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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.

JEL-Classification: C50, E61, F15, F42, H60

Keywords: EMU versus "Rest of Europe", fiscal policy coordination, fiscal spillovers, GVAR analysis, regional shocks, impulse response analysis, trade weights

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

by

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Abstract

This paper identifies and measures fiscal spillovers in the EU countries empirically using a global vector autoregression (GVAR) model. 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. We find moderate spillover effects of fiscal policy shocks originating in Germany and France. However, there is significant variation regarding magnitude of the spillovers among destination countries and country clusters. Furthermore, we find some evidence that spillovers generated by German or French fiscal spillovers are stronger for EMU than non-EMU countries in Europe.

JEL codes: C50, E61, F15, F42, H60

Keywords: EMU versus "Rest of Europe", fiscal policy coordination, fiscal spillovers, GVAR analysis, regional shocks, impulse response analysis, trade weights

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1. Introduction

It is undisputed among economists that the growing interdependence due to a common currency and a single monetary policy legitimizes a certain degree of economic policy coordination among Euro area Member States. However, empirical analyses 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 modeling approach has been pioneered by Pesaran et al. (2004) and further contributions such as Dees et al. (2007). It allows consistent modeling 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 are then 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. International interdependencies can thus be modeled in a transparent fashion and in a way that is both consistent with theory and consistent with the data. The recent crisis can serve as a good example of how global economies are highly interlinked via a vast amount of transmission channels demonstrating that foreign and global developments have strong effects on national markets.

Due to a limited amount of observations, econometric approaches, in general, have to keep a close eye on the number of parameters, especially when linkages and spillovers between a large number of countries and regions are to be examined. The GVAR offers a solution to the so-called "curse of dimensionality" by dividing variables into three distinct groups: domestic, foreign and purely global variables. The foreign variables are treated as weakly exogenous and summarize developments in foreign countries and thereby reduce the number of parameters in each VAR model. This assumption needs to be tested and is generally held for most of the countries – with the exception of the US in several models. It is essential for the estimation process, as it allows estimation of the individual country models in a first step. Subsequently, the country-specific VARs are stacked together and simultaneously solved (Di Mauro and Pesaran, 2013).[1]

For our purposes, the individual EU countries, as well as several of the most important international trading partners, can be modeled with a special focus on the effects of either single-country or coordinated fiscal shocks such as increases in fiscal spending. Fiscal variables analyzed 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

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

spillovers of a German fiscal expansion on French GDP (as was the aim of, for instance, Gros and Hobza, 2001, one and a half decades ago). We differentiate between fiscal shocks in individual countries and common Euro area wide shocks which are called "regional" shocks in the GVAR analysis. 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). This is because 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. 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).

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 and reviews 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 will 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

Economic theory suggests that the *justification of fiscal policy coordination* is heavily linked to the existence of cross-border spillover effects. Exogenous shocks in one country are likely to have pronounced effects which are not limited to the domestic economy. (Fiscal) policy decisions can be expected to generate spillover to other countries (as modeled in a GVAR in this paper). Therefore, real economic variables, as well as financial variables, may be influenced via several different transmission channels such as imports, relative prices, the interest rate channel and several others. Of course, the strength of such cross-border effects depends on the amount of economic ties, linkages, and the institutional framework. In a monetary union with a single monetary policy, a common currency/exchange rate and a high level of integration, spillovers can be expected to be particularly substantial (Faini, 2006).[3]

While economic policy coordination reduces the discretionary use of fiscal policy by national governments, it is argued to increase stability in the entire monetary union. One of the main instruments of fiscal policy coordination are fiscal rules. Fiscal rules are not only consistent with the rationale for coordination but are also considered to be an integral component of a monetary union in order to ensure that instability in one country does not destabilize other countries and that monetary policy can be adequate for all member states (Alcidi et al., 2016a).

Frequently, politicians claim that a common fiscal policy is especially beneficial against the background of a common currency. 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). If fiscal policy is regarded as a primary source of shocks, independent fiscal policies allow for the possibility to *diversify macroeconomic risks* (Belke and Gros, 2009a and 2009b). We would like to argue that this view is valid at least in "normal" times but now turn to the quantification of fiscal spillovers in Europe.

Definition of spillovers

Cross-border spillovers are broadly defined as the result of a shock in one economy which is transmitted through a vast number of channels to another economy. The definition illustrates

[3] Blanchard et al. (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 is 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.

that the quality and quantity of spillover effects depend on several dimensions (European Commission, 2014): the transmission channels, the type of shock and the amplification or stabilization 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: A 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 internalizes the consequences of spillover from non-coordinated policies (for an opposing view in normal times, however, see Belke and Gros, 2009a and 2009b). 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 "regional" 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 influence the propagation of national shocks which can either strengthen or weaken cross-border effects (e.g. the degree of trade openness). Obviously, *a high degree of trade openness* can be expected to further increase spillover effects. *Nominal and real rigidities* also play an important role for the amplitude and persistence of spillover effects, affecting the adjustment to shocks (European Commission, 2014).

Regarding financial spillovers, their extent depends on a large variety of 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, *governance structure, fiscal* and *monetary policy regime* (continuity, in particular, the existence or absence of supranational risk sharing mechanisms) appear to play a major role. Some even mention *distance* and *common language* in this context (Bankowski, 2016, Georgiadis and Hollmayr (2016), Slide 10: Determinants of spillovers).

Finally, the stance of monetary policy is also expected to influence spillover effects (Elekdag and Muir, 2014, Gadatsch et al., 2016): Simulations depicted by In't Veld (2016) generate evidence that debt-financed increases in government investment in surplus countries have stronger positive GDP spillovers to other member states of the Euro area when monetary policy rates are held constant (e.g. when monetary policy is operating at the lower zero bound) (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 impulse in one economy can affect other economies via *multiple channels*. The primary channels reviewed in the literature are the *demand channel* (also called trade channel), the *competitiveness channel* (also called terms of trade channel) and the *financial markets channel*. (Alcidi et al, 2016a). 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 emphasized the most (In't Veld, 2016). As fiscal policy actions influence domestic demand, this should also affect (domestic) demand for foreign goods and thereby (net-) exports of trading 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 et al., 2016b, 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". Under a regime of flexible exchange rates, a fiscal expansion increases domestic economic activity and also generates pressure on the exchange rate to appreciate and the domestic interest rate to increase.

[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.

In a monetary union, the exchange rate (between the member states) is fixed while the interest rate is not determined at national, but union level. When domestic money under circulation increases, this stimulates domestic output. The subsequent increase in domestic output raises imports and therefore also the income of other countries.

The *competitiveness channel* represents the second potential channel of fiscal spillovers. Its first variants are 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 the 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-neighbor" argument for policy coordination which makes possible the internalization of the negative spillover from fiscal policies through these channels. It is also important to realize 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 decreased due to worsening trade balances.

The *competitiveness channel* may be relevant for so-called structural fiscal policies. Due to distortionary taxation, fiscal policies are likely to influence relative prices and therefore the terms of trade (Ferrero, 2009). Furthermore, fiscal policies can be designed to primarily target the terms of trade. Such a policy is called fiscal devaluation and describes a policy which for example leads to an increase in VAT while payroll taxes are reduced (Alcidi et al., 2016b). Structural fiscal policies – apart from fiscal devaluation – which increase the labor supply may also generate spillover effects via the competitiveness channel (Alcidi et al., 2016, European Commission, 2014).

A couple of distinct mechanisms are related to the *financial market channel*. The typical and primary transmission mechanism are interest rates in different market segments as well as policy rates. A currently important mechanism is that excessive government borrowing in one country can increase risk premia of sovereign debt in other member states of a monetary union. Markets may anticipate that a commitment to a no bail-out rule is not credible implying that member countries are to some extent liable for the sovereign debt of all other member countries. However, even if the commitment is credible, the risk of financial contagion may increase risk premia in other countries – particularly via weakened financial intermediation. Spillover effects might be especially substantial when sovereign debt is at a high level and the additional fiscal expansion is debt-financed. To a certain extent, these concerns are also relevant for private debt not only because it has partly become public debt during the financial crisis (Alcidi et al., 2016b and Thirion, 2016, Caporale and Girardi, 2011, European Commission, 2014).

The working mechanisms 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, financial integration has led to increased cross-border banking exposure.

Therefore, foreign claims of banks may work as amplifiers of fiscal policy shocks (Alcidi et al., 2016a, Caporale and Girardi, 2011, European Commission, 2014).

Another important aspect is the relation between *self-fulfilling government debt crises and central banks acting as lenders of last resort for governments*.[5] According to Aguiar et al. (2015), there is a fiscal externality. Their argument contains that a small country of a monetary union might ignore the impact its borrowing decisions on inflation expectations via the credibility of the central bank's inflation target (Alcidi et al., 2016a).

Quantifying fiscal spillover effects

From a theoretical perspective, the demand for fiscal coordination is based on the existence of cross-border spillovers combined with some type of market imperfections. In order to identify and measure cross-border spillovers, it is essential to pay attention to the condition of the economy and underlying market frictions. However, the quantification of spillovers remains challenging in practice and the literature does not deliver a clear-cut answer. In the following, we present empirical results of the literature and focus on differences between the empirical approaches (for a much larger survey of the non-GVAR literature see Alcidi et al., 2016a)

In't Veld (2016) depicts several model simulations which confirm that a debt-financed increase in government investment (in surplus countries) will have positive output spillovers to the rest of the Euro area. The results indicate that spillovers are especially large if monetary policy operates at a fixed interest rate floor (e.g. at the lower zero bound). The results of the model simulations show that an increase in productive spending in Germany and the Netherlands can not only raise output in these countries but also have substantial positive cross-border effects on the remaining member states of the EMU, while the effects on current accounts are likely to be small. The effects can be strongly facilitated by directing investments to the most profitable projects. Due to the historically low cost of borrowing, debt-financed fiscal actions by surplus countries will only cause small increases in government debt but might generate an improvement in debt ratios in the rest of the Euro area. Similar results are derived by Bundesbank (2016).

Given the need to upgrade and replace aging infrastructure, higher German public investment is demanded by Elekdag and Muir (2014). The authors argue that this will not only generate short-term effects by increasing domestic demand and reducing the current account surplus but will also increase output in the long-run as well as generate *beneficial regional spillovers*. In the background of an accommodative monetary policy stance, the expansionary effects of higher public investment are further strengthened. 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

[5] See De Grauwe (2011) for a detailed discussion on this issue.

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 for 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 "regional" 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 factorization 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 weakly 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 underlining 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 et al. (2007) and Pesaran et al. (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[6] *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 the 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 that 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 modeling 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 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 visualize in section 4 based on so-called heat maps. The impacts of global shocks show a significant degree of similarity

[6] 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.

in, as the authors express it, "the cyclical behavior 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 are subject 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 (e.g. 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.[7]

The following studies are less close to ours because they 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.

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 utilize 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. A shock to government consumption in a (large) country whose government bonds are considered as nearly risk-free generates a boost to equity prices and government bond yields on the domestically and the international

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

level. Conversely, for peripheral countries, a shock to government consumption causes an increase in domestic government bond yields and decreases yields in larger neighboring countries with risk-free government bonds. While fiscal spending increases, equity prices in peripheral countries decrease. 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 modeling 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 modeling 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 modeling 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 create 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 impact of fiscal policies is 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 reduces 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 modelers 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. Large differences in the results of simulations with respect to the size and sometimes also the sign of spillovers makes it very difficult to determine the domestic and cross-border effects of economic policies. This makes the coordination very complicated and maybe 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 most cases, their absolute size is rather small. However, when the average figures are disaggregated, it becomes evident that spillovers vary considerably among countries – not only with respect to the magnitude but also to the 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 estimate a GVAR model for the following 20 countries: Austria, Australia, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States. These countries have been carefully selected: according to the latest statistics, in 2015, they accounted for roughly 45% of global GDP measured in purchasing power parity (PPP) terms. Due to our research question, we primarily focus our analysis on European countries. However, we did not take into account further economies that belong to the EU28 because data availability is limited to a short period, or statistical quality does not comply with required standards.

Our estimation period ranges from 1995Q1 to 2015Q4. We do not include earlier observations in order to avoid the modeling of too many structural breaks (e.g. the German reunification etc.).

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

As a measure of price developments, we use the GDP deflator (*defl*). 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 is not available for all countries under observation, we use data from the OECD[11] for the remaining countries.

The 10-year interest yield (*ltir*) 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.[12]

As fiscal variables, we use nominal fiscal expenditure (*exp*) and fiscal revenue (*rev*) as percent of nominal GDP. Both variables are obtained from Oxford Economics. We find evidence of seasonality for the time series of Germany, the Netherlands, Portugal, Switzerland, the UK and the US. The procedure developed 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.[13] Because only annual data is available for this variable, cubic spline interpolation is used to obtain quarterly data.

Additionally, we include exchange rate indices published by the Bank of international Settlements (BIS) in our basic specifications. According to the BIS, the (broad) indices comprise of

[8] Concept: GDP, real index, quarterly, seasonally adjusted, base year (2010=100).
[9] Concept: GDP, VIXOBSA, Volume Index, OECD reference year (=2010), seasonally adjusted.
[10] Concept: GDP, Deflator, Seasonally adjusted, Index.
[11] Concept: DOBSA, Deflator, OECD reference year (=2010), seasonally adjusted.
[12] We do not include the long-term interest rate for Greece because its gyrations are in significant sub-time periods (Troika programs, see Alcidi et al., 2016) not market-based and could not be dealt with and corrected within our estimated GVAR model. Other studies in the field are proceeding similarly (see, for instance, Ricci-Risquete and Ramajo-Hernández, 2015).
[13] Variable code: NLGXQA.

61 countries and are calculated as geometric weighted averages of the bilateral exchange rate. As we use of real indices, the 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 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).

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 published by the IMF Direction of Trade Statistics database. It can of course not be ruled out 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).

For the construction of regions and therefore the aggregation of country-specific VARs, 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[14].

3.2 The global vector autoregressive (GVAR) framework

The GVAR framework combines the estimation of country-specific VECM models which include national as well as foreign variables. Due to the curse of dimensionality, 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.[15]

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:

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

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

[15] 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 et al. (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.

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. As depicted by Dees et al. (2007), x_{it}^* is assumed to be „long-run forcing" for x_{it} implying that the error correction terms of the country-specific VECMX* models do not significantly affect x_{it}^*. This aspect is closely connected with 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 with the assumption that all countries are small relative to the 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:

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

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:

$$z_{it} = W_i x_t \tag{4}$$

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 analyze the effects of a shock to a domestic variable in country i on other domestic variables as well as 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 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 analyze 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 generalized impulse response functions. These impulse responses, though broadly interpretable, are informative and capture overall spillover effects (Hebous and Zimmermann, 2013)

3.3 Estimation of Generalised Impulse response functions

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. GIRFs are used by the large majority of GVAR studies (see, for instance, Dees et al., 2007).

The GIRF is an alternative to the Orthogonalized Impulse Response Function (OIRF) of Sims (1980). The OIRF approach requires the impulse responses to be computed with respect to a set of orthogonalized shocks, while the GIRF 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 OIRF, 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.[16] Hence, we decided to summarize the dynamic of the macroeconomic variables in the system following a domestic or regional 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 fiscal policy showing the transmission of shocks to the local economy and also to other countries in the sample (Ricci-Risquete and Ramajo-Hernández, 2015). However, one needs to be cautious when interpreting the effect of shocks using GIRFs as they do not exclude the possibility of a correlation of the error terms.

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

Formally, the GIRF represents 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:

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

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

3.4 Shock selection

As we do not use a single synthetic indicator of the stance of public finances in our benchmark model and model government spending and revenue separately, we are able to analyze the effects of each fiscal policy in a more comprehensive manner. Although we focus on restrictive fiscal policy shocks, it can be expected that the precise effects of a fiscal shock differ depending on whether the shock is triggered by a change in spending or on the revenue side. The importance of jointly modeling both public revenue and public expenditure has often been discussed in the literature and is straightforward (Blanchard and Perotti, 2002).[17] In our analysis, we only analyze contractionary fiscal policy shocks.

Regarding the origin of shocks, we differentiate between national and regional shocks. We are shocking a single country's fiscal policies (Germany, France) and, secondly, investigate so-called "regional" fiscal policy shocks in the Euro area. To be more specific, we employ the GIRFs in order to analyze the dynamic effects of the following shocks:

(1) Negative shock "Change in Government Expenditure" in Germany

(2) Positive shock "Change in Government Revenue" in Germany

(3) Negative shock "Change in Government Expenditure" in France

(4) Positive shock "Change in Government Revenue" in France

(5) Negative shock "Change in Government Expenditure" in the Euro area

(6) Positive shock "Change in Government Revenue" in the Euro area

The magnitude of each shock listed above is one standard error.

We analyze the effects on each individual country as well as the entire regions. The regions used are the "Euro area" containing the countries of the EMU, the region called "Rest of Europe" comprising European countries which are not part of the EMU. In this regard, the latter country group is supposed to represent countries which are part of or at least affiliated with the EU but not part of the Euro area. The small region of "North America" contains only Canada and the US.

Since each economy is potentially related to the others, these simulations will determine the degree of international spillovers. Regarding the country-individual shocks, the country where the shock originates is temporarily excluded from the region "Euro area". This allows us to interpret the impulse response for the Euro area as the sum of true spillover effects to the members of the EMU. Otherwise, if the country was still be part of the region, the spillover effects would be mixed up with the effects in the economy where the shock originates.

[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."

A central focus of our analysis is on impulse responses following a Euro area-wide budget deficit or surplus ("austerity", "fiscal compact"). A regional shock of a given variable is not focused on a particular economy, but simultaneously occurs in every country of a predefined region. As pointed out by Dees et al. (2007), a "regional" 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 "regional" 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).

Assessing "regional" shocks is legitimate in countries where public sector balances co-move with those of 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. Therefore, the "regional shock" is defined with respect to the Euro area only, thus excluding the United States and other non-European countries (Dragomirescu-Gaina and Philippas, 2015).

4. Empirical Results

4.1 Unit Root Tests

Although the GVAR methodology can be applied to stationary and/or integrated variables, we follow Pesaran et al. (2004) 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 (cointegrating) relations (Dees et al., 2007). Therefore, we 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

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

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	-10.54	-4.062
Δrev		-6.853	-4.606		-6.280	-4.621	-3.680	-10.19	-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 for the domestic variables of Greece, Ireland, Italy, Portugal and the UK. We perform additional tests (e.g. Phillips-Perron tests) and obtain 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 start 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 increase the maximum to 4 respectively 2 lags. In Table 2, we present the lag length used in the estimation process which is primarily based on the results of residual autocorrelation tests.[19] When we detected more than one lag combinations which did not indicate residual autocorrelation at the 5% level, the choice was based on the results of the Schwarz-

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

Bayesian information criterion. Overall, the weak evidence of serial correlation in the residual for our benchmark specification.

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 et al. (2000). Additionally, we use the eigenvalues and the persistence profiles (PPs) which refer to the time profiles of the effects of variable-specific shocks on the cointegrating relations in the GVAR model. Therefore, the PPs are used in order to observe the convergence behavior of the assumed number of cointegrating relations in the country model.

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 axillary regressions 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 realizations 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 variable might be violated in the US model. Therefore, we exclude the foreign "star" variables for the long-term interest rate and the inflation rate from the US model. For real GDP, we find no evidence of a violation of the weak exogeneity assumption. For Germany, we find larger evidence that the foreign real GDP variable is not weakly exogenous. Although Germany's weight is significantly smaller than that of the US, it might be more important for the economic development of the countries in our sample because we focus almost entirely on European countries. Therefore, we exclude the foreign real GDP variable from the German model.[20]

As our analysis focuses on the interpretation of the GIRFs, we feel confident that our model is overall well specified. For the estimation of the GIRFs, we simulated the model by using bootstrap procedures. We use 2500 draws to obtain median estimates as well as the confidence intervals. Because of a large number of endogenous variables and data limitations due to our relatively small sample, we performed shrinkage on the correlation matrix for point and bootstrap estimates as well as data generation.

The GIRFs presented in the Figures 1 to 6 primarily reflect the effects on domestic *rgdp*. 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 horizontal axis shows the time horizon, whereas the vertical axis measures the response of each variable (in percentage change) for each country

4.3 Global VAR estimations

4.3.1. Shock to German government total expenditure

The GIRFs for a one percentage point negative shock to German government total expenditure are presented in Figure 1.[21] The negative German government total expenditure shock is accompanied by a significant decline in German real GDP of around 0.81% after four quarters and by 1.02% after 8 quarters (see Figure 1).

The transmission of the shock to the regional and country-specific 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 resembles those in comparable GVAR studies as those of Dees et al. (2007) and of Ricci-Risquete and Ramajo-Hernández (2015). The impulse responses stabilise after 8-12 depending in most cases indicating that our model is stable. For most countries, the effect becomes insignificant after four to six quarters. Therefore, we mainly focus our analysis on the effect after four quarters and therefore on the short-run effects of the German shock.[22]

Regarding fiscal spillovers to specific countries to the individual Euro area countries, we find the strongest effects for Finland (-0.98%), Ireland (-0.81%) and the Netherlands (-0.58%). Furthermore, we estimate relatively moderate effects on Italy and Austria (both: -0.51%). Weaker effects are found for France (-0.41%), Spain (-0.43%) and Portugal (-0.45%). As somehow expected, the effect on Greek real GDP is not significant at all and of very low magnitude (-0.30%). Surprisingly, the effect on Belgian GDP (-0.35%) is also relatively low and barely

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

[21] The shock has been rescaled to match a decrease of one percentage point.

[22] The following values in brackets in this section represent the accumulated effect on real GDP after four quarters if not stated otherwise.

significant after four quarters. The GDP-weighted effect on the Euro area (not including Germany) is about -0.48%.

Regarding the effects on European countries which are not part of the Euro area, we observe, somehow surprisingly, the strongest effects for Sweden (-0.77%) followed by the effect on Danish real GDP (-0.59%). Weaker effects are found for the United Kingdom (-0.39%) and Switzerland (-0.30%). The weakest effect is identified for Norway (-0.25%). The overall GDP-weighted impact on the region "Rest of Europe" (-0.42%) can be compared with the effect on the Euro area in terms of magnitude and significance.

Overall, we do *not* find evidence in favor of *the expansionary fiscal contraction hypothesis* (Giavazzi and Pagano, 1990, De Castro, 2006, and Kameda, 2012). Regarding the comparisons between effects on EMU countries and other European countries, we find some evidence that spillovers in the monetary union are stronger. This empirical pattern arises primarily from a comparison of the individual country shocks. Apart from a surprisingly strong effect on Swedish GDP, the spillover effects on non-EMU countries are relatively low compared to member states of the EMU. For example, according to the intense trade and financial relationships, we would have expected that spillovers from a German fiscal shock to be more important for Switzerland than Italy or Finland. This aspect is partly, although to a much lesser extent, reflected by the larger effect on the region "Euro area" compared to the effect on the "Rest of Europe". This may mirror the (amplifying) effect of a common monetary policy in the Euro area. However, we find a large amount of heterogeneity regarding spillover effects within the Euro area. In our opinion, this heterogeneity can be explained by trade relationships to a larg(er) extent. 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.

Our empirical results are somehow comparable 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). We have chosen to present two maps, one of them showing the results of Georgiadis and Hollmayr (2016) and the other one presents our own results. Both graphs in Figure 7 show the magnitude of spillovers of a fiscal shock in Germany (defined as the absolute mean estimates GIRFS after two respectively four quarters) to other European countries.[23]

In general, we find higher spillovers compared with the results of Georgiadis/Hollmayr (2016). In their study, the authors only find "moderate" spillover for the UK and partly for France and Italy. Putting our results into perspective, the most drastic differences can be found for Finland, Sweden and Ireland. While we find (very) large effects on these countries, Georgiadis/Hollmayr (2016) on the other hand find very low spillover. Furthermore, out results indicate rather low spillovers to the UK.

Regarding the effects on inflation, we observe a decrease in the Euro area and in the "Rest of Europe" 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). For interest rates, we observe no significant effect on Euro area long-term Interest rates, while we find negative impacts on interest rates in North America and Rest of Europe which are significant but very low in magnitude (between 1-3 basis points of quarterly interest rates (4-12 basis points of annual interest rates)[24].

[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.

[24] 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

4.3.2 Shock to French government total expenditure

Figure 2 presents the GIRFs of a negative one percentage point shock to French government total expenditure. It results in a decrease of 0.68 percentage points decrease in French real GDP after four quarters

The pattern of the results turns out to be rather similar to the German fiscal shock. Again, for the majority of countries, the shock is significant on impact and remains significant until around 6 quarters. However, the magnitudes clearly differ from those for the German fiscal shock as they are smaller in general. We again focus on the accumulated effects after 4 quarters and primarily on the relative size of effects between countries and regions.

Regarding the effects on the Euro area, the strongest effects are observed for Germany (-0.47%), Ireland (-0.46%) and the Netherlands (-0.38%). Relatively mediocre effects are found for Austria (-0.29%), Italy (-0.27%), Portugal (-0.29%) and Spain (-0.30%). Weaker effects are found for Finland (-0.22%) and surprisingly Belgium (-0.23%). Again, we find the weakest spillover for Greek real GDP (-0.21%) after four quarters which is already insignificant after 4 quarters. The effect on the real GDP in the Euro area (not including France) measuring the GDP-weighted spillover to the Euro area is about 0.35%.

Similar to the results of the German shock, we find the strongest effects for Sweden (-0.43%) and Denmark (-0.36%) regarding the remaining European countries. Medium effects are found for Switzerland (-0.29%) and the UK (-0.23%). Weakest effects are again found for Norway (-0.17%). Overall, the GDP-weighted spillover to region “Rest of Europe” is 0.26%.

Overall, we find again stronger effects within the EMU compared to the “Rest of Europe”. Concerning fiscal spillovers to specific countries, the effects on Southern EMU member countries such as Spain and Portugal relatively more pronounced than in the case of a German fiscal shock. Again 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. This again our results indicate evidence of the (amplifying) effect of a common monetary policy in the Euro area. Comparing the French and the German shock, we overall find stronger spillover effects for the German shock on GDP of European Countries.

Regarding the impact on inflation and interest rates, French inflation decreased significant on impact while Euro area inflation is negatively but not significantly affected. We observe significant effects on the inflation rate in “Rest of Europe”. However, the magnitudes are very low. The impact on interest rates is negative but not significant for the Euro area und North America but we find evidence of a small significant decrease of interest rates in “Rest of Europe”.

4.3.3 Shock to German total public revenue

The GIRFs results of a positive percentage point 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.

The lack of significance 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). [25] Taking this as a starting point, Ricci-Risquete and

basis points of the quarterly yield. In order to obtain annual yield effects, the responses have to be multiplied by 4.

[25] This phenomenon is well-known in the general GVAR literature (see Dees et al., 2007) and particularly from the fiscal spillover GVAR literature (Dragomirescu-Gaina and Philippas, 2015, and Ricci-Risquete and Ramajo-Hernández, 2015).

Ramajo-Hernández (2015), Georgidas and Hollmayr, 2016, Hebous and Zimmermann (2013) and Nickel and Vansteenkiste (2013) 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). Therefore, we continue with interpreting the mean estimates with a special focus on the effects after 6 periods. However, our results have to be interpreted with caution due to the issues regarding the significance discussed above.

We choose to compare the effects after 4 periods in order to remain a certain degree of comparability with respect our previous estimates. However, by choosing to analyze the effects after 4 periods, we risk to neglect some of the effects as shocks to fiscal revenue (e.g. by changing taxes) can be expected to affect the economy not as fast as a change in spending. 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. This aspect is supported by our results as the impulses take longer to stabilize. Therefore, we also include the effect after 8 periods in our analysis. However, relative strength of spillovers across countries is generally invariant as the relative effects after four, six and eight quarters are very similar.

Comparing our results with the German fiscal spending shock, we find a similar ranking in terms of spillover for the countries of the Euro area magnitudes indicating that our results are results are overall robust with respect to the source of the fiscal shock. The strongest effects are again found for Finland (Q4:0.59%, Q8:0.889%), Ireland (Q4:0.349%, Q8:0.698%) and the Netherlands (Q4:0.318%, Q8:0.628%). Medium-size effects are found for Austria (Q4:0.252%, Q8:0.449%), Spain (Q4:0.274%, Q8:0.511%), France (Q4:0.245%, Q8:0.433%), Italy (Q4:0.239%, Q8:0.376%) and Portugal (Q4:0.230%, Q8: 0.467%). Again, the weakest effects are found for Greece (Q4:0.102%, Q8:0.344%) and Belgium (Q4:0.105%, Q8:0.248%). The GDP-weighted spillover on the Euro area (not including Germany) is around 0.252% after four quarter and 0.450% after eight quarters.

With regard to the remaining European countries, we observe some changes in the ranking of spillover magnitudes. The largest effect of a positive shock to German fiscal revenue is on the Swiss real GDP (Q4:0.473%, Q8:0.794%). This is a striking contrast to the previous results for the shock on fiscal spending in Germany. However, in accordance with the previous results, the effects on the Scandinavian countries of Sweden (Q4:0.401%, Q8:0.630%)) and Denmark (Q4:0.303%, Q8:0.494%) are again high. The effect on the UK is rather limited (Q4:0.167%, Q8:0.324%) and the weakest impact is observed for the Norwegian real GDP (Q4:0.167%, Q4:0.249%). The GDP-weighted spillover to the region “Rest of Europe” is about 0.234% (0.415%) after 4 periods (8 periods).

Overall, we observe similar results compared with the previous shock to German fiscal spending. The biggest difference is apparent for Switzerland. Furthermore, the Swiss response is the only one which is significant after four and even eight periods. As theoretically expected, a revenue shock appears to take longer to affect the domestic and foreign economies. However, the overall effect of both shocks are similar in magnitude in the medium-run. The impacts on inflation rates and interest rates are negative as expected but not significant and very low in magnitude.

4.3.4 Shock to French total public revenue

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

Again, the revenue shock needs more time to become effective than the fiscal expenditure shock, as expected from theory. However, the expected negative effect materializes for all countries and regions and appears to stabilize much faster compared with our results in 4.3.3. The effects are significant throughout – which should be emphasized with an eye on our brief discussion in section 4.3.3 about the meaning of insignificance in the fiscal spillover GVAR context.[26]

Regarding the effects on the Euro area, the strongest effects are observed for Ireland (Q4:0.38%, Q8:0.57%), and Finland (Q4:0.34%, Q8:0.45%) followed by Italy (Q4:0.30%, Q8:0.41%), Germany (Q4:0.27%, Q8:0.42%) and the Netherlands (Q4:0.25%, Q8:0.43%). Weaker effects are found for Greece (Q4:0.23%, Q4:0.43%) Portugal (Q4:0.20%, Q8:0.34%), Spain (Q4:0.19%, Q8:0.39%), Belgium (Q4:0.19%, Q8:0.27%) and Austria (Q4:0.18%, Q8:0.28%), the effect on the real GDP in the Euro area (not including France) measuring the GDP-weighted spillover to the Euro area is about 0.2% (Q8:0.26%).

We find the strongest effects for Sweden (Q4:0.42%, Q8:0.43%) and Denmark (Q4:0.21%, Q8:0.34%)) regarding the remaining European countries. Medium effects are found for Switzerland (Q4:0.16%, Q8:0.31%) and the UK (Q4:0.16%, Q8:0.26%). Weakest effects are again found for Norway (Q4:0.12%, Q8:0.20 %). Overall, the GDP-weighted spillover to region "Rest of Europe" is 0.14% (Q8:0.19%).

Comparing the results with our findings for a French spending shock, the find a similar ranking with only a small number of changes regarding relative magnitudes of spillover. For Euro area countries, we again find the strongest effects for Ireland, the Netherlands and Germany. For the latter, the effects are a little smaller compared to the spending shock. For Italy and Greece, the spillover effects of a revenue shock are larger. For the remaining countries, we observe a similar pattern. Regarding the effects on non-EMU countries in Europe, the effects are very similar across countries.

Similar to the French spending shock, we overall find stronger effects on EMU countries. The effects of the spending shock appear to be stronger even when we take into account that revenue shocks might take longer to fully generate their effects on the economies. Regarding EMU countries, we observe some marginal changes. In comparison to the German revenue shock, the North-South divide is less strongly visible.

4.3.5 "Regional" shock to total public expenditure

The GIRFs for a "regional" shock to total public expenditure are presented in Figure 5. Therefore, fiscal expenditure in all countries in the EMU are simultaneously shocked based on the country's GDP share of total regional GDP. Therefore, it is not possible to observe spillovers directly but we obtain an impression of the effects of a coordinated shock to Euro area fiscal expenditure.

Our results indicate 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 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. 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.

[26] 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.

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 favor of the expansionary fiscal contraction hypothesis.

Regarding an evaluation of the effects, we again focus on the effect after 4 quarters. The largest effects are visible for Finland (-1.182%), Ireland (-1.04%) and Germany (-0.961%). Strong effects are also observable for Italy (-0.759%), the Netherlands (0.734%). Weaker effects are found for Austria (-0.585%), Portugal (-0.562%) and Spain (-0.541). The lowest effects are again found for Greece (-0.386%) and Belgium (-0.528%). Overall, we obtain a GDP-weighted impact on Euro area GDP of -0.753%.

For non-EMU countries, Sweden is most strongly affected (-0.911%) followed by Denmark (-0.692%). Like before, the effects on the UK (-0.482%) and especially Norway (-0.355%) are relatively weak. The overall effect on the region "Rest of Europe is -0.5352.

Interpreting our results, it is not surprising that the overall effects on EMU countries are higher compared to non-EMU countries as the shocks originate in the EMU. However, the effects on non-EMU countries are relatively high. Therefore, we interpret our results as evidence of a strong dependency of European countries outside the EMU on developments within 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 as an immediate 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). 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.

The effect on interest rates is larger and with respect to the "Rest of Europe" and "North America significant. For "North America", the annual interest rate reduction is about 6 basis points after 4 quarter (up to 12 basis points for "Rest of Europe"). For the Euro area, the effect is not significant but up to 12 basis points after 4 lags.

4.3.6 "Regional" shock to total public revenue

Let us finally turn to the GIRFs for a 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 turns out to be negative overall, as theoretically expected. However, there is a lack of significance throughout. One exception is again Switzerland. As before, we focus on the median estimates. Again, the results have to be interpreted with caution.

The biggest effects are again on Finland (Q4:0.454, Q8: 0.793), Germany (Q4:0.372, Q8: 0.605) Ireland (Q4: 0.302, Q8: 0.596) and the Netherlands (Q4:0.267, Q8:0.500). Medium-size effects

are found for Austria (Q4:0.213, Q8:0.373), France (Q4:0.214, Q8:0.373), Portugal (Q4:0.201, Q8: 0.408) and Spain 0.178, 0.463. The weakest effects are obtained for Italy (Q4: 0.129, Q8: 0.330), Beldium (Q4:0.077, Q8:0.213) and, again, Greece (Q4:0.07, Q8: 0.280). The overall effect on the Euro area is 0.238 (Q8: 0.452).

For Switzerland, we find a very strong effect after four and 8 quarters (0.445 respectively 0.729). For Sweden (Q4:0.343, Q8: 0.557) and Denmark (Q4: 0.261, Q8: 0.446) the effects are high as well. Like before, for the UK (Q4: 0.144, Q8:0.289 and especially for Norway (Q4: 0.126, Q8:0.230) the effects are pretty weak. As expected, the effects on the region "Rest of Europe" (Q4:0.206, Q8:0.373) are smaller than on the EMU.

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

To summarize, 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, may remain at levels that might seem to be under the threshold of policymakers' attention. In this regard, we corroborate the conclusions by Gros and Hobza (2001).

The 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 4.3.1 for the fiscal spillovers to Finland, Ireland, vis-à-vis the domestic effect of a cut in German public expenditure). However, since the domestic fiscal policy multiplier is already rather high (due to the zero interest rate policies), the absolute size of spillovers cannot not grow further considerably (Auerbach and Gorodnichenko, 2015, and Gros and Hobza, 2001).

In general, the results of our GVAR analysis confirm the theoretically-based hypothesis that the absolute size of short-run cross-border externalities is in the cases of most of the financially distressed countries such as Greece, Spain and Portugal 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. 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.

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 a bit more delayed when fiscal expansion through a reduction in government expenditure was considered (contrary to what was assumed by Gros and Hobza, 2001).

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). Our results indicate that *spillovers of fiscal shocks originating in EMU countries are much larger for EMU destinations*

than for destinations located in the "Rest of the EU". However, we cannot answer the question whether it is a results of the common currency or simply because of higher economic ties (e.g. trade relationships).[27]

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.

The results are overall roughly similar across the country-specific shocks. In most cases, the effects are very lower for each of our (aggregated) regions. In most cases, the effect on annual interest rates is far below 10 basis points. Regarding the significance, the effects on "North America" and "Rest of Europe" are more often significant. 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 12 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.

4.5 Robustness checks

An important caveat that one needs to keep in mind is the strong influence of assumptions under which the GVAR analysis is run on the empirical results. This caveat is related to the way in which the 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 to model 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 program countries (Alcidi et al., 2016).

[27] Of course, higher economic ties might also be the results of the common currency.

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). 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 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).

The results of our structural break tests are displayed in Table 4.[28] Overall, not surprisingly there is evidence of structural instability to 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). 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 there is some indication of a break. With this good result, our study ranges at the lower bound of GVAR estimations available in the literature.[29]

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). Seen on the whole, thus, we feel legitimized to interpret our estimated GVAR model as structurally stable and as a suitable workhorse to estimate fiscal spillovers.

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 heteroscedasticity 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-periods 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).

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

[29] 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.

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 not 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 decentralized policy actions provides a rationale for centralizing or at least co-ordinate the decision-making of a certain policy area (Alcidi et al., 2016). A necessary but not sufficient condition for the latter is a thorough quantification of the fiscal spillovers in Europe. One valuable application of the results gained by our paper would be to link it to the policy debate about the recommendation for Germany to conduct an expansionary fiscal policy to provide relief to other countries in recession, such as Italy.[30]

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 modeled 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.

Seen on the whole, we find moderate spillover effects of fiscal policy shocks originating in Germany or France. However, there is significant variation regarding magnitude of the spillovers among destination countries and country clusters. Spillovers of a German fiscal expenditure shock are strongest on Finland, Ireland, the Netherlands (about 0.6-0.8) and Sweden, followed by Austria and Italy (about 0.5). Notably, the effects on France are of medium size (0.4). Regarding the overall pattern of the results, we thus corroborate the empirical results presented by Georgiadis and Hollmayr (2016), among others.

What is more, the effects of fiscal spillovers originating in Germany or France are higher for euro area member countries than for non-member countries. Spillovers to the South of the Euro area are higher if the fiscal shock originates in France than we deal with a German fiscal shock. Effects from France to the South of the Euro area stronger than those originating in Germany. Finally, our empirical results reveal a notable asymmetry between France and Germany. In the case of a French fiscal spending shock the highest spillovers are those to Germany, Ireland and the Netherlands. However, as stated above, the spillovers of a German fiscal expenditure shock on French GDP, in turn, are of average size, albeit significant.

This paper contributes to the literature in several ways. Firstly, papers using GVAR for studying coordinated fiscal policies are still scarce. Secondly, unlike other GVAR models with fiscal

[30] See https://ec.europa.eu/epsc/publications/strategic-notes/towards-positive-euro-area-fiscal-stance_en.

variables, 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 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 modeling of the central banks). In addition, we could try to include more endogenous country variables in the GVAR. However, these endeavors 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 modeling the ECB as a separate entity which would be a superior way to incorporate the euro area-wide interest rate.

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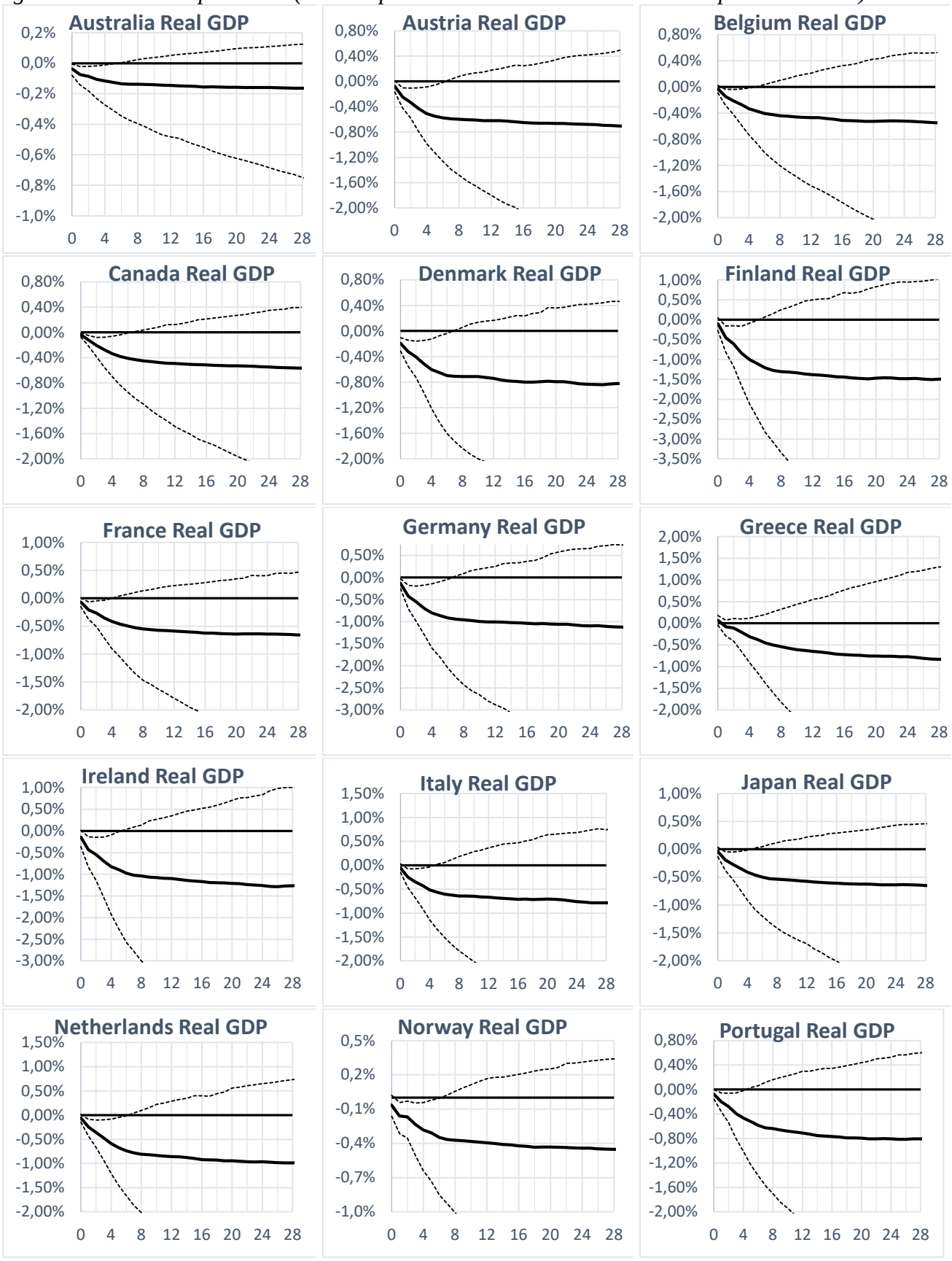
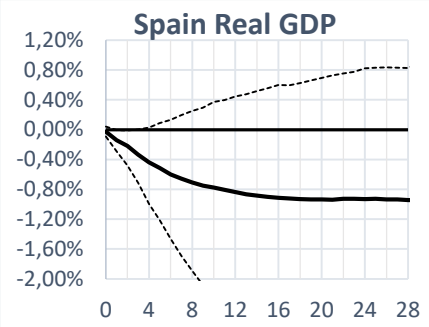
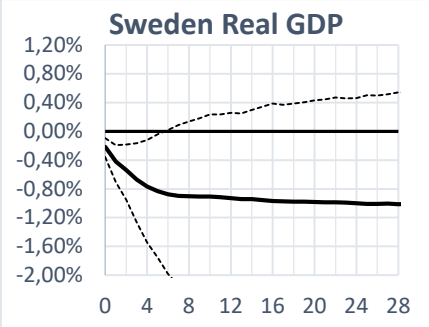
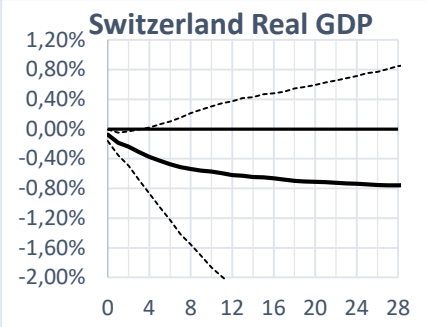
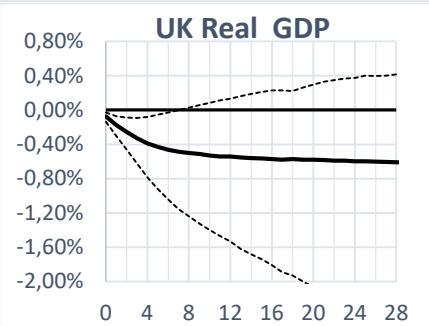
Figure 1. *Generalized impulse responses of a negative one percentage point shock to German government total expenditure (bootstrap mean estimates with 80% bootstrap error bounds)*

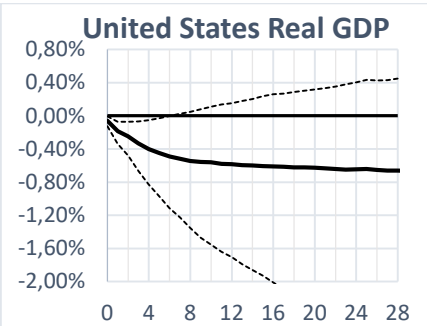


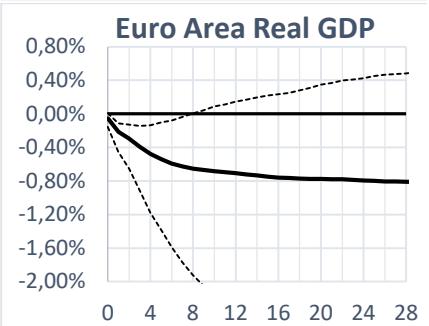

Spain Real GDP
1,20%
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

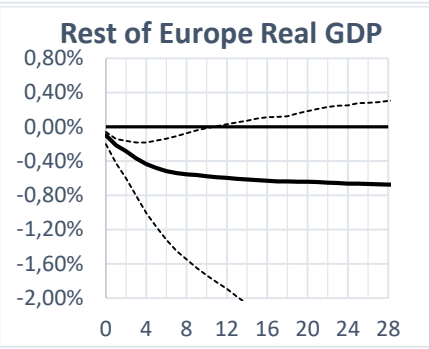

Sweden Real GDP
1,20%
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

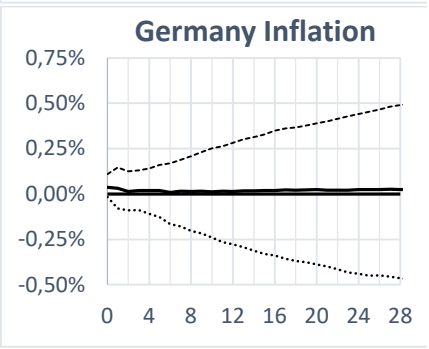

Switzerland Real GDP
1,20%
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

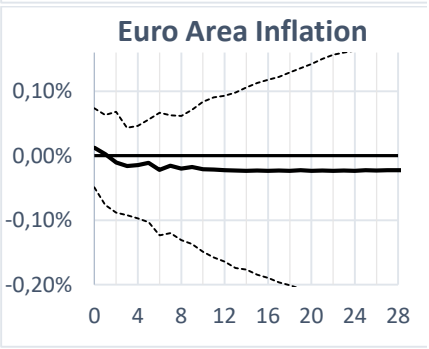

UK Real GDP
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

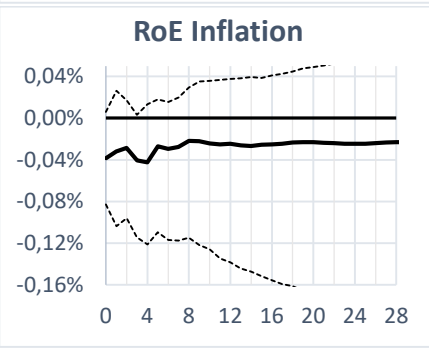

United States Real GDP
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

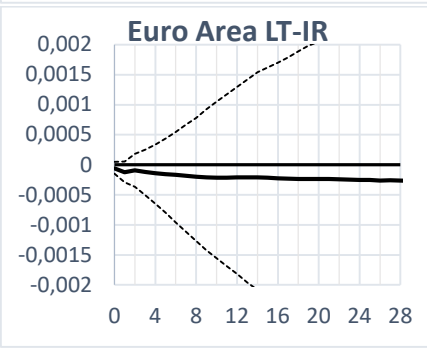

Euro Area Real GDP
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

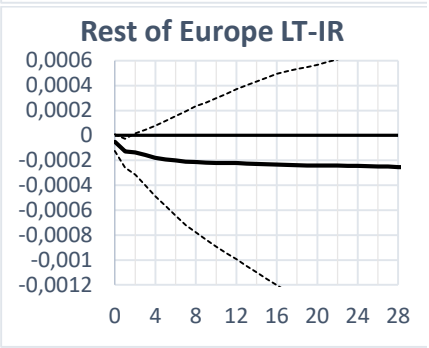

Rest of Europe Real GDP
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28


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

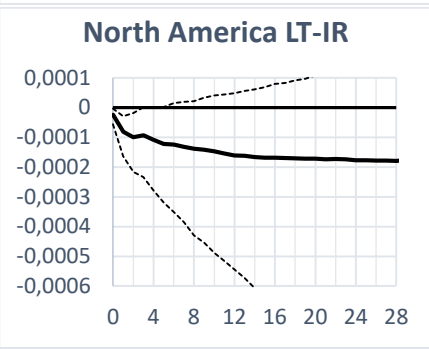
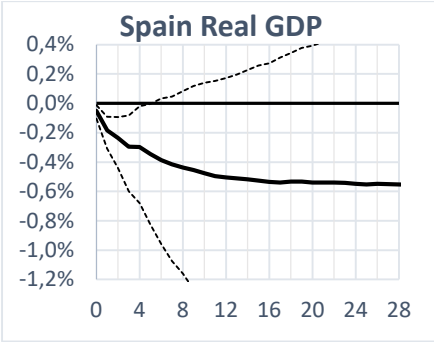
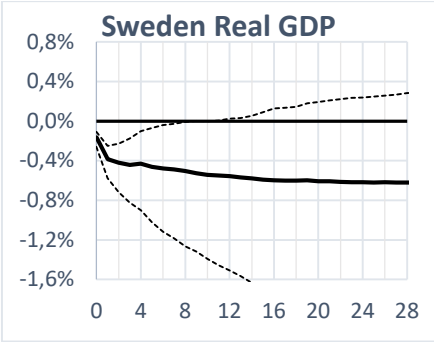
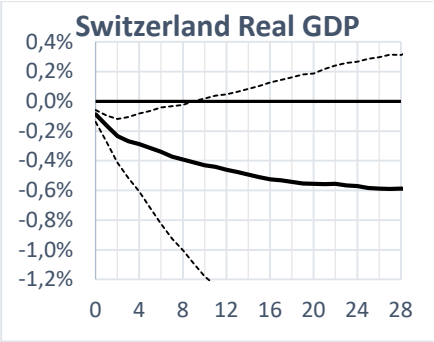
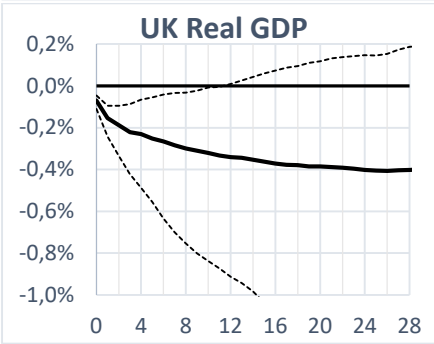

North America LT-IR
0,0001
0
-0,0001
-0,0002
-0,0003
-0,0004
-0,0005
-0,0006
0 4 8 12 16 20 24 28

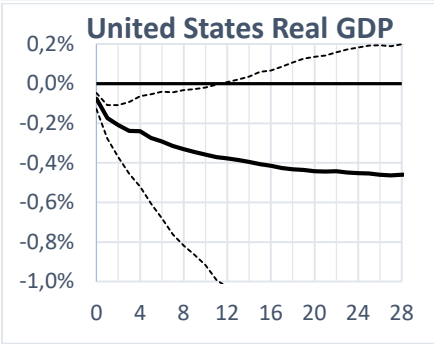
Figure 2. *Generalized impulse responses of a negative one percentage point shock to French fiscal expenditure (bootstrap mean estimates with 80% bootstrap error bounds)*

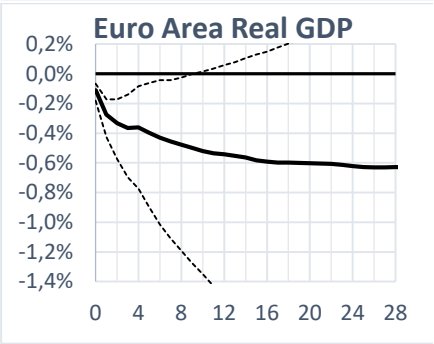

Spain Real GDP
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
-1,2%
0 4 8 12 16 20 24 28

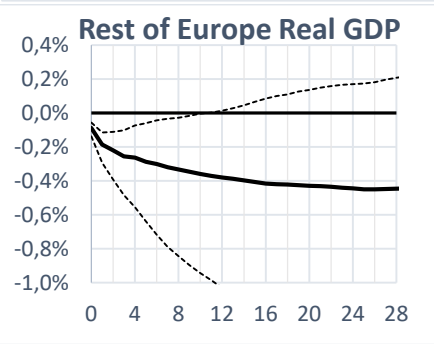

Sweden Real GDP
0,8%
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
0 4 8 12 16 20 24 28

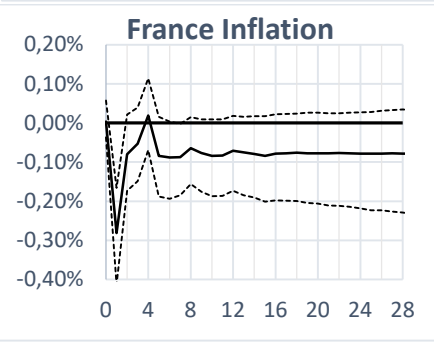

Switzerland Real GDP
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
-1,2%
0 4 8 12 16 20 24 28

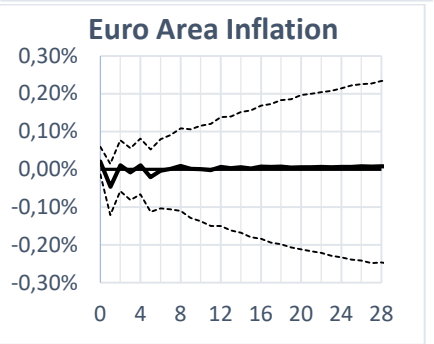

UK Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28

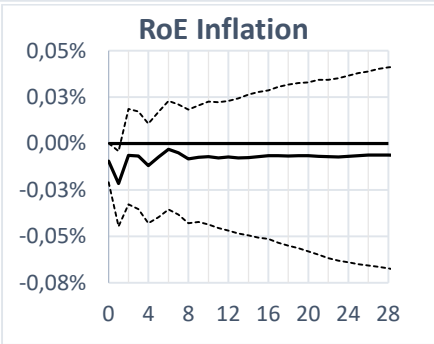

United States Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28

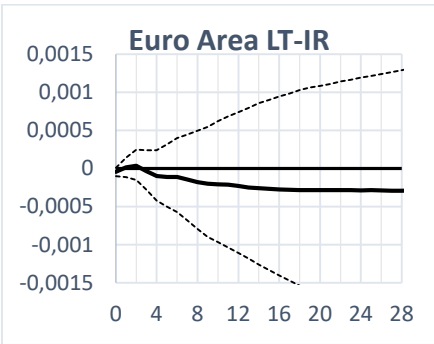

Euro Area Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
-1,2%
-1,4%
0 4 8 12 16 20 24 28

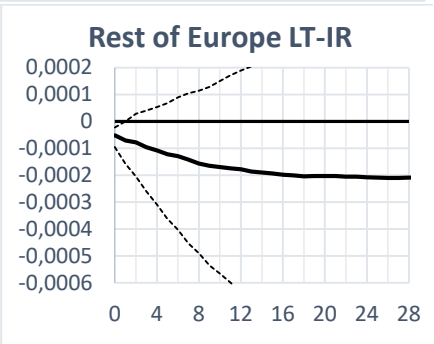

Rest of Europe Real GDP
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28


France Inflation
0,20%
0,10%
0,00%
-0,10%
-0,20%
-0,30%
-0,40%
0 4 8 12 16 20 24 28


Euro Area Inflation
0,30%
0,20%
0,10%
0,00%
-0,10%
-0,20%
-0,30%
0 4 8 12 16 20 24 28


RoE Inflation
0,05%
0,03%
0,00%
-0,03%
-0,05%
-0,08%
0 4 8 12 16 20 24 28


Euro Area LT-IR
0,0015
0,001
0,0005
0
-0,0005
-0,001
-0,0015
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

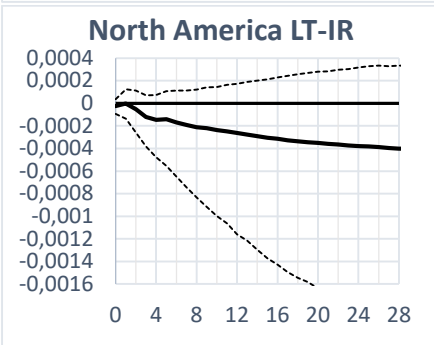
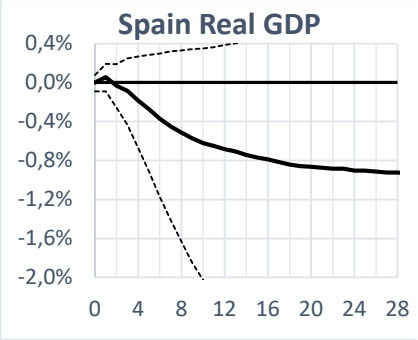
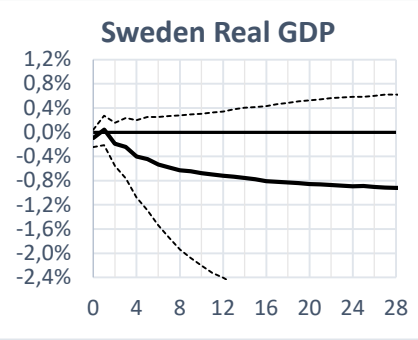
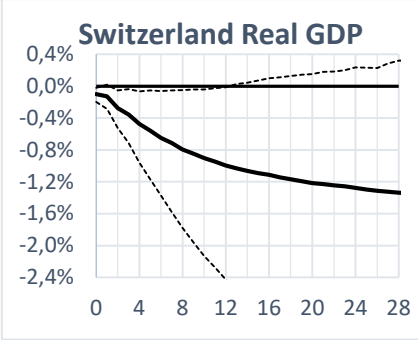
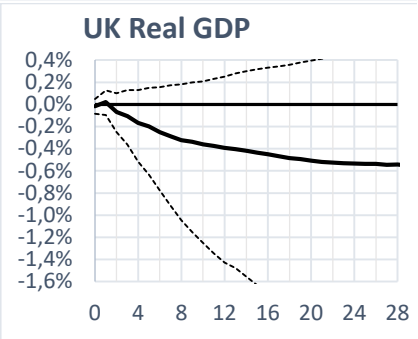

North America LT-IR
0,0004
0,0002
0
-0,0002
-0,0004
-0,0006
-0,0008
-0,001
-0,0012
-0,0014
-0,0016
0 4 8 12 16 20 24 28

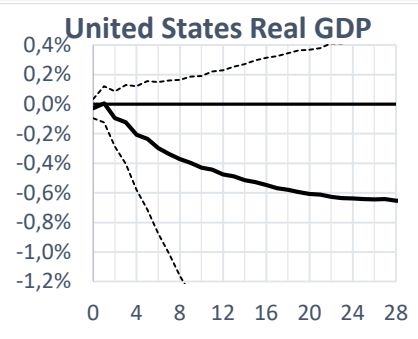
Figure 3. *Generalized impulse responses of a positive one percentage point shock to German total public revenue (bootstrap mean estimates with 80% bootstrap error bounds)*

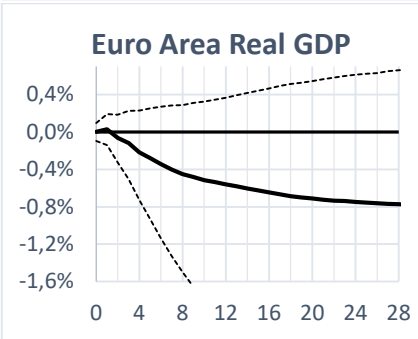

Spain Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
-2,0%
0 4 8 12 16 20 24 28

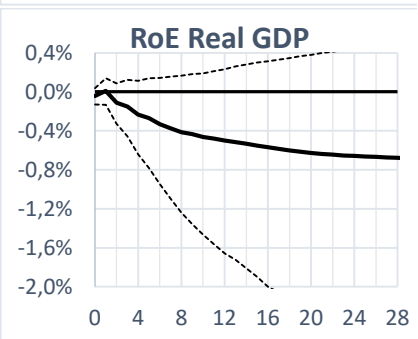

Sweden Real GDP
1,2%
0,8%
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
-2,0%
-2,4%
0 4 8 12 16 20 24 28

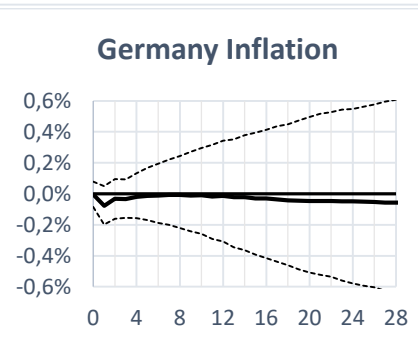

Switzerland Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
-2,0%
-2,4%
0 4 8 12 16 20 24 28

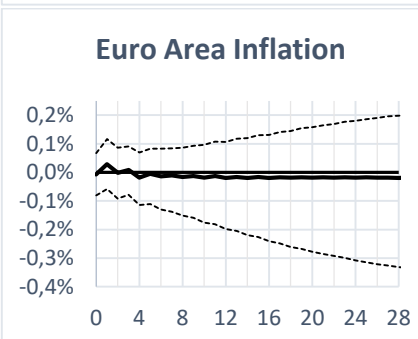

UK Real GDP
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
-1,2%
-1,4%
-1,6%
0 4 8 12 16 20 24 28

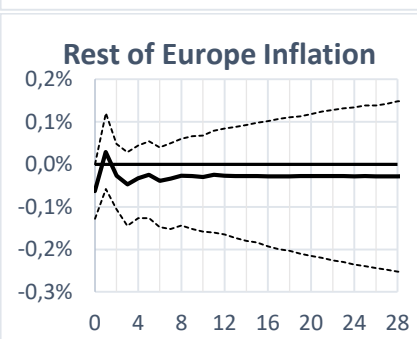

United States Real GDP
0,4%
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
-1,2%
0 4 8 12 16 20 24 28

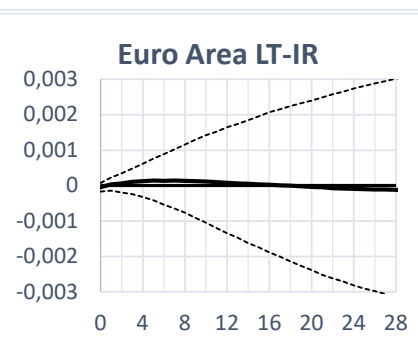

Euro Area Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
0 4 8 12 16 20 24 28

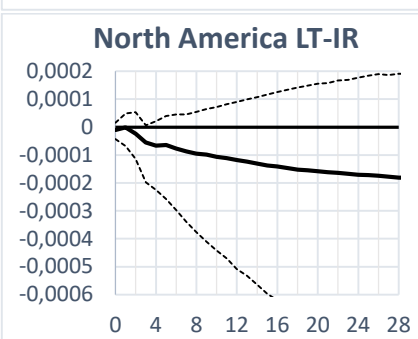

RoE Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
-1,6%
-2,0%
0 4 8 12 16 20 24 28


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
0,2%
0,1%
0,0%
-0,1%
-0,2%
-0,3%
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


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

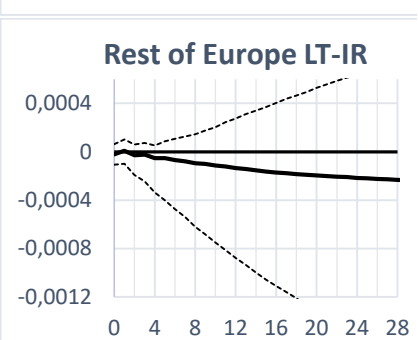
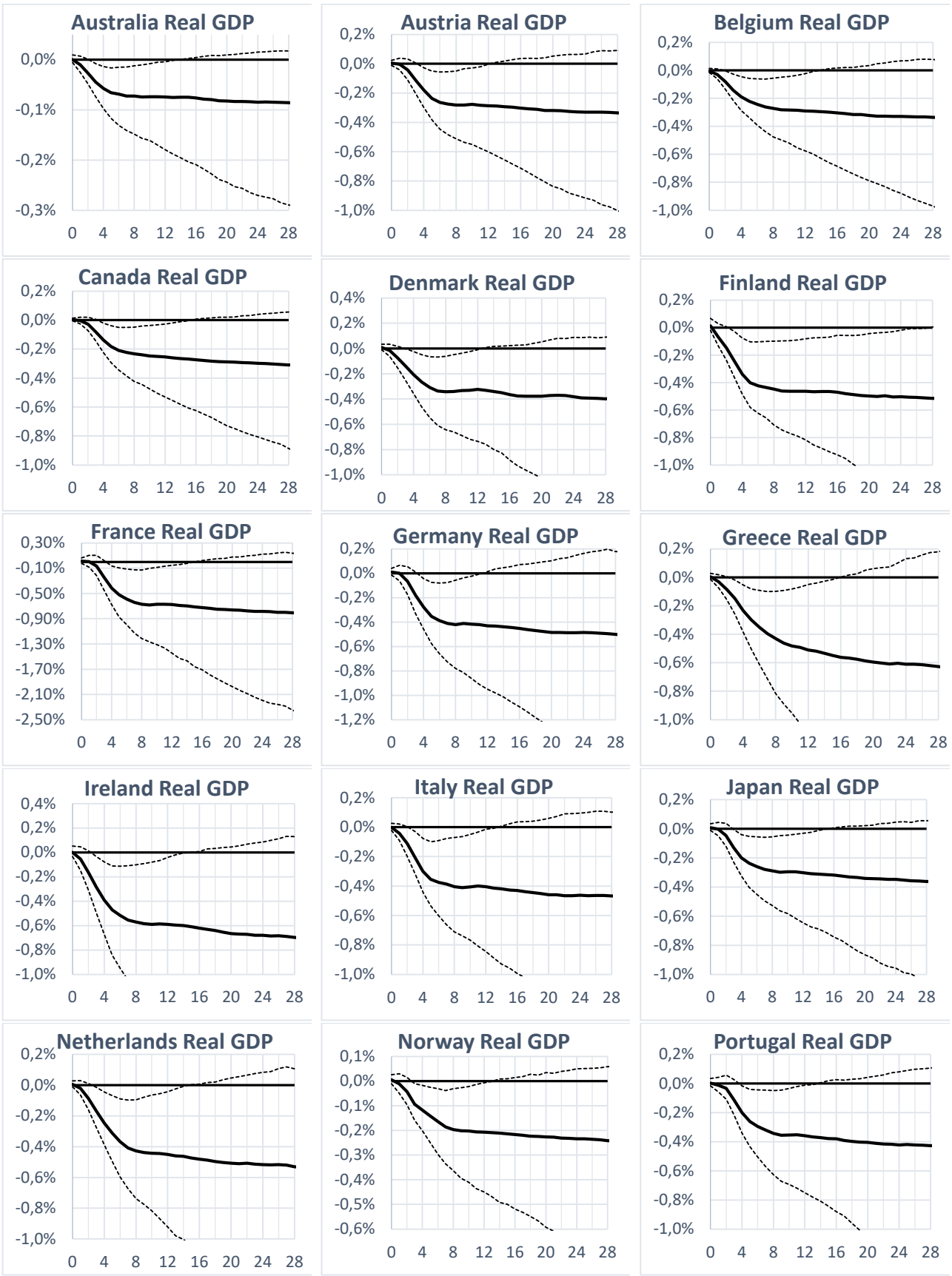
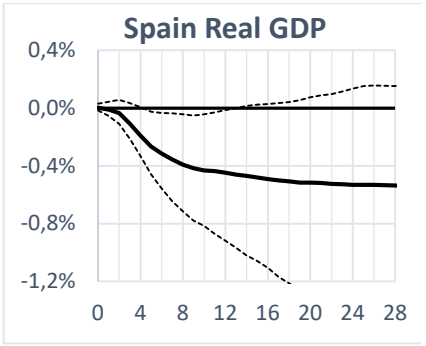
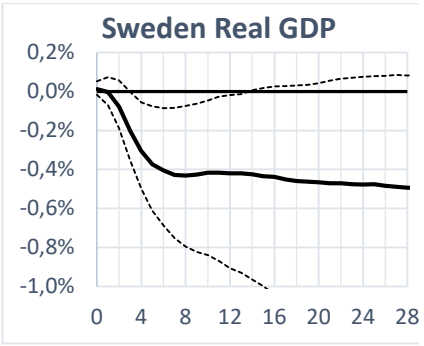
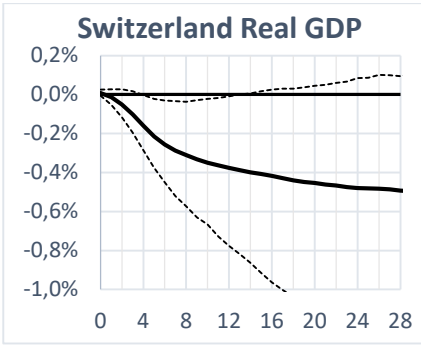

Rest of Europe LT-IR
0,0004
0
-0,0004
-0,0008
-0,0012
0 4 8 12 16 20 24 28

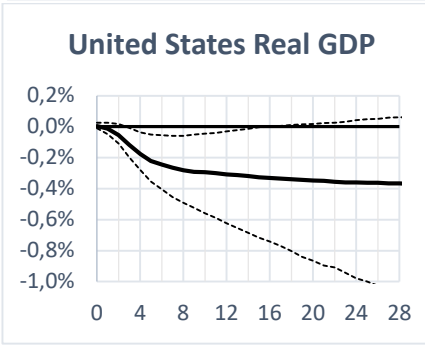
Figure 4. *Generalized impulse responses of a positive one percentage point shock to French total public revenue (bootstrap mean estimates with 80% bootstrap error bounds)*

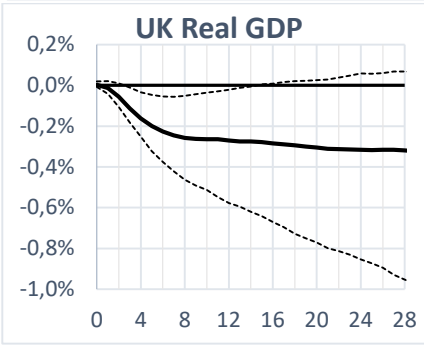


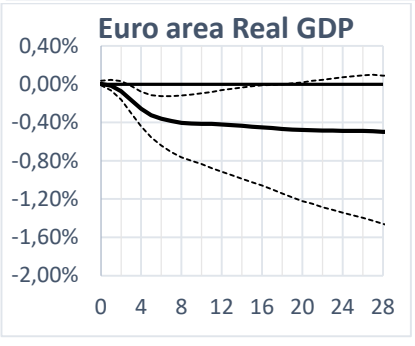

Spain Real GDP
0,4%
0,0%
-0,4%
-0,8%
-1,2%
0 4 8 12 16 20 24 28

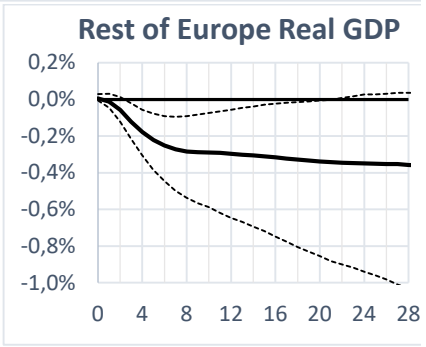

Sweden Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28

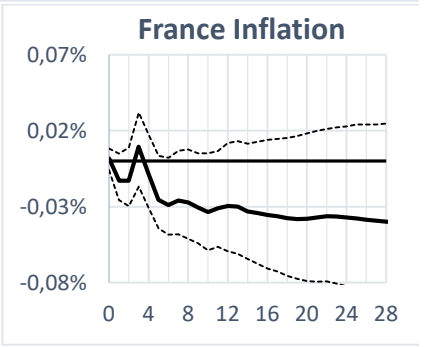

Switzerland Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28

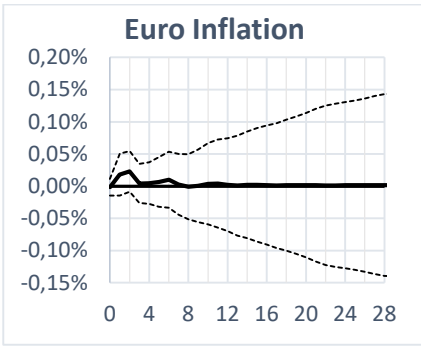

United States Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28

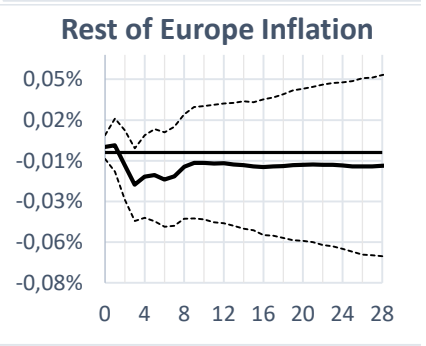

UK Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28

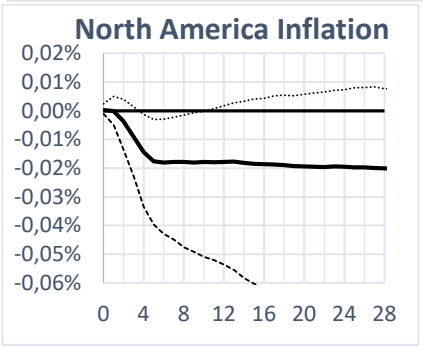

Euro area Real GDP
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

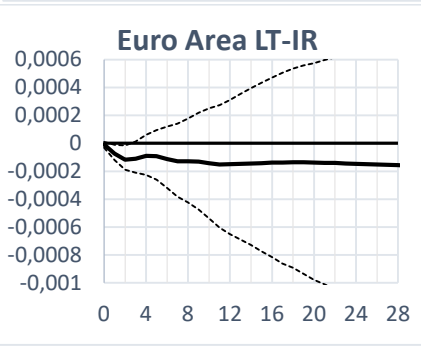

Rest of Europe Real GDP
0,2%
0,0%
-0,2%
-0,4%
-0,6%
-0,8%
-1,0%
0 4 8 12 16 20 24 28

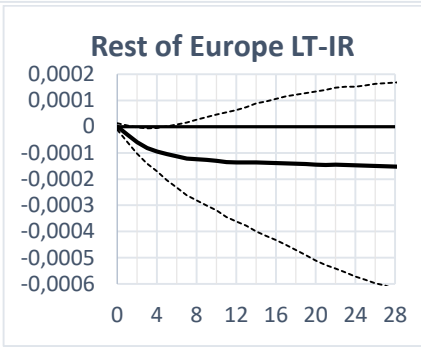

France Inflation
0,07%
0,02%
-0,03%
-0,08%
0 4 8 12 16 20 24 28


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


North America Inflation
0,02%
0,01%
0,00%
-0,01%
-0,02%
-0,03%
-0,04%
-0,05%
-0,06%
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 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

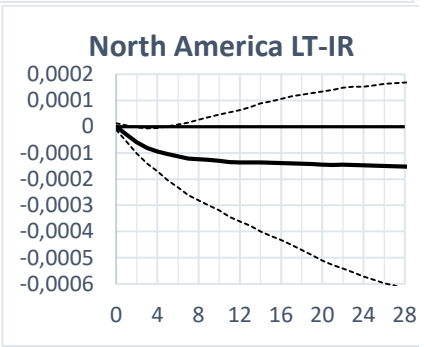
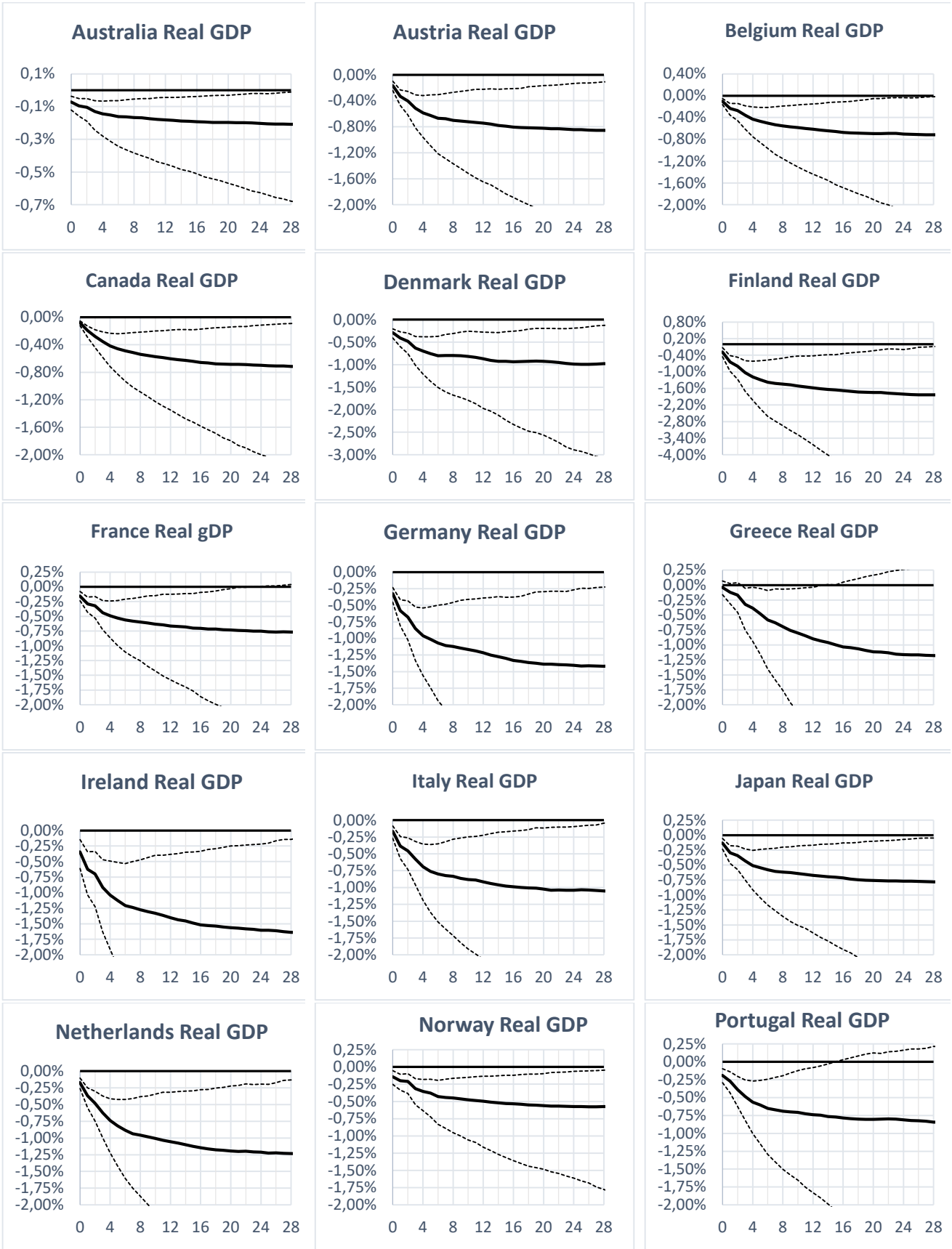
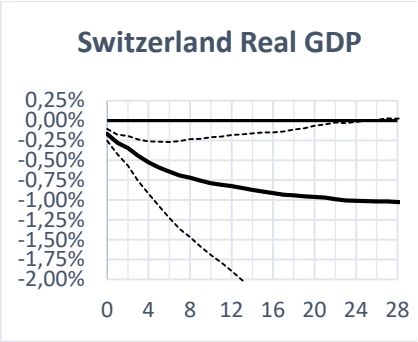
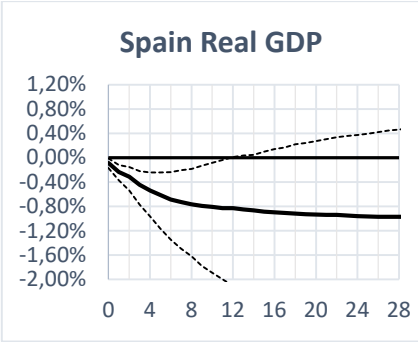
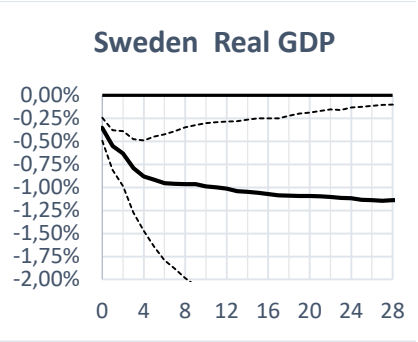

North America LT-IR
0,0002
0,0001
0
-0,0001
-0,0002
-0,0003
-0,0004
-0,0005
-0,0006
0 4 8 12 16 20 24 28

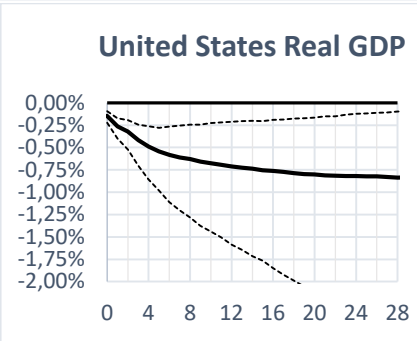
Figure 5. *Generalized impulse responses of a negative unit (1 s.e.) "regional" shock to government total expenditure (bootstrap mean estimates with 80% bootstrap error bounds)*

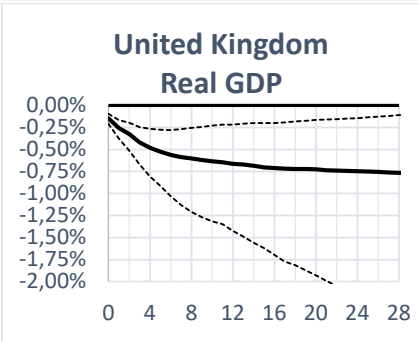


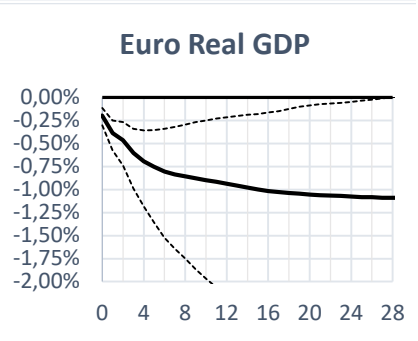

Switzerland Real GDP
0,25%
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28

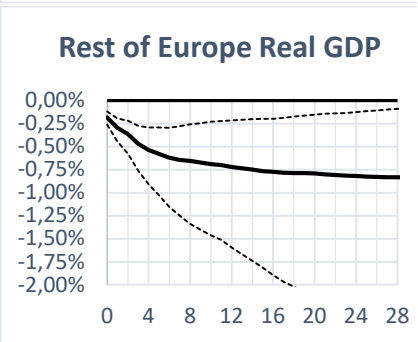

Spain Real GDP
1,20%
0,80%
0,40%
0,00%
-0,40%
-0,80%
-1,20%
-1,60%
-2,00%
0 4 8 12 16 20 24 28

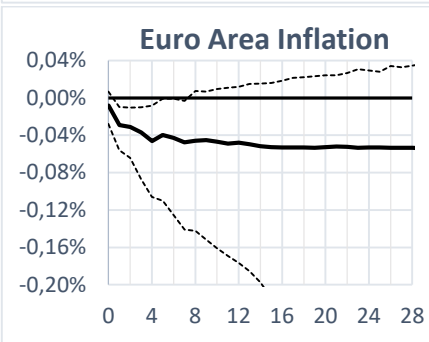

Sweden Real GDP
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28

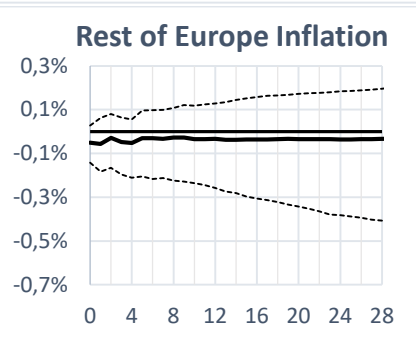

United States Real GDP
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28

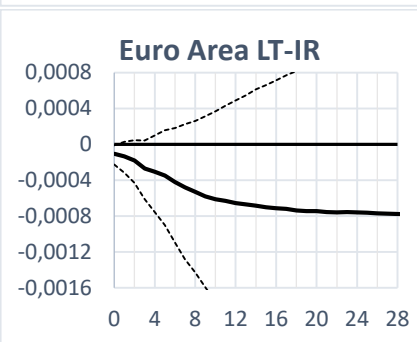

United Kingdom Real GDP
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28

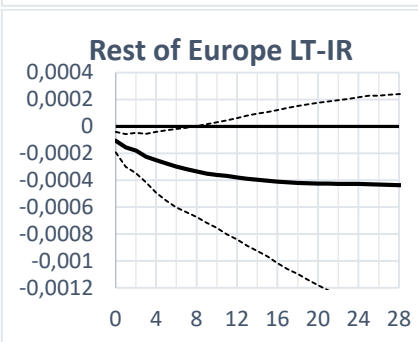

Euro Real GDP
0,00%
-0,25%
-0,50%
-0,75%
-1,00%
-1,25%
-1,50%
-1,75%
-2,00%
0 4 8 12 16 20 24 28


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
0,0004
0,0002
0
-0,0002
-0,0004
-0,0006
-0,0008
-0,001
-0,0012
0 4 8 12 16 20 24 28

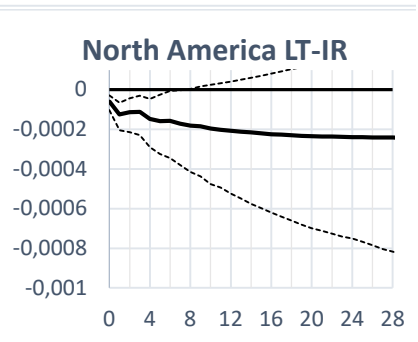
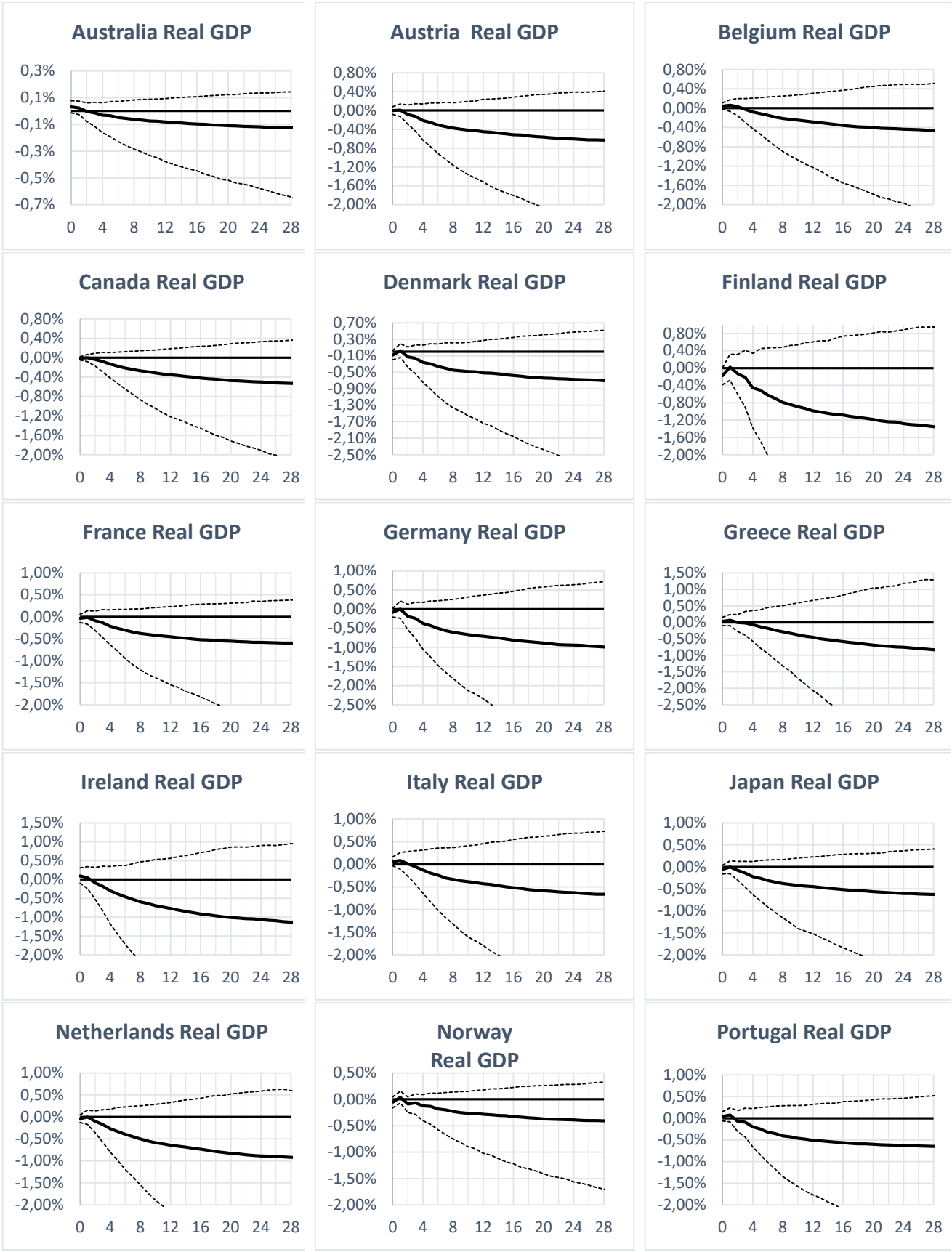

North America LT-IR
0
-0,0002
-0,0004
-0,0006
-0,0008
-0,001
0 4 8 12 16 20 24 28

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)*



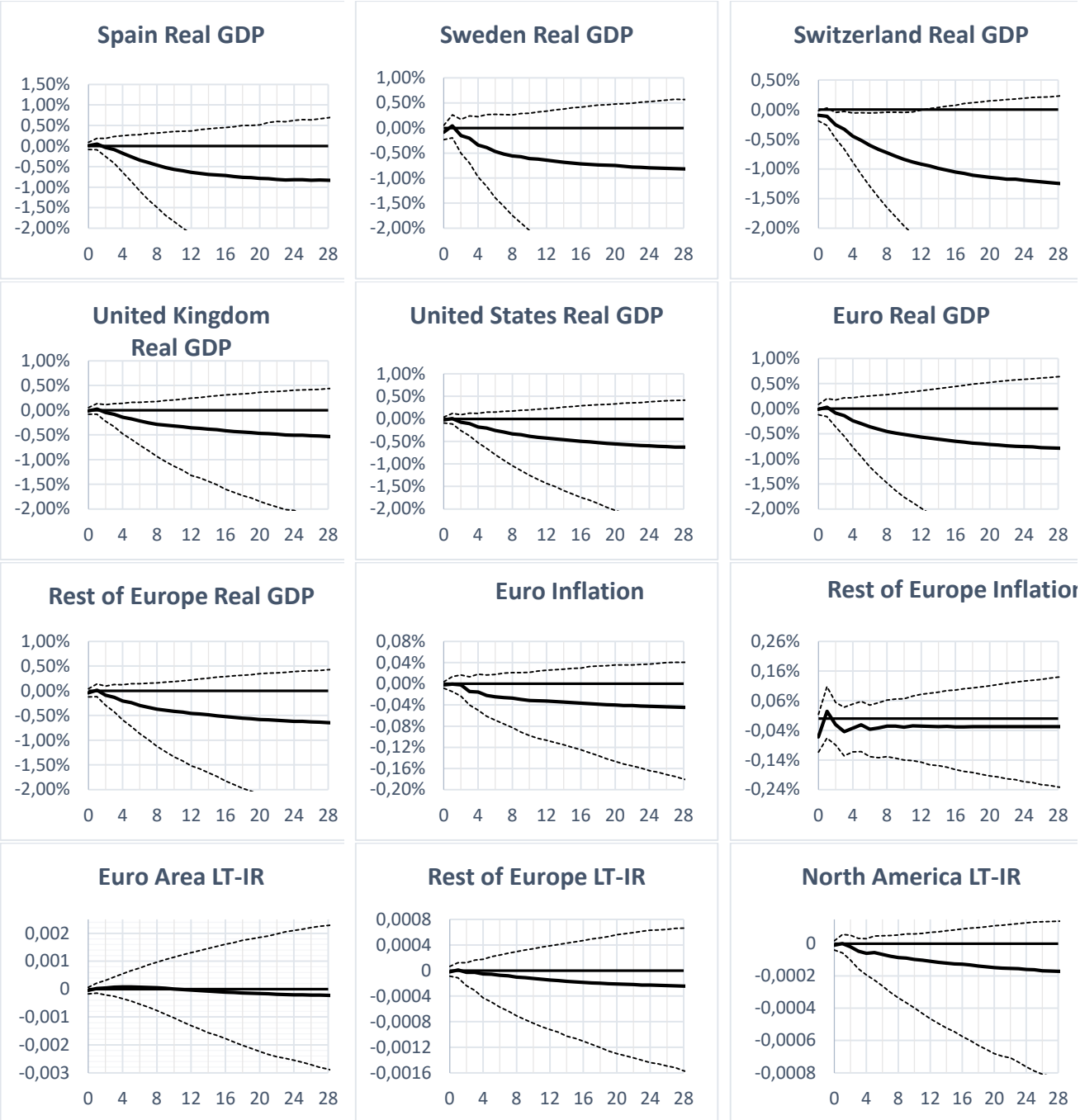
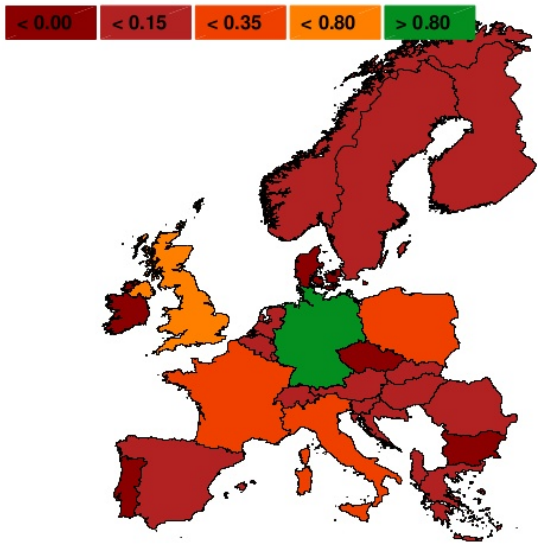

Spain Real GDP
1,50% 1,00% 0,50% 0,00% -0,50% -1,00% -1,50% -2,00%
0 4 8 12 16 20 24 28
Sweden Real GDP
1,00% 0,50% 0,00% -0,50% -1,00% -1,50% -2,00%
0 4 8 12 16 20 24 28
Switzerland Real GDP
0,50% 0,00% -0,50% -1,00% -1,50% -2,00%
0 4 8 12 16 20 24 28
United Kingdom Real GDP
1,00% 0,50% 0,00% -0,50% -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 -0,0002 -0,0004 -0,0006 -0,0008
0 4 8 12 16 20 24 28

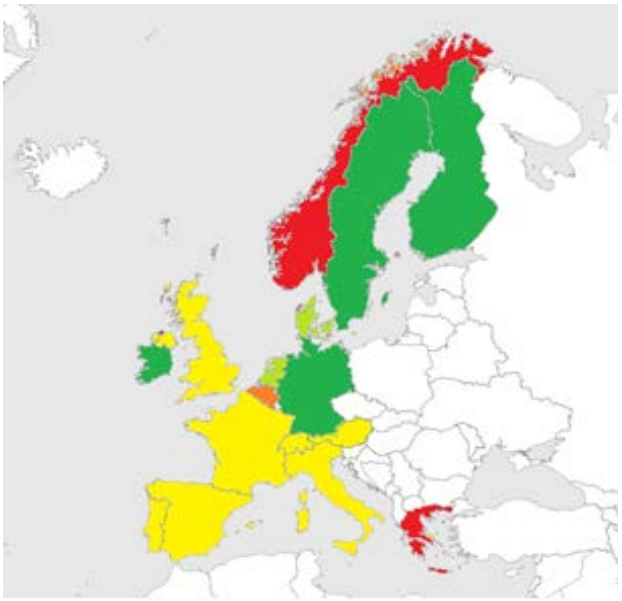
Figure 7. *Spillover reactions after a German government spending shock (Comparison with Georgiadis/Hollmayer (2016))*

7(a): Results of Geogiadis/Hollmayer (2016)



Source: Georgiadis and Hollmayr (2016), Slide 9

7(b): Our results



Source: Own calculations. Results after 4 Quarters. Notes: Spillover effects, Green>0.70, Bright green<0.70, Yellow<0.55, Orange<0.4, Red <0.35. Units are percent change in real GDP.

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