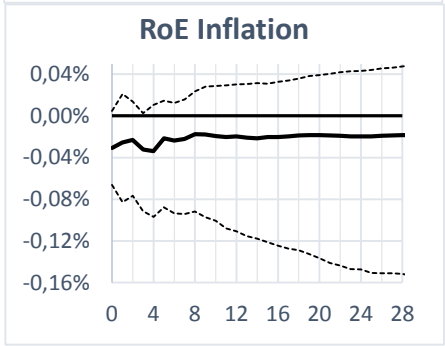

United States Real GDP
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

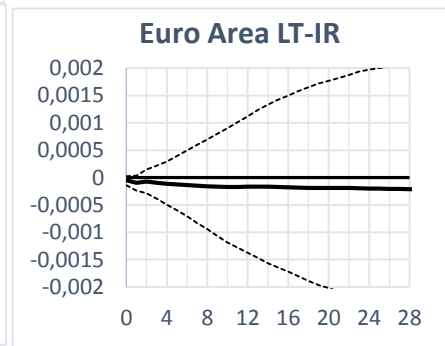

Euro Area Real GDP
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

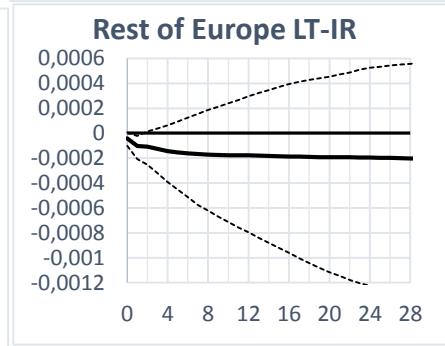

Rest of Europe Real GDP
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28


Germany Inflation
0,75%
0,50%
0,25%
0,00%
-0,25%
-0,50%
0 4 8 12 16 20 24 28


Euro Area Inflation
0,10%
0,00%
-0,10%
-0,20%
0 4 8 12 16 20 24 28


RoE Inflation
0,04%
0,00%
-0,04%
-0,08%
-0,12%
-0,16%
0 4 8 12 16 20 24 28


Euro Area LT-IR
0,002
0,0015
0,001
0,0005
0
-0,0005
-0,001
-0,0015
-0,002
0 4 8 12 16 20 24 28


Rest of Europe LT-IR
0,0006
0,0004
0,0002
0
-0,0002
-0,0004
-0,0006
-0,0008
-0,001
-0,0012
0 4 8 12 16 20 24 28

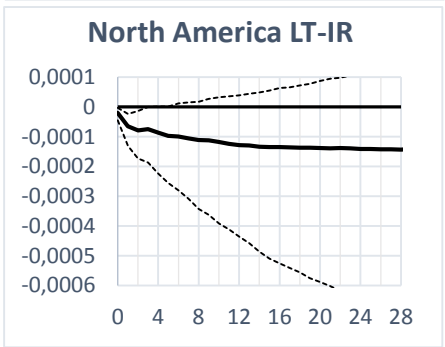
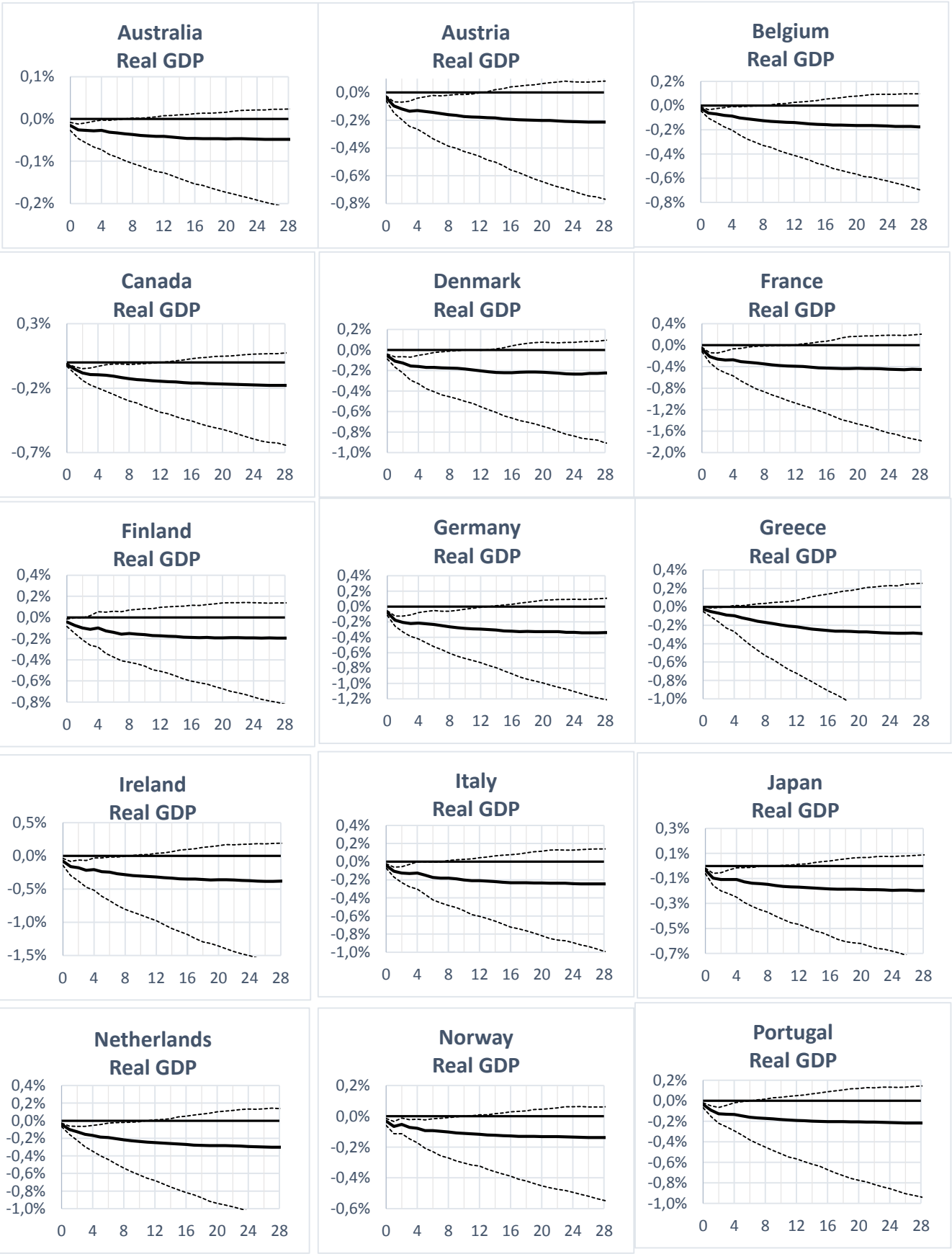
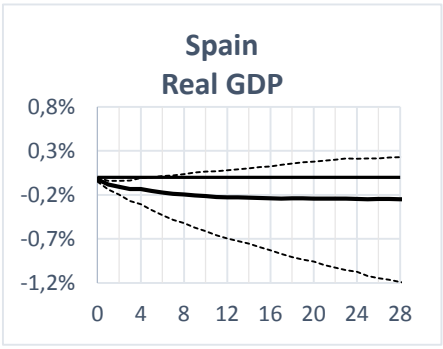
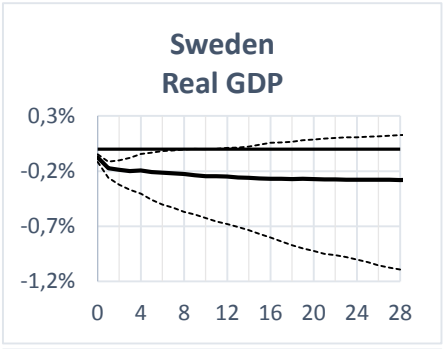
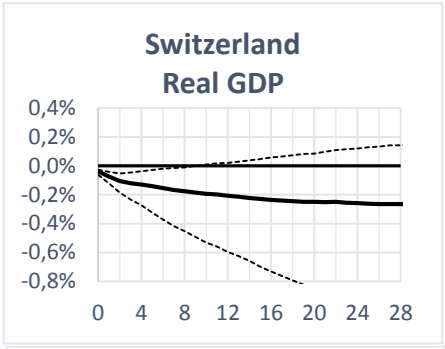

North America LT-IR
0,0001
0
-0,0001
-0,0002
-0,0003
-0,0004
-0,0005
-0,0006
0 4 8 12 16 20 24 28

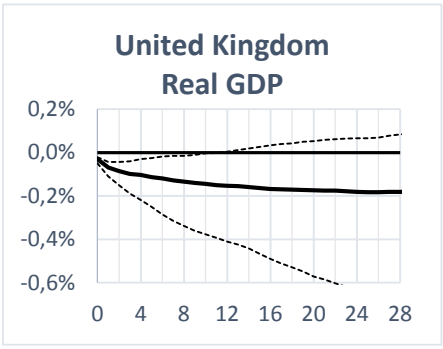
Figure 2. *Generalized impulse responses of a negative unit (1 s.e.) shock to French fiscal expenditure (bootstrap mean estimates with 80% bootstrap error bounds)*

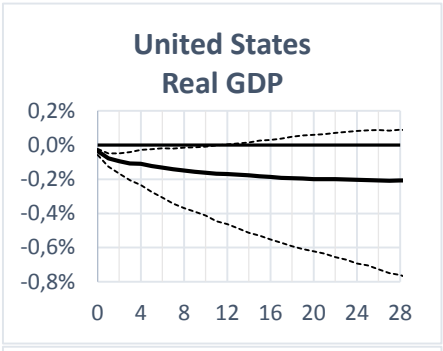


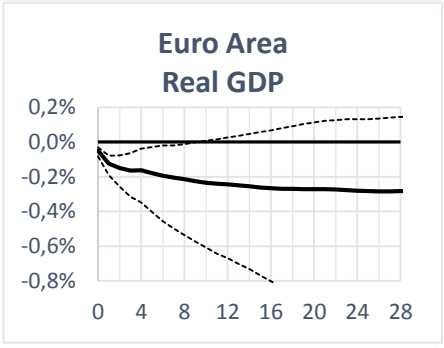

Spain
Real GDP
0,8%
0,3%
-0,2%
-0,7%
-1,2%
0 4 8 12 16 20 24 28

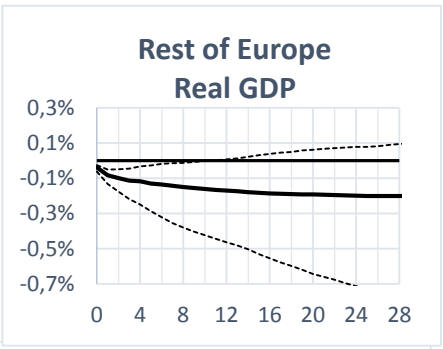

Sweden
Real GDP
0,3%
-0,2%
-0,7%
-1,2%
0 4 8 12 16 20 24 28

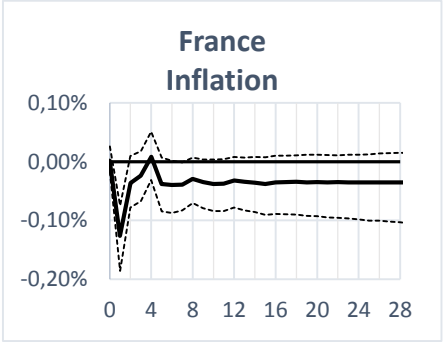

Switzerland
Real GDP
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
0 4 8 12 16 20 24 28

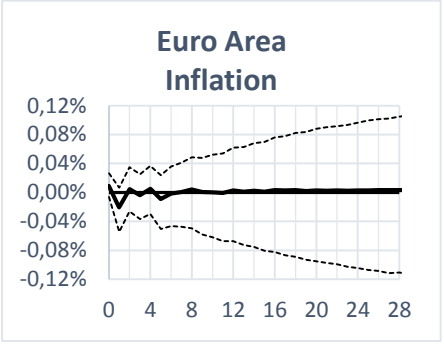

United Kingdom
Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
0 4 8 12 16 20 24 28

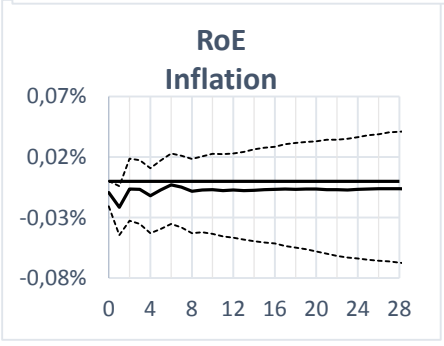

United States
Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
0 4 8 12 16 20 24 28

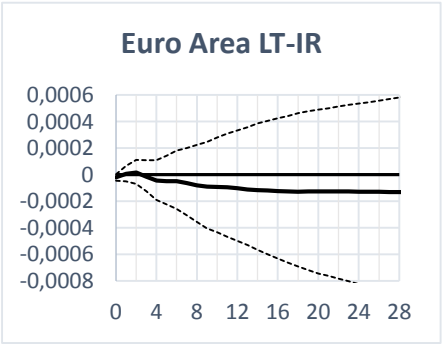

Euro Area
Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
0 4 8 12 16 20 24 28

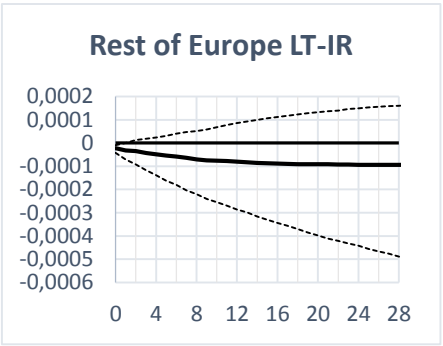

Rest of Europe
Real GDP
0,3%
0,1%
-0,1%
-0,3%
-0,5%
-0,7%
0 4 8 12 16 20 24 28


France
Inflation
0,10%
0,00%
-0,10%
-0,20%
0 4 8 12 16 20 24 28


Euro Area
Inflation
0,12%
0,08%
0,04%
0,00%
-0,04%
-0,08%
-0,12%
0 4 8 12 16 20 24 28


RoE
Inflation
0,07%
0,02%
-0,03%
-0,08%
0 4 8 12 16 20 24 28


Euro Area LT-IR
0,0006
0,0004
0,0002
0
-0,0002
-0,0004
-0,0006
-0,0008
0 4 8 12 16 20 24 28


Rest of Europe LT-IR
0,0002
0,0001
0
-0,0001
-0,0002
-0,0003
-0,0004
-0,0005
-0,0006
0 4 8 12 16 20 24 28

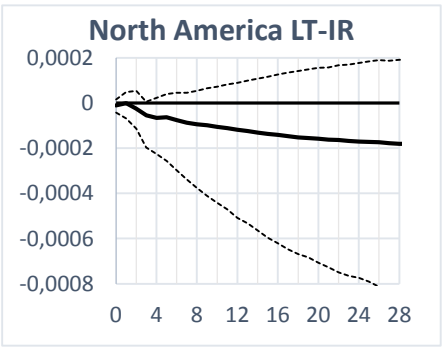
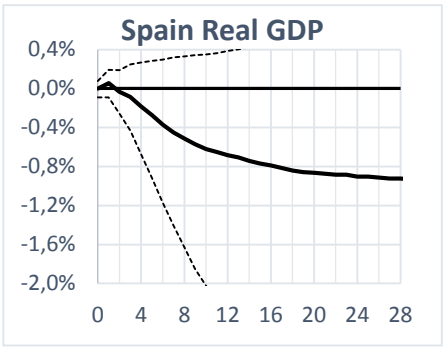
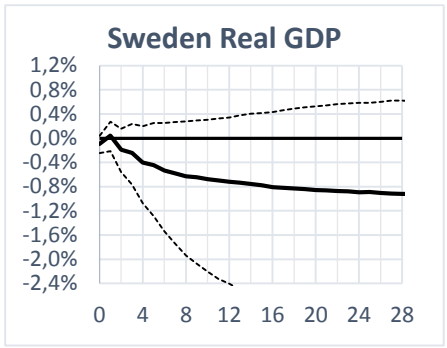
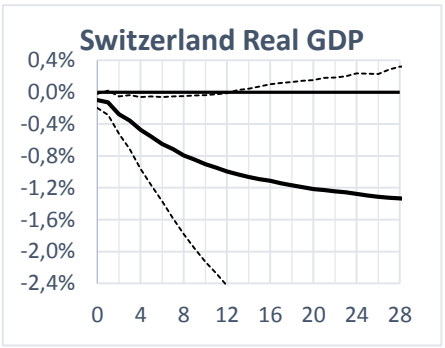
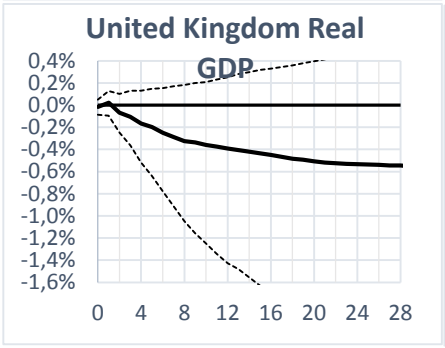

North America LT-IR
0,0002
0
-0,0002
-0,0004
-0,0006
-0,0008
0 4 8 12 16 20 24 28

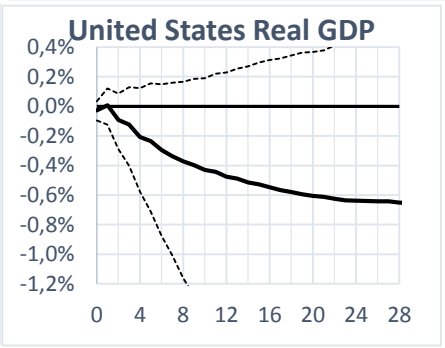
Figure 3. *Generalized impulse responses of a positive unit (1 s.e.) shock to German total public revenue (bootstrap mean estimates with 80% bootstrap error bounds)*

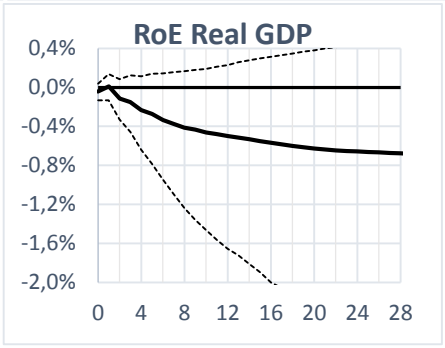

Spain Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
-2,0%
0 4 8 12 16 20 24 28

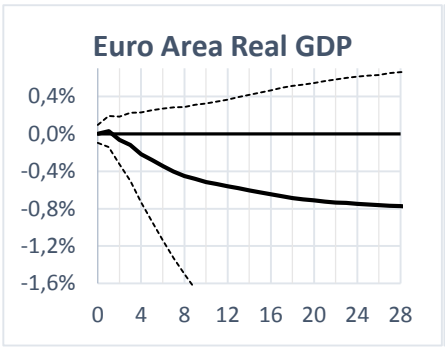

Sweden Real GDP
1,2%
0,8%
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
-2,0%
-2,4%
0 4 8 12 16 20 24 28

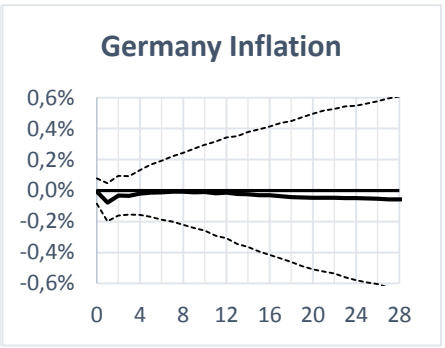

Switzerland Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
-2,0%
-2,4%
0 4 8 12 16 20 24 28

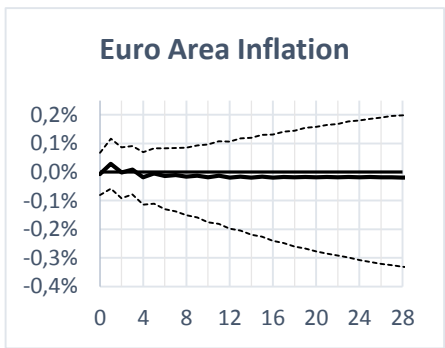

United Kingdom Real GDP
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
-1,2%
-1,4%
-1,6%
0 4 8 12 16 20 24 28

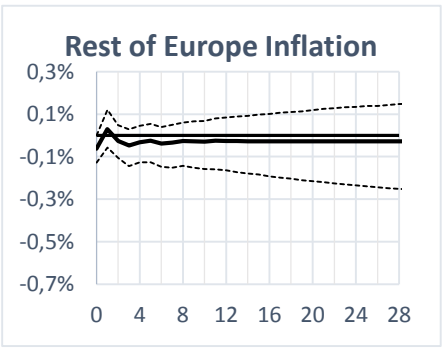

United States Real GDP
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
-1,2%
0 4 8 12 16 20 24 28

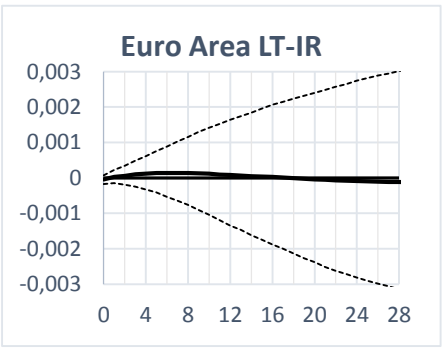

RoE Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
-2,0%
0 4 8 12 16 20 24 28

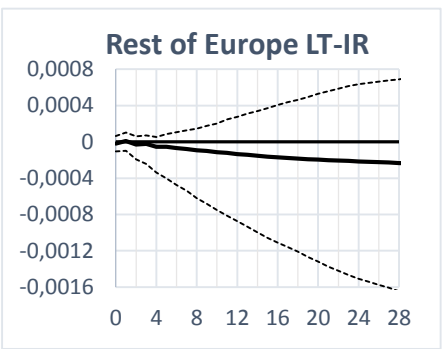

Euro Area Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
0 4 8 12 16 20 24 28


Germany Inflation
0,6%
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
0 4 8 12 16 20 24 28


Euro Area Inflation
0,2%
0,1%
0,0%
-0,1%
-0,2%
-0,3%
-0,4%
0 4 8 12 16 20 24 28


Rest of Europe Inflation
0,3%
0,1%
-0,1%
-0,3%
-0,5%
-0,7%
0 4 8 12 16 20 24 28


Euro Area LT-IR
0,003
0,002
0,001
0
-0,001
-0,002
-0,003
0 4 8 12 16 20 24 28


Rest of Europe LT-IR
0,0008
0,0004
0
-0,0004
-0,0008
-0,0012
-0,0016
0 4 8 12 16 20 24 28

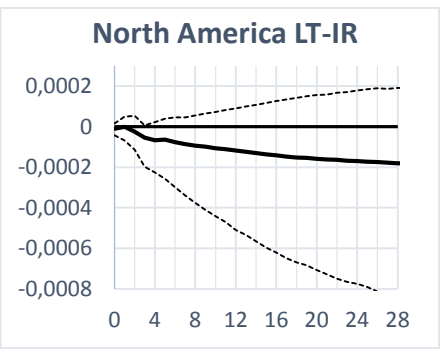
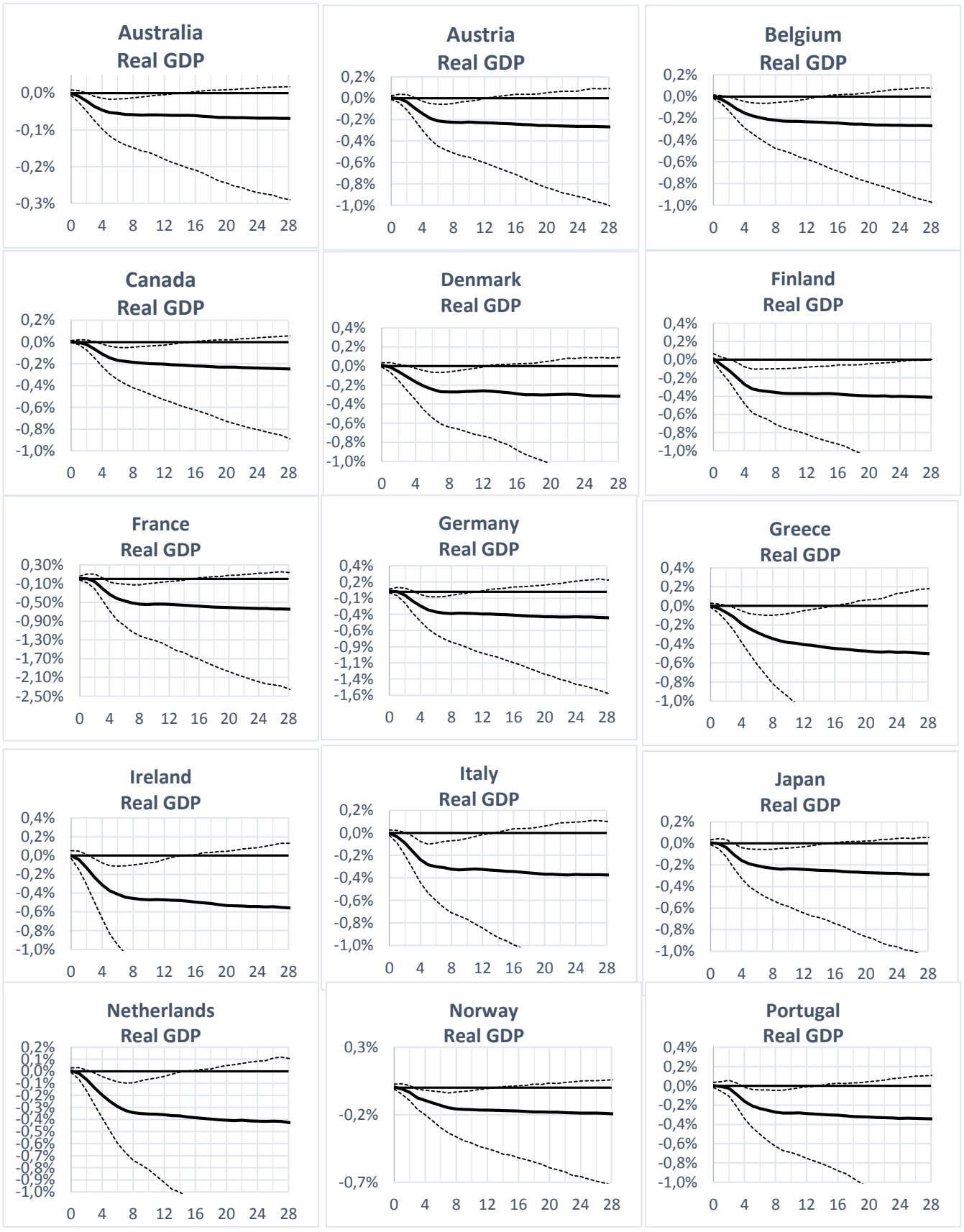

North America LT-IR
0,0002
0
-0,0002
-0,0004
-0,0006
-0,0008
0 4 8 12 16 20 24 28

Figure 4. *Generalized impulse responses of a positive unit (1 s.e.) shock to French total public revenue (bootstrap mean estimates with 80% bootstrap error bounds)*



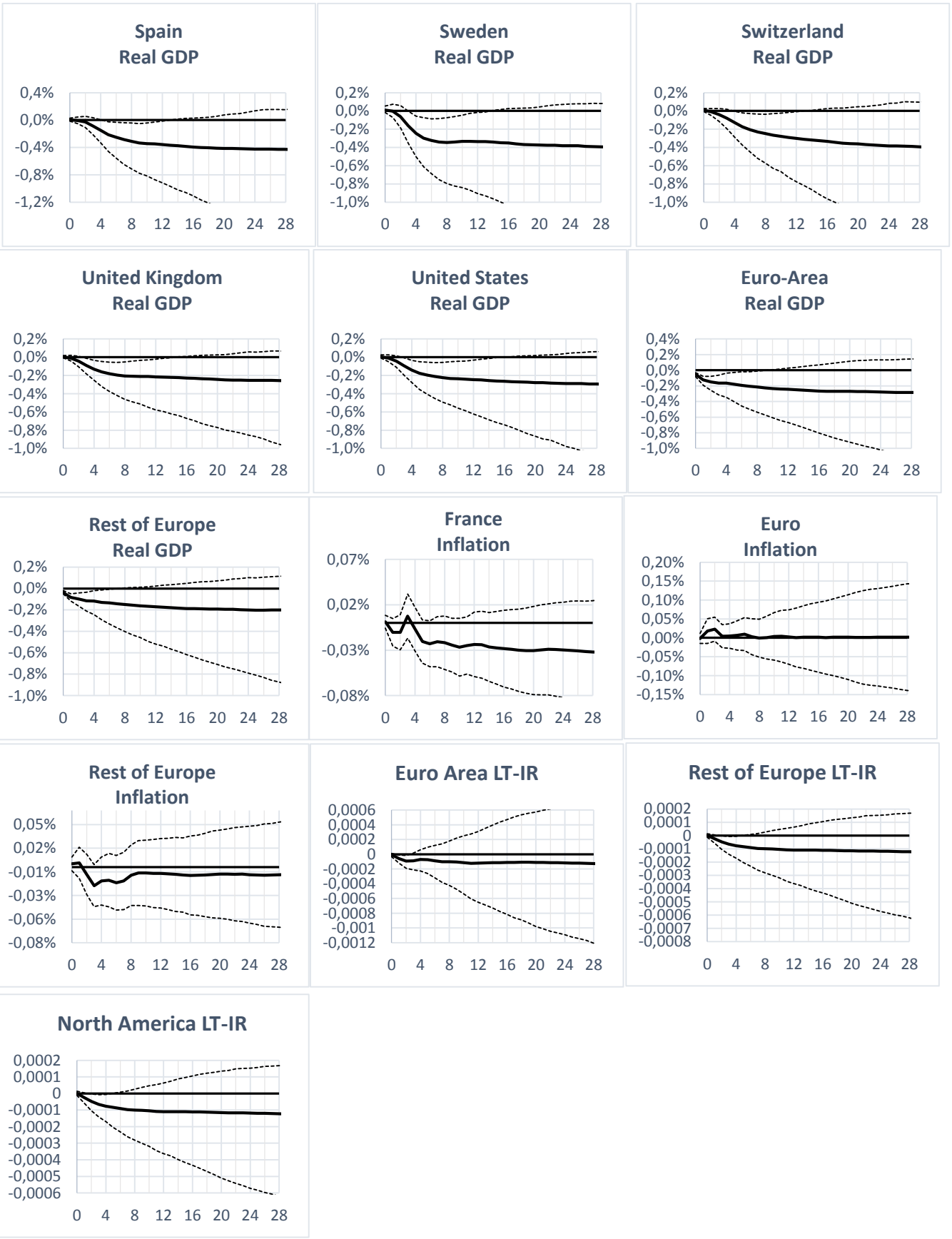
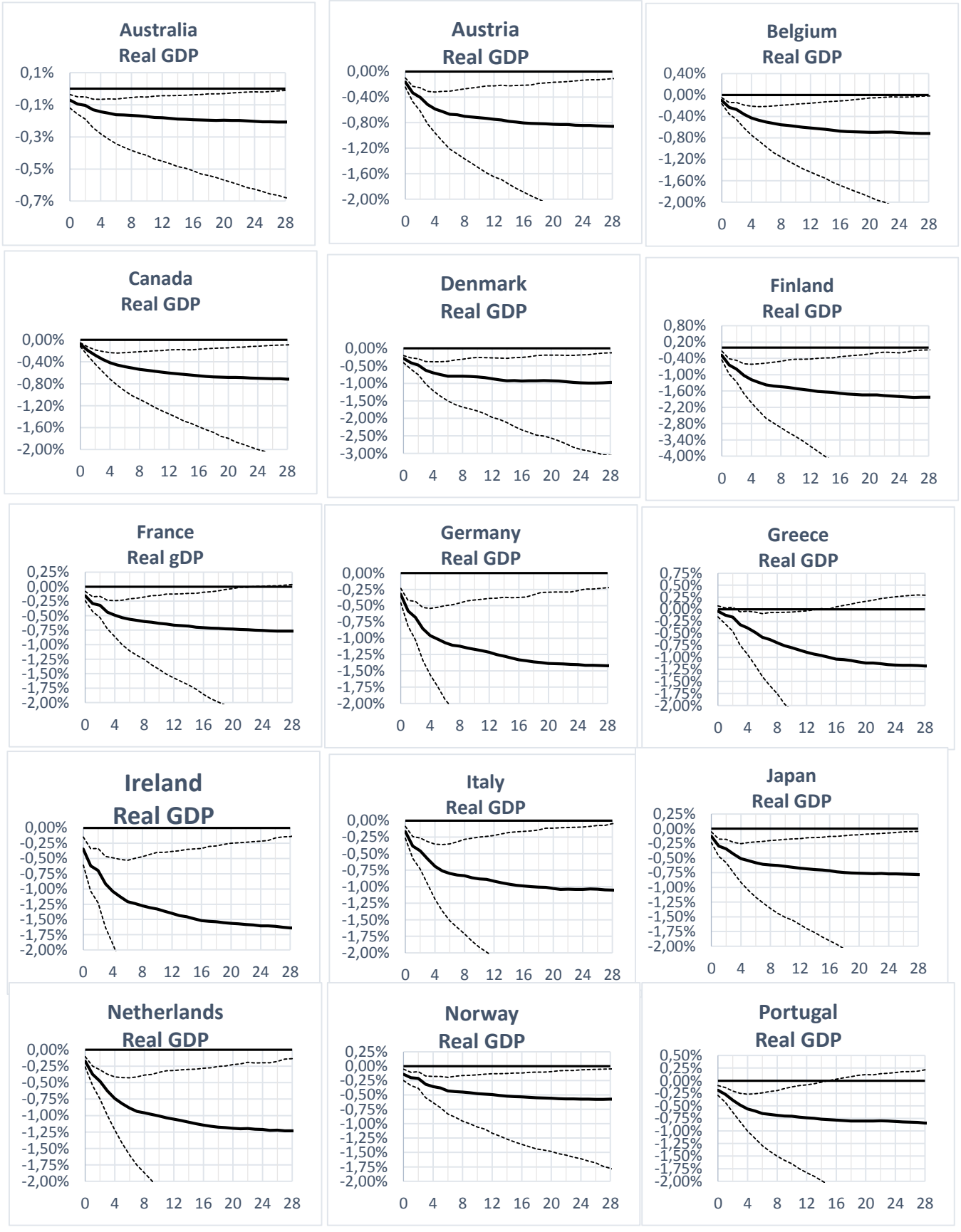
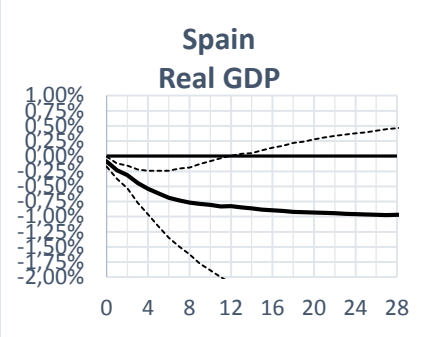
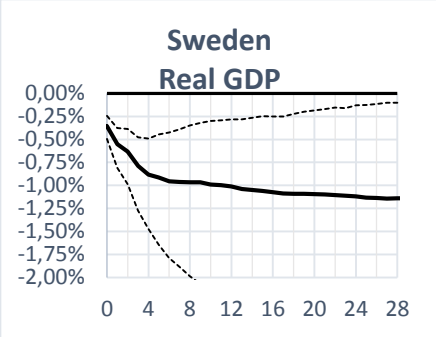
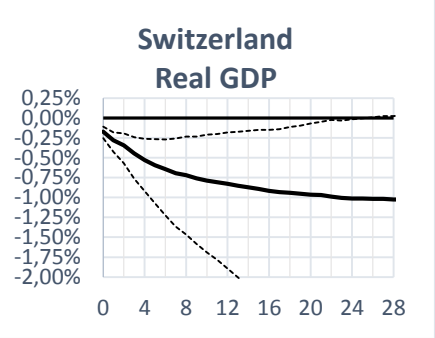

Spain
Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
0 4 8 12 16 20 24 28
Sweden
Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28
Switzerland
Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28
United Kingdom
Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28
United States
Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28
Euro-Area
Real GDP
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28
Rest of Europe
Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28
France
Inflation
0,07%
0,02%
-0,03%
-0,08%
0 4 8 12 16 20 24 28
Euro
Inflation
0,20%
0,15%
0,10%
0,05%
0,00%
-0,05%
-0,10%
-0,15%
0 4 8 12 16 20 24 28
Rest of Europe
Inflation
0,05%
0,02%
-0,01%
-0,03%
-0,06%
-0,08%
0 4 8 12 16 20 24 28
Euro Area LT-IR
0,0006
0,0004
0,0002
0
-0,0002
-0,0004
-0,0006
-0,0008
-0,001
-0,0012
0 4 8 12 16 20 24 28
Rest of Europe LT-IR
0,0002
0,0001
0
-0,0001
-0,0002
-0,0003
-0,0004
-0,0005
-0,0006
-0,0007
-0,0008
0 4 8 12 16 20 24 28
North America LT-IR
0,0002
0,0001
0
-0,0001
-0,0002
-0,0003
-0,0004
-0,0005
-0,0006
0 4 8 12 16 20 24 28

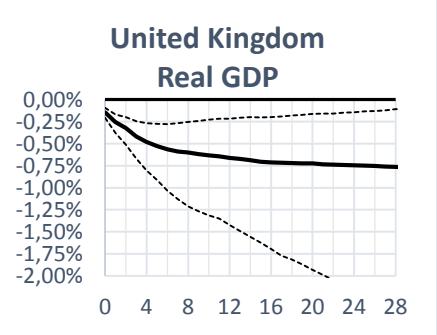
Figure 5. *Generalized impulse responses of a negative unit (1 s.e.) "regional" shock to government total expenditure (bootstrap mean estimates with 80% bootstrap error bounds)*

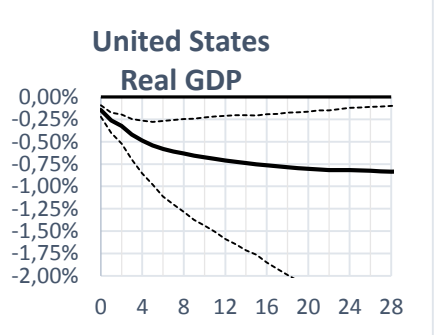


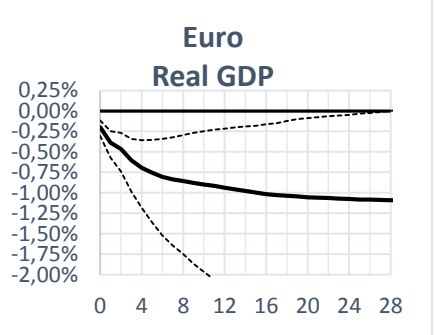

Spain
Real GDP
1,00%
0,75%
0,50%
0,25%
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28

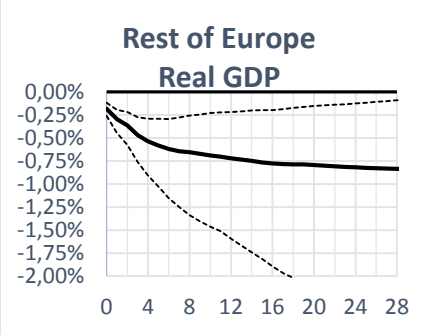

Sweden
Real GDP
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28

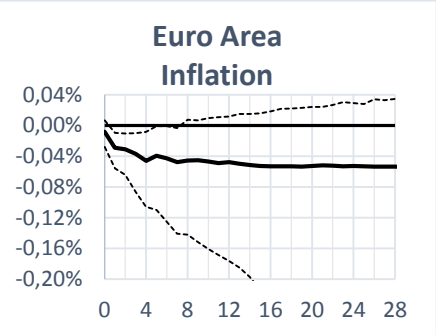

Switzerland
Real GDP
0,25%
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28

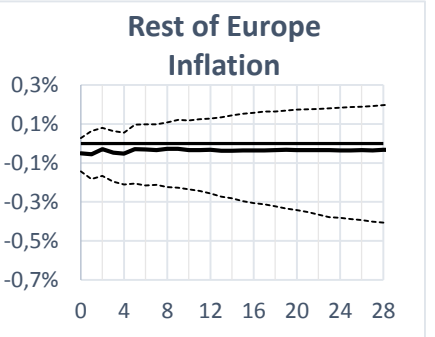

United Kingdom
Real GDP
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28

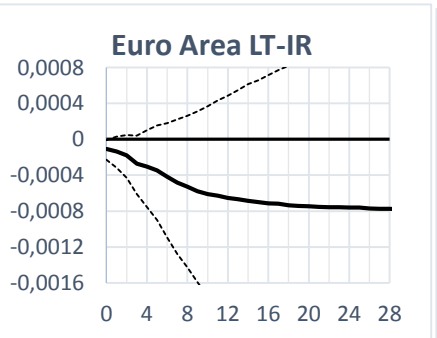

United States
Real GDP
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28

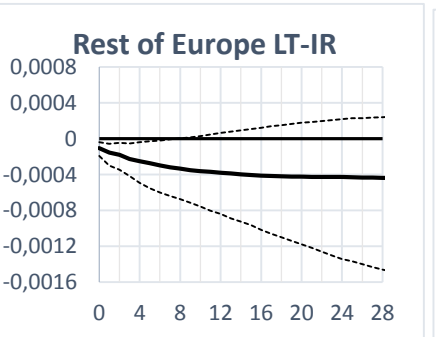

Euro
Real GDP
0,25%
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28


Rest of Europe
Real GDP
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28


Euro Area
Inflation
0,04%
0,00%
-0,04%
-0,08%
-0,12%
-0,16%
-0,20%
0 4 8 12 16 20 24 28


Rest of Europe
Inflation
0,3%
0,1%
-0,1%
-0,3%
-0,5%
-0,7%
0 4 8 12 16 20 24 28


Euro Area LT-IR
0,0008
0,0004
0
-0,0004
-0,0008
-0,0012
-0,0016
0 4 8 12 16 20 24 28


Rest of Europe LT-IR
0,0008
0,0004
0
-0,0004
-0,0008
-0,0012
-0,0016
0 4 8 12 16 20 24 28

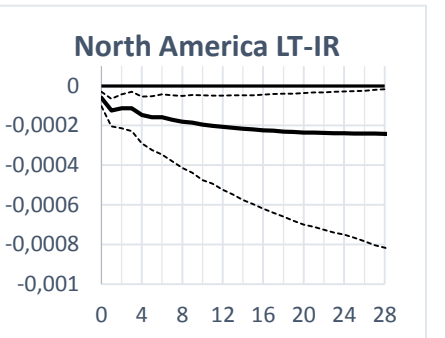
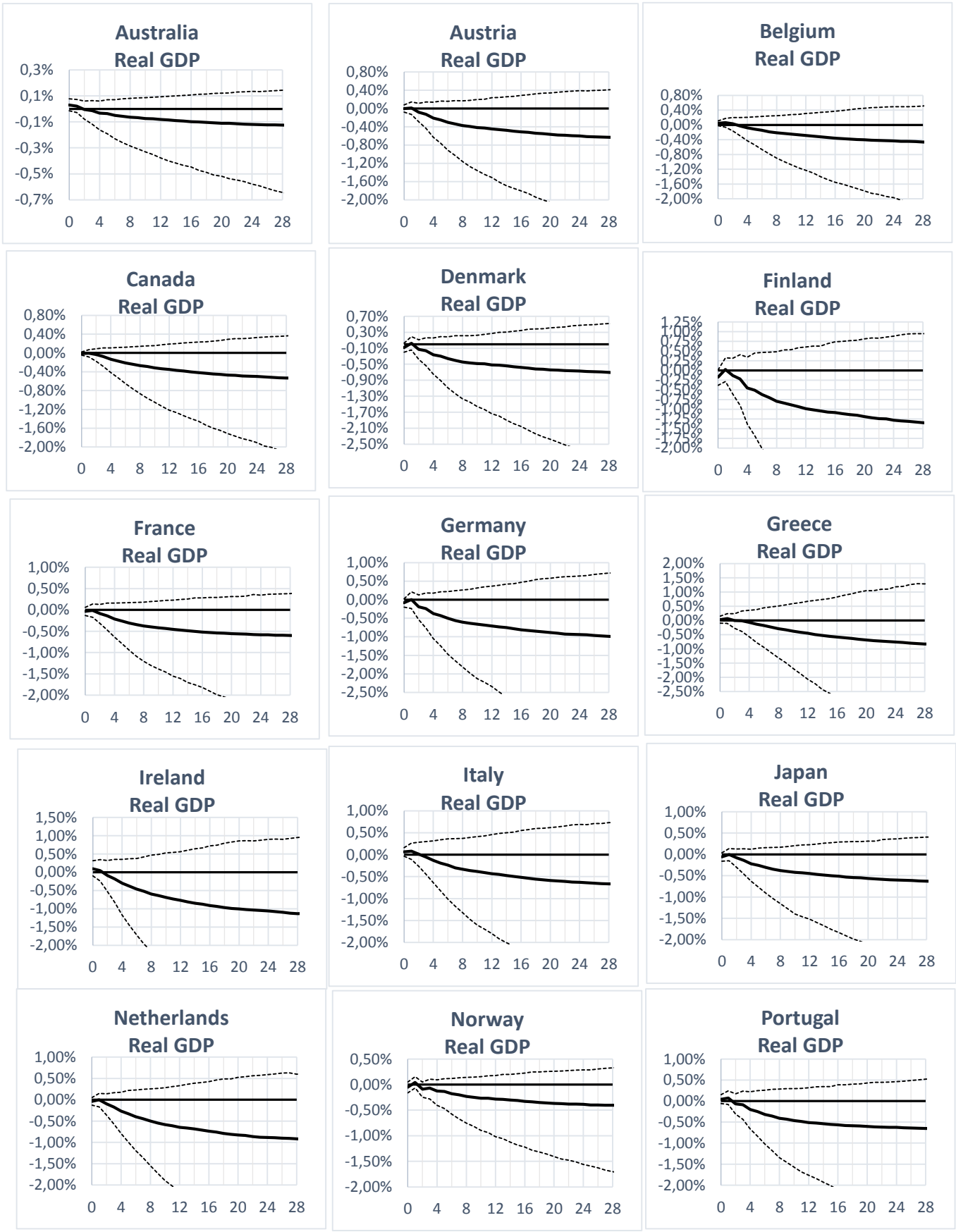
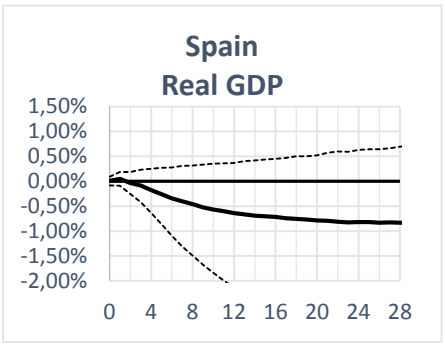
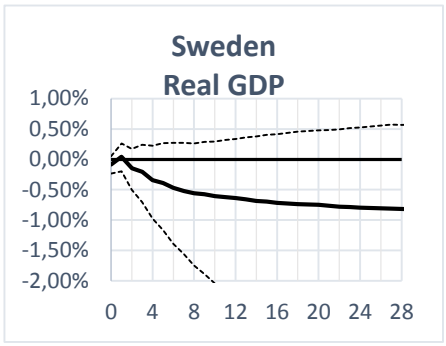
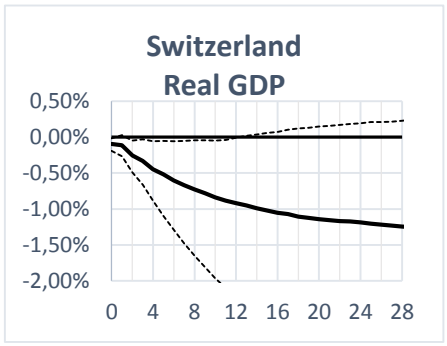

North America LT-IR
0
-0,0002
-0,0004
-0,0006
-0,0008
-0,001
0 4 8 12 16 20 24 28

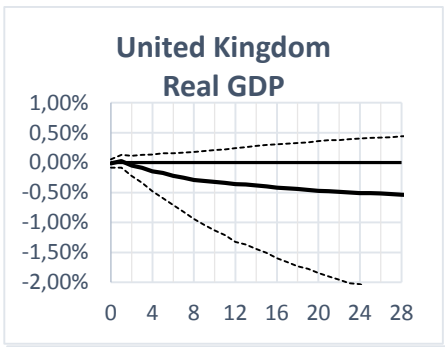
Figure 6. *Generalized impulse responses of a positive unit (1 s.e.) "regional" shock to total public revenue (bootstrap mean estimates with 80% bootstrap error bounds)*

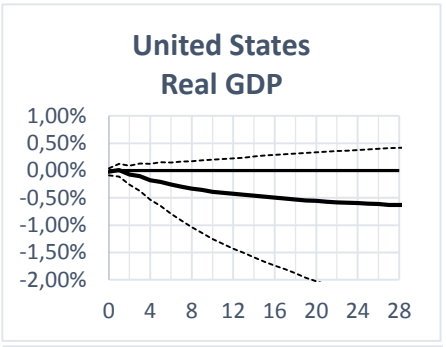


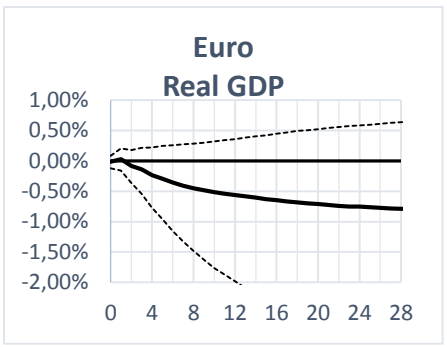

Spain
Real GDP
1,50%
1,00%
0,50%
0,00%
-0,50%
-1,00%
-1,50%
-2,00%
0 4 8 12 16 20 24 28

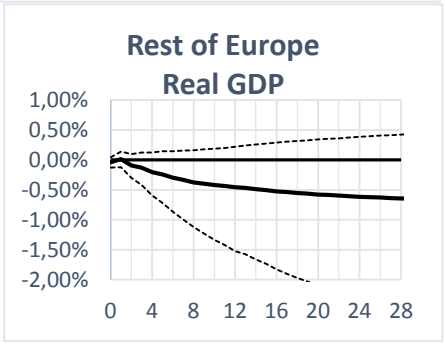

Sweden
Real GDP
1,00%
0,50%
0,00%
-0,50%
-1,00%
-1,50%
-2,00%
0 4 8 12 16 20 24 28

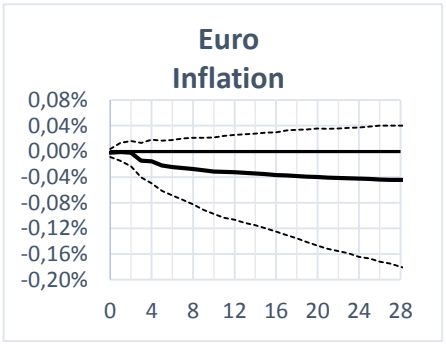

Switzerland
Real GDP
0,50%
0,00%
-0,50%
-1,00%
-1,50%
-2,00%
0 4 8 12 16 20 24 28

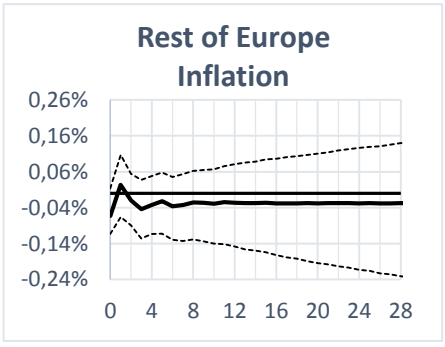

United Kingdom
Real GDP
1,00%
0,50%
0,00%
-0,50%
-1,00%
-1,50%
-2,00%
0 4 8 12 16 20 24 28

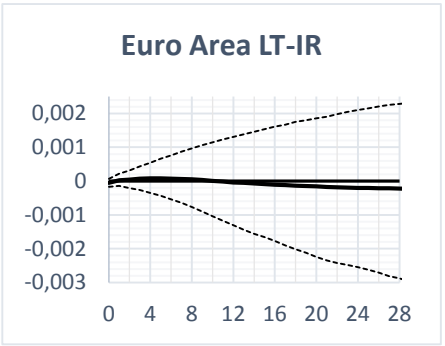

United States
Real GDP
1,00%
0,50%
0,00%
-0,50%
-1,00%
-1,50%
-2,00%
0 4 8 12 16 20 24 28

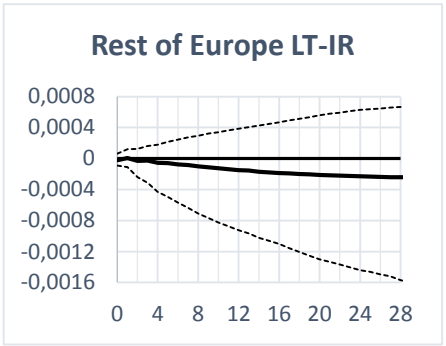

Euro
Real GDP
1,00%
0,50%
0,00%
-0,50%
-1,00%
-1,50%
-2,00%
0 4 8 12 16 20 24 28

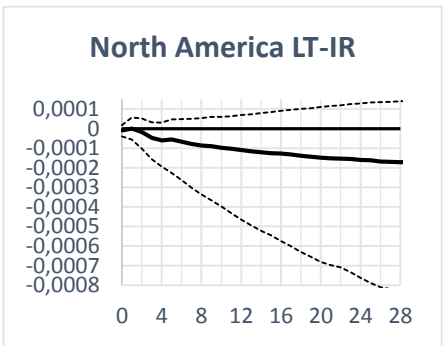

Rest of Europe
Real GDP
1,00%
0,50%
0,00%
-0,50%
-1,00%
-1,50%
-2,00%
0 4 8 12 16 20 24 28


Euro
Inflation
0,08%
0,04%
0,00%
-0,04%
-0,08%
-0,12%
-0,16%
-0,20%
0 4 8 12 16 20 24 28


Rest of Europe
Inflation
0,26%
0,16%
0,06%
-0,04%
-0,14%
-0,24%
0 4 8 12 16 20 24 28


Euro Area LT-IR
0,002
0,001
0
-0,001
-0,002
-0,003
0 4 8 12 16 20 24 28


Rest of Europe LT-IR
0,0008
0,0004
0
-0,0004
-0,0008
-0,0012
-0,0016
0 4 8 12 16 20 24 28


North America LT-IR
0,0001
0
-0,0001
-0,0002
-0,0003
-0,0004
-0,0005
-0,0006
-0,0007
-0,0008
0 4 8 12 16 20 24 28