View metadata, citation and similar papers at core.ac.uk

brought to you by CORE

provided by New University of Lisbon's Repository

NOVA

SCHOOL OF BUSINESS AND ECONOMICS

MASTER THESIS

SUPERVISOR: JOAO B. DUARTE

The dynamics of Sovereign Debt in the Eurozone: A Panel VAR Analysis

VANESSA BARBARA SCHMIDT

Master of Science (M. Sc.) in Economics

Matriculation Number 4197

Lisbon, January 4th, 2019

THE DYNAMICS OF SOVEREIGN DEBT IN THE EUROZONE: A PANEL VAR ANALYSIS

ABSTRACT:

In this paper, the relationship between economic growth and public debt is revisited using a panel VAR. The focus is on the Eurozone and the time horizon starts when the Euro was introduced. The three main results of the study are: (i) public debt harms economic growth and growth leads to decrease in debt, (ii) spillover effects of public debt and economic growth between core and periphery countries in the Eurozone are found and (iii) the periphery countries respond more to internal and external shocks than the core countries.

Keywords: Panel VAR, Sovereign Debt, Growth, Spillover

Contents

Acronyms

ECB European Central Bank

FD First Difference

FEVD Forward Error Variance Decomposition

FOD Forward Orthogonal Deviation

GDP Gross Domestic Product

GMM General Method of Moments

IRF Impulse Response Function

VAR Vector Autoregression

List of Figures

List of Tables

1 Introduction

The financial crisis and the the following debt crisis in the Euro area gave rise to the fear that the monetary union could collapse and that some countries have to pay the debt of others. This fear continues to shape the political discussions about public debt and the economic policy measures in the Eurozone. Painful austerity programs were introduced during the financial crisis. However, a negative effect of debt on growth is highly disputed and there are contradicting results in the literature. Keynesian theory suggests that the government should spend more during a recession in order to create demand and stabilise the economy. But such a credit-financed expansionary fiscal policy was not possible in the Eurozone. If this is justified is controversial.

This paper aims to contribute to the discussion about the effect of public debt in the Eurozone. A panel vector autoregressive (VAR) study is conducted with the 11 founding members of the Eurozone and Greece. The time horizon starts after the introduction of the Euro, so quarterly data from 2000 until 2018 is used. In a first step, the average effect of debt and growth and vice versa is estimated and in the second step, inflation, long- and short-term interest rates are included in the model to analyse the interactions of these five variables. The third estimation analyses the effects between debt and growth for the core and the periphery countries separately. In the last step, spillover effects between core and periphery countries are estimated.

The main findings of the paper are that an increase in debt leads to a decrease in growth and an increase in growth leads to a decrease debt. A debt-to-GDP shock of 1% leads to 0.2% less economic growth A second result is that core and periphery countries are highly interrelated and shocks in one part of the Eurozone are transmitted to the others. A debt-to-GDP shock of 1% in the periphery countries implies 1% less growth in the core countries one year later, while a debt-to-GDP shock of 1% in the core countries implies 4% less growth one year later in the periphery countries. The third and last result is that the periphery countries respond more to shocks in the core area, as seen above, but also to shocks in their own area. A debt-to-GDP shock of 1% implies 0.33% less growth in the periphery countries and debt-to-GDP shock of 1% implies only 0.05% less growth in the core countries.

This study contributes to the literature in a number of ways. As in [Lof and Malinen, 2014] a panel VAR approach is used, but this study includes three other endogeneous variables: Long-term interest rates are included because theoretically high debt leads to higher interest rates and that depresses growth. The short-term interest rate is included, because it reflects the monetary policy of the European Central Bank (ECB) and it is also a benchmark for other interest rates. Inflation is supposed to account for the heterogeneities in the monetary union. Also [Checherita-Westphal and Rother, 2012] focus on the Eurozone and includes additional variables, but the authors use a panel data approach, which might suffer from endogeneity due to simultaneity or reversed causation and thus, the effect of debt on growth is likely to be overstated. Furthermore, the authors have a longer time horizon, while this study focuses only on the time when the Euro was introduced. In addition, the spillover analyses between periphery and core countries contributes to the existing literature.

This paper is organised as follows: In the second part of this section, the literature review is presented. In the next section, the data and in the third section the methodology is explained. In section four, the empirical results are presented followed by a section that summarises various robustness tests. Section six discusses and concludes.

1.1 Literature review

The first groundbreaking publication in this debate about the debt and growth nexus is [Reinhart and Rogoff, 2010]. At the beginning of the debt crisis, they found a threshold of a debt-to-GDP ratio of 90%, beyond which growth slows down quicker. For many politicians, this was a proof that austerity programs are justified. But the famous team from Havard made mistakes, which questioned the credibility of their results. These famous mistakes released a huge debate in academia.

The main critics are about the methodology that [Reinhart and Rogoff, 2010] used and relate to their data selection. [Herndon et al., 2014] find striking methodological errors and accuses them of choosing a certain selection of countries and time periods that supported their results. [Egert, 2015] tests the hypothesis of a non-linear relationship, but he cannot find a robust non-linear relationship in his model. [Eberhardt and Presbitero, 2015] show the difference between

countries and argues that there is no general threshold which is true for every country, because countries are very heterogeneous.

[Checherita-Westphal and Rother, 2012] support the hypothesis of a threshold. The authors conduct a microeconometric panel data analysis and finds a threshold in the Euroarea. The authors of the highly disputed publication also published a revised paper, so [Reinhart et al., 2012] study episodes of high public debt and find that in these periods, growth is low.

Some authors do not find an effect. They argue that many studies suffer from endogeneity and especially from reversed causation. [Pattillo et al., 2011] find that studies, which suffer endogeneity tend to overstate the negative effect of debt. [Lof and Malinen, 2014] conduct a panel VAR analysis and the authors find an impact of growth on debt, but not vice versa. Correlation is undeniable, but if causation exists is disputed. [Panizza and Presbitero, 2014] try to answer this question by using an instrumental variable for debt that does not effect directly economic growth. But they cannot find an answer.

As mentioned above, this study complements the study by [Lof and Malinen, 2014], because the additional variables inflation, long- and short-term interest rates are included and it complements the study by [Checherita-Westphal and Rother, 2012], because here a macroeconometric rather than a microeconometric tool is used. For the spillovers, a methodology inspired by [Bhattarai et al., 2018] is used.

2 Data

The two main variables of interest are debt and growth, so the debt-to-GDP ratio and the growth rate of GDP from the same quarter last year is used. From the literature it is already known that this effect is either hard to detect or maybe not existing, so other variables are included that could be either channels through which debt affects growth or play an important role in the interrelations. To complement the study inflation, long-term interest rate and short-term interest rate are included. Inflation can capture heterogeneities, which are usually reflected in the exchange rates and the monetary policy, but this is not possible in a monetary union. The long-term interest rate is selected because it shows the risk assessment of the ability of a country to pay back its credit. In theory, higher debt leads to a higher risk to be able to pay it back and

thus to higher long-term interest rates. Similarly, a higher risk of default could unsettle investors and thus, could harm growth. The short-run interest rate reflects the decisions of the ECB, so it is interesting to investigate the reactions of the monetary policy.

The dataset is extracted from Eurostat. The time frequency is quarterly and the horizon is from the first quarter in 2000 to the first quarter in 2018. Seasonally and calendar adjusted data is used. The study focuses on the Eurozone, where the following 12 countries provided sufficient data: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherland, Portugal and Spain. The relatively short time period is compensated with the panel dimension. Comparing to other studies, one advantage here is that only the contemporary dynamics are analysed. The only structural breaks in the data are the financial crisis and the following debt crisis. All countries were founding members of the Eurozone, except Greece that entered in 2001. So, the dynamics of the named countries are analysed, since they are in the Eurozone. This is interesting, because the Eurozone membership has overall a strong impact on the macroeconomic situation of a country.

In the panel dimension, all five variables are stationary and thus, there are no cointegration relationships possible. The results of the Granger causality tests support the choice of a VAR model, because between all variables exist granger causality at least in one direction. The complete results of the Granger causality tests are reported in table 5 in the appendix.

3 Methodology

The available dataset consists of five endogenous variables of 12 countries. In order to use all the available information, a panel VAR model is chosen. In a VAR, the time series of a set of endogenous variables is analysed. The panel analysis adds the cross-sectional dimension, which are here the 12 countries. One big advantage of this method is that even a relatively small time horizon can be compensated by the panel dimension and thus the resulting dataset is rich enough.

Following [Canova and Ciccarelli, 2013] a panel VAR has three main characteristics: cross sectional heterogeneity, dynamic interdependencies and static interdependencies. Cross-sectional heterogeneities are unit specific intercepts and slope coefficients. In this study, the

only cross-sectional heterogeneity are the country fixed effects. Since all countries are in a monetary union, relatively strong homogeneity is assumed and furthermore, the main interest of the study is the average effect in the Eurozone. In a model with dynamic interdependencies, in every equation for every country the lags of all variables of every single country would be included. For the same reason as before, dynamic interdependencies are excluded here. Static interdependencies are the cross-sectional correlation of the error terms. This interdependency exists in the model and can be used for a spillover analysis.

The panel VAR model can be written as following:

$$Y_{it} = A_0 + A_1 Y_{it-1} + A_2 Y_{it-2} + A_3 Y_{it-3} + A_4 Y_{it-4} + u_{it} \tag{1}$$

with $i = 1, ..12$ countries and $t = 1, ...73$ moments in time. Y_{it} is a vector that contains the endogenous variables of every country and the vector Y_{it-1} contains its lags. The error term u_{it} can be decomposed in $u_{it} = \epsilon_{it} + \alpha_i$, where ϵ_{it} is independent and identically distributed and α_i represents the country fixed effects.

The equation shows again that there are no intercept and slope hetergeneities, because A_0 and A_1 are not unit specific. The only unit specific element is the country fixed effect α_i. Furthermore, for country i no variables of other countries enter the regression, so there are no dynamic interdependencies in the presented model. The error terms of the different units are correlated, so $Cov(u_{it}, u_{jt}) \neq 0$ if $i \neq j$. These covariances of the errors of different units are the static interdependencies.

3.1 Estimation

In a microeconometric framework, fixed effects would be the appropriate method, because every country would have a country-fixed effect which is correlated with the explanatory variables and thus not random. But in a dynamic panel with a relatively small time horizon the estimators are biased, see [Nickell, 1981]. Additionally, in a VAR, every variable is both, independent and dependent. It follows that the fixed effects would be correlated with both, the independent and the dependent variables and this would again lead to inconsistent results.

Instead, the model explained above can be estimated by a General Method of Moments (GMM) estimation, where instruments are used to have sufficient moment conditions for the feasibility of the estimation. The GMM estimation can be extended to the system GMM estimator. This method estimates all equations at the same time and in order to do that it uses additionally moment conditions that are constructed with information of the series in levels. These additional information lead to a better performance of the system GMM estimator comparing to the normal one. Another main advantage of the system estimator is that a constant can be included. Additionally, in the estimation one can use the collapse option, which allows that not the full set of instruments has to be used and thus, to reduce the number of moment conditions. This reduction makes large estimations feasible.

Nevertheless, the fixed effects need to be eliminated. In the GMM estimation, there are two alternative methods to do so. One method is applying first difference (FD) and because α_i is time independent, its first difference is zero and thus, the individual effect is removed. One disadvantage of this method is that serial correlation is induced in the error term, because for example $\Delta\epsilon_{it} = \epsilon_{it} - \epsilon_{it-1}$ and $\Delta\epsilon_{it-1} = \epsilon_{it-1} - \epsilon_{it-2}$ are apparently serial correlation, even though the untransformed errors were not. The second method is the forward orthogonal deviations (FOD) transformation. Here, one has to take the average of all future observations and subtract it from the current value. Again, the fixed effect is eliminated, because it is constant in time and thus the average of all future observations is equal to every single observation. In the FOD, the last value is dropped, because it has no future observation. In contrast to the FD transformation, where the first value is dropped, because it has no previous observation. Because the FD method introduces serial correlation, the FOD method will be used in this paper. The resulting model then is given by:

$$\Delta Y_{it} = A_1 \Delta Y_{it-1} + A_2 \Delta Y_{it-2} + A_3 \Delta Y_{it-3} + ... + A_T \Delta Y_{it-T} + \Delta\epsilon_{it} \tag{2}$$

where Δ represents either the first difference or the forward orthogonal deviation.

3.2 Model specification

Two different models will be specified and analysed: A two-variate model with GDP growth and debt-to-GDP ratio and a five-variate model that includes additionally the variables inflation, long-term interest rate and short-term interest rate.

For the lag selection, the Model and Moment Selection Criteria are used. Following [Andrews and Lu, 2001], the Akaike information criterion is not consistent here, so the Bayesian and the Hannan-Quinn information criteria are used. Since the data are quarterly, four lags should always be preferred. In both models, four lags are choosen here, because even though one lag has the lowest information criteria, the information criteria of four lags lies not far apart.

3.3 Identification

The estimated models are reduced form panel VARs. The shock of each variable in a reduced form VAR is not distinguishable. Thus, the structural form of the model is needed in order to identify the shocks. The estimates of the reduced form do not have enough information to recover the entire structural form, so restrictions are needed to fully identify the shocks.

For the identification, the Cholesky approach is used here. In the Cholesky identification, the variables have to be ordered recursively. The variable ordered first is the most exogenous one or in other words, this variable is not influenced contemporaneously by the shocks of the other variables. The variable ordered last is the most endogenous one and thus, it is influenced by shocks of all other variables contemporaneously.

In this study, the order of [Caldara and Kamps, 2008] is followed. The authors argue that government spending has to be ordered first, because there exists a delay between the political decision and the actual spending, so it can affect other variables immediately, but it can only be affected with a lag. Output is ordered second, because its reaction is slower than inflation. Inflation is ordered third and the interest rates are the most endogenous variables, so they are ordered last. [Lof and Malinen, 2014] also uses the argumentation of [Caldara and Kamps, 2008] and applies it to a panel VAR with debt-to-GDP ratio ordered first similar to government spending and GDP growth ordered second similar to output. The authors

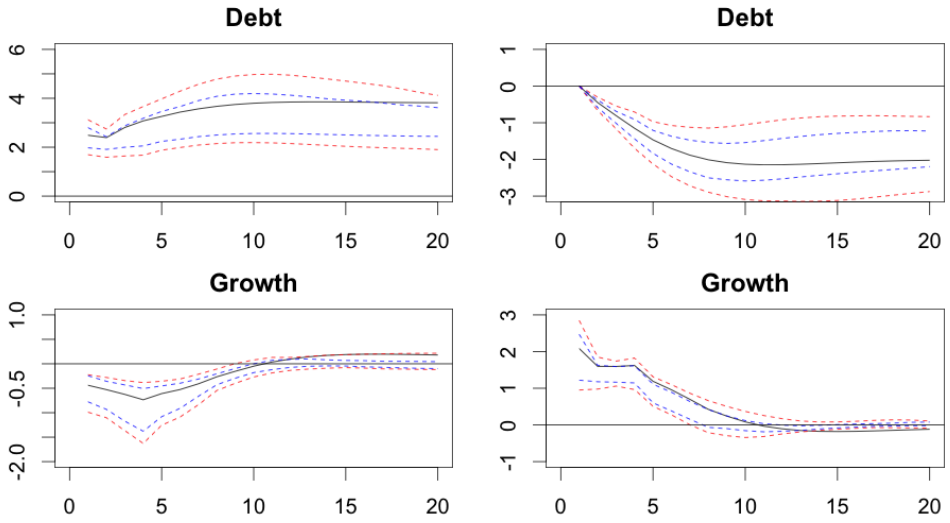
test the robustness of the result with a reversed identification order and with the debt level instead of the debt-to-GDP ratio and they find that the order has no substantial effect on the results. In this study, different orders are also tested and the results are indeed the same.

4 Estimation results

In the following two subsections the impulse response functions (IRFs) and the forward error variance decomposition (FEVD) of the two-variate and the five-variate model are presented. The IRFs show the reaction of a single shock. The FEVD shows where the reaction of one variable comes from and thus, complements the structural analysis. In the FEVD, all shocks happen at the same time and the reactions to the different structural shocks are revealed. The third subsection presents the cross-country heterogeneity analysis and subsection four the spillover analysis.

4.1 Two-variate model

Figure 1: IRFs of debt and growth



(a) Reactions to a debt shock (b) Reactions to a growth shock

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

Figure 1 shows the IRFs of debt and growth to a debt and a growth shock. The first result is that all IRFs are significant. An increase in debt leads to a decrease in growth and an increase in growth leads to a decrease in debt. So, the variables are affecting each other significantly.

While the effects on debt are very persistent, the growth rate converges after two and a half years back to its initial level. Only after around 70 years, debt is completely back at its steady state level, so it is highly persistent.

The finding that a growth shock leads to a persistent decrease in debt is reasonable, because when GDP growth increases unexpectedly, the revenues of the government also increase and thus, it can repay its debt. The persistency is also intuitive, because once a portion of the debt is paid back, the level stays lower. On the other hand, an increased level of debt shocks the economy temporary, because for example public investment is crowded out, interest rates are rising and private households decide to save more and spend less. In the next periods, the government does not demand new credit anymore, so interest rates decrease again, there is again more credit supply and private consumption increases again, so the economy gets back to its initial level.

Table 1: FEVD 2-variate model

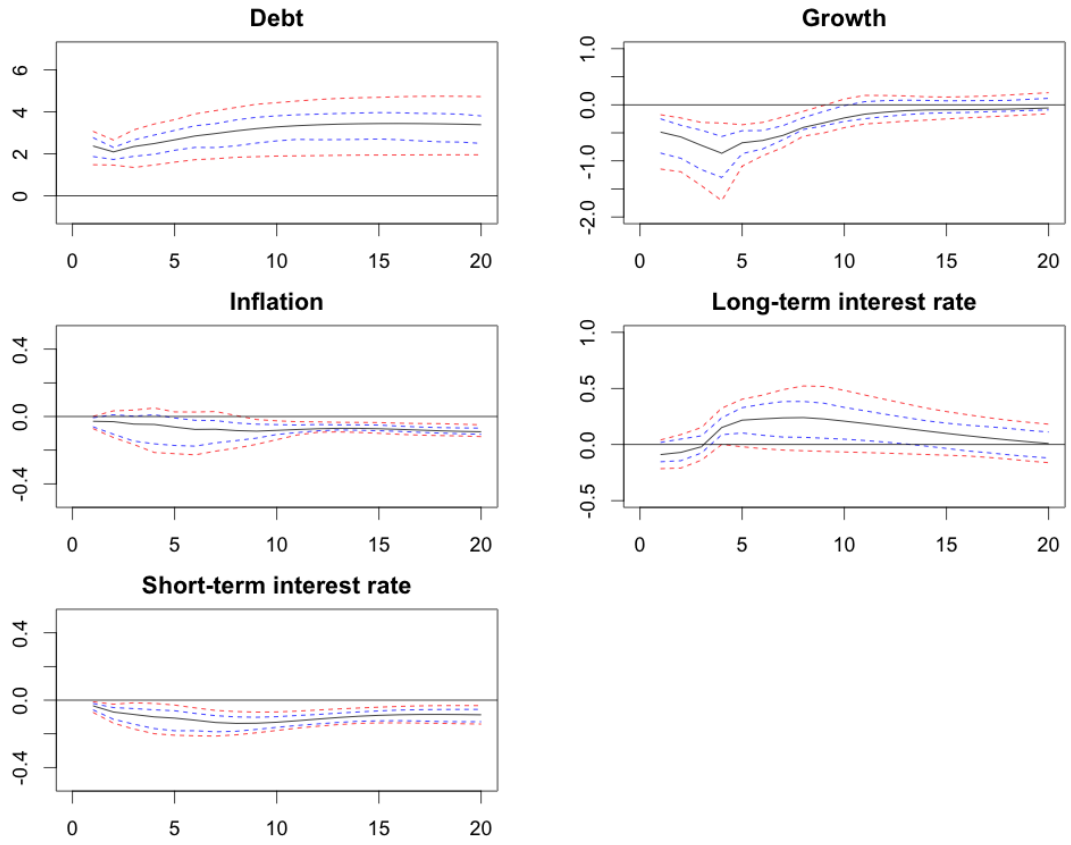
debt2gdp			gdp_growth		
steps	debt2gdp	gdp_growth	steps	debt2gdp	gdp_growth
1	1.00	0.00	1	0.07	0.93
2	0.98	0.02	2	0.11	0.89
...	...	...	...	...	...
7	0.81	0.19	7	0.26	0.74
8	0.79	0.21	8	0.26	0.74
...	...	...	...	...	...
20	0.76	0.24	20	0.26	0.74

In table 1, the FEVD, so the contributions of both shocks to the movement of debt and of growth are shown. By construction, debt is only moved by its own shock in the first period, because it is ordered first in the Cholesky identification. Vice versa, debt does effect growth contemporaneously, in the first period, 7% of the movement of growth is explained by the debt shock. For both variables, the share of the shock of the other variables increases in the next periods. After two years, the contribution of debt for growth is around 26%. This contribution is constant until the last period, which is period 20 or rather after 5 years. The contribution of growth for debt is 21% after two years. This contribution increases slightly and in the last period it reaches 24%.

4.2 Five-variate model

In this section, only the responses of debt and the reactions on a debt shock will be presented, which are the main contributions of this paper. The complete results can be looked up in figure 7 in the appendix.

Figure 2: IRFs to a debt shock



Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

Figure 2 shows the reactions to a debt shock. Again, the reaction of debt is very persistent and growth decreases, but the effect vanishes after two years. These effects are similar, but slightly smaller than in the two-variate model. The reaction of inflation is not significant. In a monetary union, this is expected, because inflation can only be influenced by the central bank and thus, it is quite exogenous for the members of the Eurozone and cannot be used to repay national debt. The function for the member states could be to balance out different levels of competitiveness. The reaction of both interest rates is significant. Long-term interest rates increase due to the debt shock. One reason can be that higher government debt makes the government bonds riskier, because the repayment can be more difficult. In the EU, it could also

be that a higher level of debt leads to a political conflict with the EU and thus, the risk to leave the EU increases and thus, bond prices increase. Another reason can be that credit demand exceeds supply and thus, the price rises. Short-term interest rates decrease with a debt shock. Since the short-term interest rate indicates the monetary policy reaction, this could be the case because the ECB could try to provide liquidity to the market when long-term interest rates and maybe also other interest rates rise because of a debt shock. Another explanation could be that government debt are seen as safe assets and thus, when banks have more safe assets, they are also willing to lend more to each other.

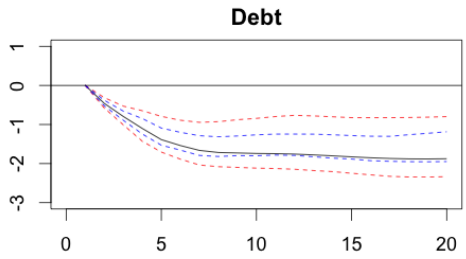
Table 2: FEVD from debt in 5-variate model

steps	gdp_growth	inflation	long-t. interest rate	short-t. interest rate
			debt2gdp	
1	0.06	0.00	0.04	0.02
2	0.09	0.00	0.2	0.03
...	...	...	...	...
7	0.20	0.02	0.06	0.07
8	0.20	0.02	0.07	0.08
...	...	...	...	...
20	0.20	0.06	0.09	0.13

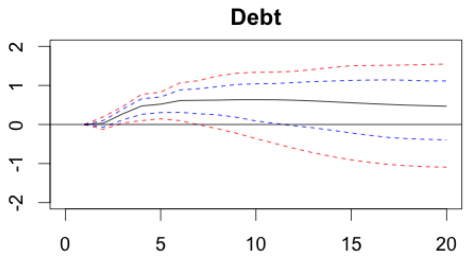
Table 2 shows how much the debt shocks contributes to the movements of the other four variables. Debt is ordered first in the Cholesky decomposition and thus, it influences all other variables contemporaneously. The biggest contribution of debt is on growth. Already in the first period, 6% of the movement of growth comes from debt, the contribution increases in the next periods and then stabilizes at a contribution of 20%, similar to the two-variate model. In addition, debt contributes around 7% or rather 8% to the interest rates in the end of the second year. For the short-term interest rate, this influence increases up to 13% in the last period. Similar to the non-significant IRFs of inflation, the contribution of debt to the movement of inflation is with around 2% tiny, but also increasing up to 6% in the last period.

Figure 3 shows the reaction of debt to the shocks of the other four variables. Similar to the two-variate model, a growth shock leads a decrease in debt. With an inflation shock, the reaction of debt is not significant. As explained above, this is a reasonable result. A positive shock of the long-term interest rate leads to a significant increase in debt. The reasoning behind that reaction

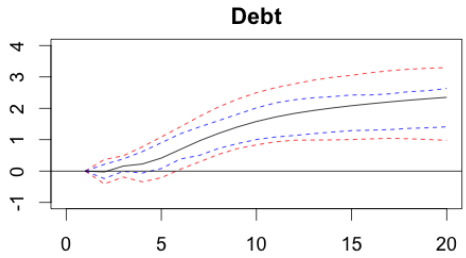
Figure 3: IRFs of debt



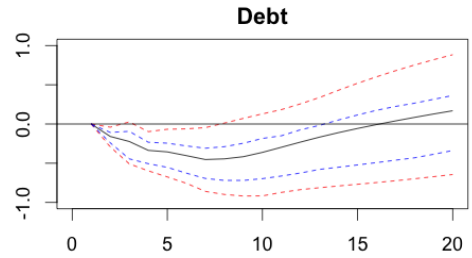
(a) Reaction to a growth shock



(b) Reaction to a inflation shock



(c) Reaction to a long-term interest rate shock



(d) Reaction to a short-term interest rate shock

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

is that higher long-term interest rates make debt more expensive and thus, debt increases. Since the shock is unexpected, the government can not plan on it and decide to spend less. It has to bear the increased costs, because its decisions are slower than the market. The reaction of the short-term interest rate is ambiguous and only little significant. Firstly, it decreases, after around two years it starts to increase again and after three years it passes the steady state level and keeps increasing. Higher interest rates in the money market restrict the governments ability to borrow, this could be the reason behind the first decrease. Once the money market is back to its equilibirum, the higher costs of borrowing could be reflected in the increased debt-to-GDP ratio.

Table 3 presents the FEVD of the debt-to-GDP ratio. Because of the Cholesky identfication, only in the fifth period all five variables contribute to the movement of debt. Debt is contemporaneously only affected by itself and every period one more variable enters. The short-term interest rate is the last one that enters in period five. The main contribution comes still from growth, but the influence of the long-term interest rate increases over time. In the last period, so after 5 years, it reaches 17%, which is the same size of the contribution of growth. Interestingly, the contribution of growth is almost the same as in the two variate model while

Table 3: FEVD of debt in 5-variate model

debt2gdp					
steps	debt2gdp	gdp_growth	inflation	long-t. interest rate	short-t. interest rate
...	...	...	...	...	...
5	0.85	0.12	0.02	0.01	0.01
6	0.81	0.14	0.02	0.02	0.01
7	0.78	0.16	0.02	0.03	0.01
8	0.76	0.17	0.02	0.04	0.01
...	...	...	...	...	...
20	0.64	0.17	0.02	0.17	0.00

the contribution of debt itself decreased in the five-variate model. So, one can conclude that the contribution of growth is quite robust, while the contribution of debt on itself captures also the effect of other variables. The contribution of inflation and short-term interest rate is tiny and constant.

Table 4: FEVD of growth in 5-variate model

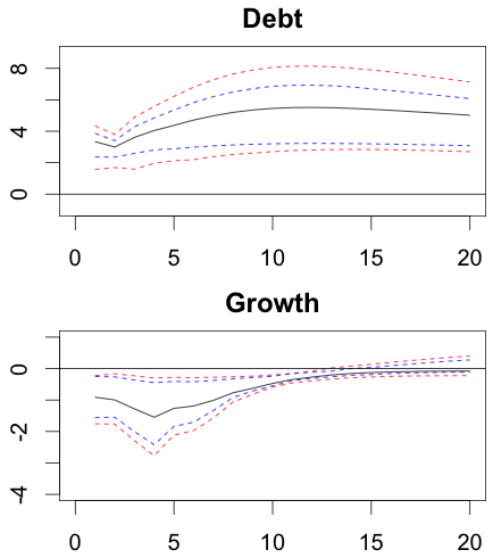
gdp_growth					
steps	debt2gdp	gdp_growth	inflation	long-t. interest rate	short-t. interest rate
...	...	...	...	...	...
5	0.17	0.76	0.00	0.04	0.02
6	0.19	0.73	0.01	0.06	0.02
7	0.20	0.70	0.01	0.08	0.02
8	0.20	0.68	0.01	0.09	0.02
...	...	...	...	...	...
20	0.20	0.64	0.01	0.13	0.02

Table 4 shows the FEVD of growth. Remarkably, it looks pretty similar to the FEVD of debt in many ways. Inflation and short-term interest rate have as well a very tiny and constant contribution. The long-term interest rate has also an increasing contribution, while its contribution is only 4% in the fifth period, it increases until 13% in the last period. The contribution of debt decreased from around 26% in the two-variate model to around 20% in the five-variate model. Overall, the FEVD shows that above all the long-term interest rate is an important variable in the debt growth nexus, because it contributes largely to the movement of both.

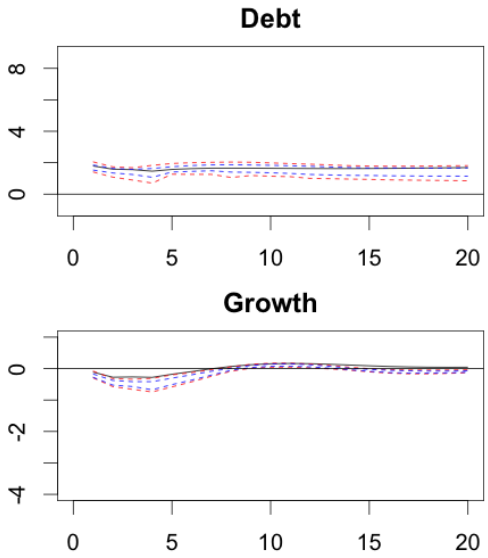
4.3 Heterogeneities

In the models above, a sufficient homogeneity of the countries is assumed. In order to check if there are nevertheless different dynamics among the countries, the same estimation is conducted for two different groups of countries: the core and the periphery countries. Here, as periphery countries are classified Greece, Ireland, Portugal and Spain. The core countries are the other eight countries: Austria, Belgium, Finland, France, Germany, Italy, Luxembourg and the Netherlands.

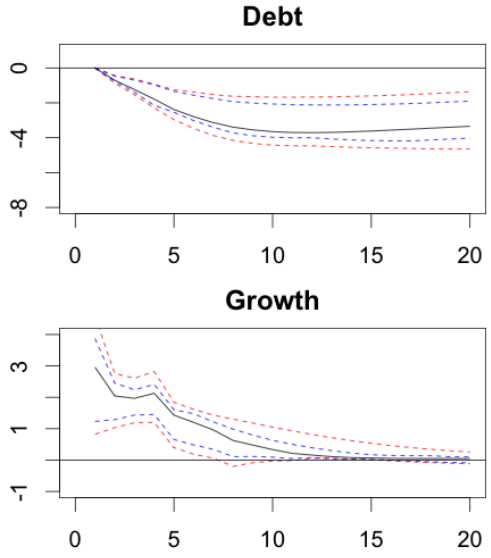
Figure 4: IRFs of periphery and core countries separately



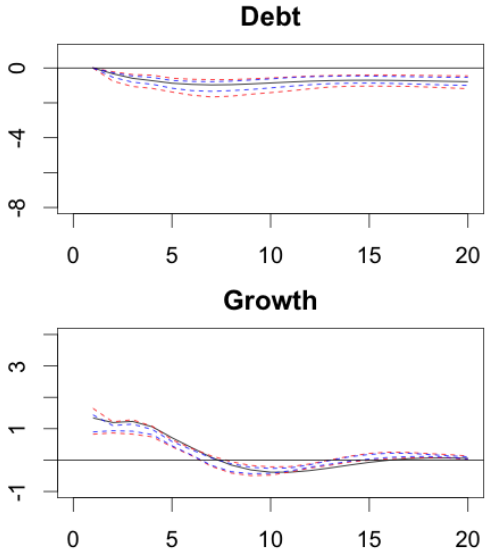
(a) Periphery countries: Reaction to a debt shock



(b) Core countries: Reaction to a debt shock



(c) Periphery countries: Reaction to a growth shock



(d) Core countries: Reaction to a growth shock

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

Figure 4 shows the estimated IRFs of the periphery and the core countries. At first sight, the graphs look pretty similar, which supports the assumed homogeneity. Though, the scale is quite different. The shocks of the periphery countries are slightly bigger and the reactions are much bigger. So, the periphery countries respond more to unexpected shocks, while the core countries seem to absorb the shocks better. Nevertheless, the assumed homogeneity holds.

4.4 Spillovers

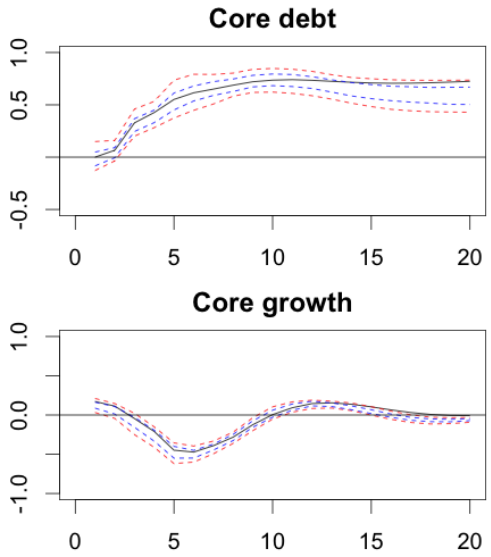
Another interesting question is if a shock in a certain area of the Eurozone affects another area. For example if the debt crisis in the periphery countries affected the core countries of the Euro area.

There are two different methods to find out about the spillover effect. One method is to look at the covariances of the residuals of the different countries. As mentioned above, the correlation of the spillovers are static interdependencies and here, besides the fixed effect, they are the only heterogeneities allowed in this model. One disadvantage of this model is the fact that they are static, so no dynamics of the spillovers are captured. Another disadvantage is that they are hard to interpret, because there are covariances between all 12 countries for all variables. The second and more convenient method is to include the structural error of a variable of one group of countries as an additional variable in the estimation of another group of countries, inspired by the method of [Bhattarai et al., 2018].

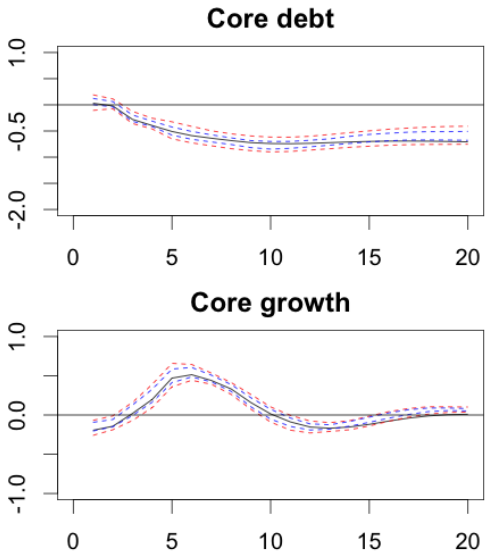
This second method will be used in this study. There are two groups of countries: the periphery and the core countries. In a first step, a panel VAR for the two groups is estimated separately. Then, the residuals of both panel VARs are identified. The structural error of debt and growth is obtained for both groups. In the second step, the two structural errors of the core countries are each included in a new panel VAR estimation of the periphery countries and vice versa.

Figure 5 shows the IRFs the debt and growth spillovers from the periphery to the core countries and figure 6 the spillovers from core to periphery. In both estimations, the reactions of debt and growth to all spillovers are significant. As in the section about cross-country heterogeneities, the IRFs show similar patterns at a first sight, but the scale of the periphery

Figure 5: Spillovers from periphery to core countries

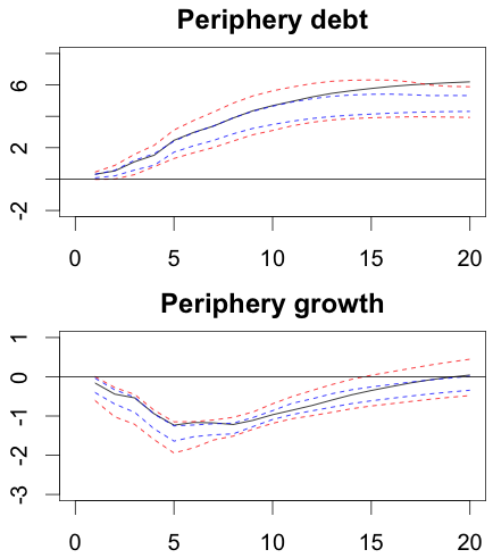


(a) Reaction to a debt shock in the periphery countries

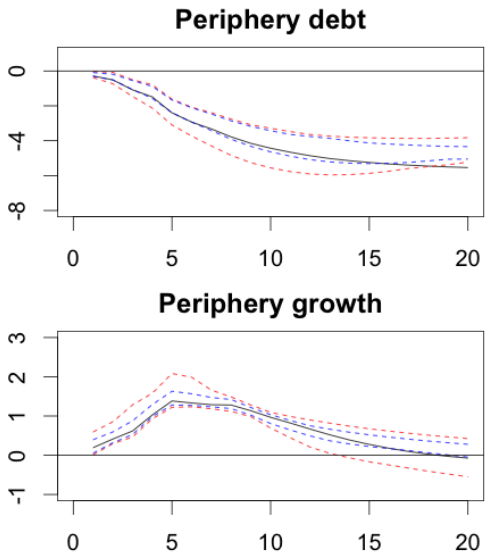


(b) Reaction to a growth shock in the periphery countries

Figure 6: Spillovers from core to periphery countries



(a) Reaction to a debt shock in the core countries



(b) Reaction to a growth shock in the core countries

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

countries is again much bigger. The differences are even more striking in this spillover analysis than in the simple cross-country heterogeneities analysis. It is a strong result, that even these pretty different groups in the Eurozone are highly interrelated and shocks in certain areas are transmitted to others. The second important result is that periphery countries respond more to shocks in their own area but also to shocks outside the periphery.

5 Robustness

To increase the credibility of the results various robustness tests are conducted for both models, the small one with two variables and the big one with five variables. Overall, the results are very robust.

One concern of the study is the mechanical effect of GDP growth on the debt-to-GDP ratio. To avoid it, the study was performed with the lagged debt-to-GDP ratio in order to eliminate the mechanical effect. Additionally, the same study is conducted with logged GDP instead of GDP growth rate and logged debt instead of the debt-to-GDP ratio. The resulting IRFs are the figures 12 to 18 in section 7.4 in the appendix. Especially the two-variate model is pretty robust and the results do not change. The five-variate model shows less significant IRFs with the logged data, but the results are still robust. A second disputatious point of this study is the identification strategy, because the order of the variables is based on assumptions. However, other identification orders do not change the results. In the study, a constant for all countries is included in addition to the fixed effect. Excluding this constant does not change the results either. Also annual data leads to similar results.

There are two types of government debt: general government debt and central government debt. As the name suggests, general government debt is broader and includes all gross government debt. Central government debt does not include the debt of the governments of states and departments, additionally, social security funds are neither included. In the study, general government debt is used, but using central government debt does not change the results.

The last robustness check is controlling for other dynamics in the data. In order to control for time effects, a dummy variable which equals one during the crisis is included in the model. The real effective exchange rate can be used to control for external competitiveness, to avoid endogeneity, the first lag is included as a control. The controls are included as exogenous variables in the estimation. The results are again similar.

6 Discussion

This paper studies the dynamics of sovereign debt in the Eurozone. The main contributions are that only the Eurozone is studied, that the empirical model is a VAR and that the variables inflation, long- and short-term interest rate are additionally included in the model. Moreover, the spillover analysis contributes to the literature. There are three main results of this study.

The first two results are that an increase in growth decreases debt and an increase of debt also decreases growth. So, it is not a one-way relationship, as assumed in many microeconometric models in the literature, but a two-way causality. The finding that higher growth leads to a decrease in debt is quite intuitive, but the alarming result is that an increased level of debt really harms growth. There are two main channels how debt could affect economic growth. The first channel is through its effects on private savings and private investment. The second channel is through a loss of confidence. In both cases, the long-term interest rates play a crucial role.

The first channel works as follows. If the government borrows more, the private sector lends more money to the government instead of either lending it to the private sector, which is said to be more efficient or instead of consuming it. So, GDP decreases, because less efficient investments are made and consumption decreases. The finding in the model, that long-term interest rates rise due to a debt shock support the reasoning, because it makes the government bonds more attractive, this crowds out private investment and households have a higher incentive to save. But this scenario only happens if credit demand exceeds credit supply. If the economy is in a recession and there are more savings in the economy than credit is demanded, the additional spending of the government boosts economic growth. This situation is well known as the Keynesian deficit spending. In the Eurozone, there are currently high savings, very low interest rates and the economy suffers from a so-called secular stagnation, so public investments are not expected to crowd out private investments. Consequently, this channel cannot be the explanation behind the fall in GDP due to higher public debt here.

The second channel is the interrelations between debt, growth and interest rates. So, even though there is more credit supply than credit demand in the market, long-term interest rates rise, because the government looses its credibility to be able to pay back its debt. The reaction of the market is obvious, the price of the bonds rises, because they are riskier. When the price

of government bonds rises, also other interest rates rise, see [Zoli, 2013], and again, private investment and private consumption decreases and so does GDP. This loss of credibility is also the reasoning behind non-linear effects. Until a certain debt-to-GDP ratio, the government might be little risky and after a threshold, the debt burden is so high that the risk increases excessively. As mentioned in the literature review, a general threshold is not found. The turning point, when the markets looses confidence is situative and individual. However, when bond prices increase it is the role of the central bank to intervene in the market and buy the bonds until its price decreases again. The ECB used to be quite restricted though. In the Eurozone, there is the principle that nobody should pay the debt of others, so the ECB only started to buy bonds in 2012, when the crisis became very severe. Furthermore, Mario Draghi calmed down the market with his most famous citation: „whatever it takes“, saying that the ECB will do everything possible to keep everyone in the Eurozone. As long as a country is in the Eurozone, its government bonds are fairly safe. The remaining risk is that a country leaves because it wants to or because the conflict with the EU becomes insuperable. Thinking about the Greek sovereign debt crisis or the Italian budget conflict, the political conflict with the EU is the biggest risk of a member country. Higher debt usually leads to such a conflict, because either the maximum of 60% debt-to-GDP ratio or of the 3% primary deficit is exceeded. Once both parties agreed, the bond prices decreased again.

The third result is that spillovers from core to periphery and vice versa exist. The transmissions of growth are caused by the common market and the common currency. The stronger result though is that debt in one area is harming growth in the other. The channels has to be the same as discussed above for the whole Eurozone, but here, national debt is not only affecting national private consumption, investment and national bond prices but of the whole Eurozone. Also, the political conflict of one member state with the EU is affecting others. If one country leaves the Eurozone during a crisis, it might hurt all other countries and in addition, the risk that others leave increases dramatically. An additional result is that periphery countries do not absorb both internal and external shocks as good as core countries. This is reasonable, because periphery countries used to have a less diversified economies, their bargaining power in the EU is lower and they have higher macroeconomic imbalances such as higher debt-to-GDP

ratios and higher inflation for example, which might cause the fact that they do nit absorb the shocks as good as core countries.

The main resulting policy implication is that the strong imposition of rules all over the Eurozone is important, because the actions of one country affect the others. Besides, periphery countries respond more, so they could need a bit more support from the EU. Secondly, high public debt is affecting growth and long-term interest rates have a noteworthy influence. A resulting policy implication is to reduce debt. But when and how to do it is highly controversial. [Blanchard and Leigh, 2013] argue that fiscal consolidation must take place if debt is very high and they discuss arguments for and against fast fiscal consolidation. However, they conclude that this decision is very individual for every country. Also [Barseghyan and Battaglini, 2016] argue in a theoretical model that there is no one-size fits all austerity program. How to design the least costly austerity program still needs to be found out. In addition, imposing rules such as the maximum 60% debt-to-GDP ratio that nobody follows triggers the political conflict and might be a reason for higher interest rates. New fiscal rules are worth of consideration.

In this paper, the focus was on debt and its effects. Amongst others, the effect of debt on growth was studied. As already mentioned above, one avenue of further research is to examine the channel of private and public investment, through which debt could affect growth. Besides, one could also shift the focus to growth and its empirical determinants. In this case, other variables would be of interest to explain growth, such as investment, human capital and technology. Debt would be just one additional variable in this study about growth. It would be interesting to see if debt also has an influence on growth in this framework.

References

[Andrews and Lu, 2001] Andrews, D. W. K. and Lu, B. (2001). Consistent model and moment selection procedures for GMM estimation with application to dynamic panel data models. *Journal of Econometrics*, 101(1):123–164.

[Barseghyan and Battaglini, 2016] Barseghyan, L. and Battaglini, M. (2016). Political economy of debt and growth. *Journal of Monetary Economics*, 82:36–51.

[Bhattarai et al., 2018] Bhattarai, S., Chatterjee, A., and Park, W. Y. (2018). Effects of US Quantitative Easing on Emerging Market Economies. SSRN Scholarly Paper ID 3140100, Social Science Research Network, Rochester, NY.

[Blanchard and Leigh, 2013] Blanchard, O. and Leigh, D. (2013). Fiscal consolidation: At what speed?

[Caldara and Kamps, 2008] Caldara, D. and Kamps, C. (2008). What are the Effects of Fiscal Policy Shocks? A VAR-based Comparative Analysis. SSRN Scholarly Paper ID 1102338, Social Science Research Network, Rochester, NY.

[Canova and Ciccarelli, 2013] Canova, F. and Ciccarelli, M. (2013). Panel Vector Autoregressive Models: A Survey. SSRN Scholarly Paper ID 2201610, Social Science Research Network, Rochester, NY.

[Checherita-Westphal and Rother, 2012] Checherita-Westphal, C. and Rother, P. (2012). The impact of high government debt on economic growth and its channels: An empirical investigation for the euro area. *European Economic Review*, 56(7):1392–1405.

[Eberhardt and Presbitero, 2015] Eberhardt, M. and Presbitero, A. F. (2015). Public debt and growth: Heterogeneity and non-linearity. *Journal of International Economics*, 97(1):45–58.

[Egert, 2015] Egert, B. (2015). Public debt, economic growth and nonlinear effects: Myth or reality? *Journal of Macroeconomics*, 43:226–238.

[Herndon et al., 2014] Herndon, T., Ash, M., and Pollin, R. (2014). Does high public debt consistently stifle economic growth? A critique of Reinhart and Rogoff. *Cambridge Journal of Economics*, 38(2):257–279.

[Lof and Malinen, 2014] Lof, M. and Malinen, T. (2014). Does sovereign debt weaken economic growth? A panel VAR analysis. *Economics Letters*, 122(3):403–407.

[Nickell, 1981] Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Econometrica*, 49(6):1417–1426.

[Panizza and Presbitero, 2014] Panizza, U. and Presbitero, A. F. (2014). Public debt and economic growth: Is there a causal effect? *Journal of Macroeconomics*, 41:21–41.

[Pattillo et al., 2011] Pattillo, C., Poirson, and Ricci, L. A. (2011). External Debt and Growth. *Review of Economics and Institutions*, 2(3):30.

[Reinhart et al., 2012] Reinhart, C. M., Reinhart, V. R., and Rogoff, K. S. (2012). Public Debt Overhangs: Advanced-Economy Episodes since 1800. *Journal of Economic Perspectives*, 26(3):69–86.

[Reinhart and Rogoff, 2010] Reinhart, C. M. and Rogoff, K. S. (2010). Growth in a Time of Debt. *American Economic Review*, 100(2):573–578.

[Zoli, 2013] Zoli, M. E. (2013). *Italian Sovereign Spreads: Their Determinants and Pass-through to Bank Funding Costs and Lending Conditions*. International Monetary Fund. Google-Books-ID: vtxykPCeBq0C.

7 Appendix

7.1 Granger causality table

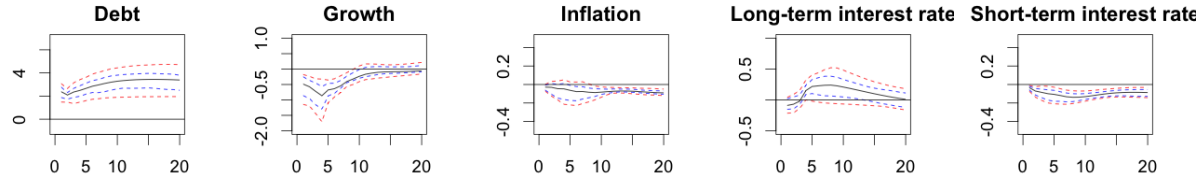
Table 5: Granger causality

	Debt-to-GDP ratio	GDP growth	Inflation	Long-term interest rate	Short-term interest rate
Debt-to-GDP ratio		✗	✓	✗	✗
GDP growth	✓		✗	✓	✗
Inflation	✗	✗		✓	✓
Long-term interest rates	✗	✗	✓		✗
Short-term interest rates	✓	✗	✓	✓	

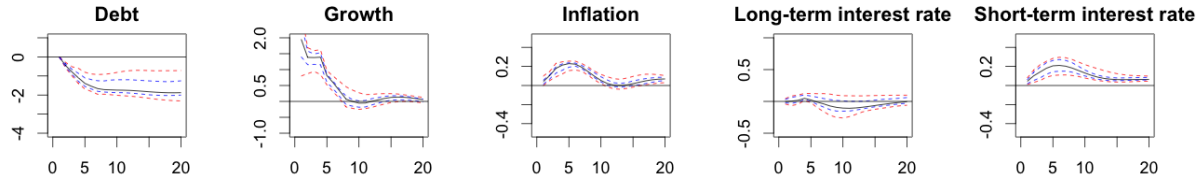
Source: Own calculations. Data: Eurostat.

7.2 Complete IRFs of the 5-variate model

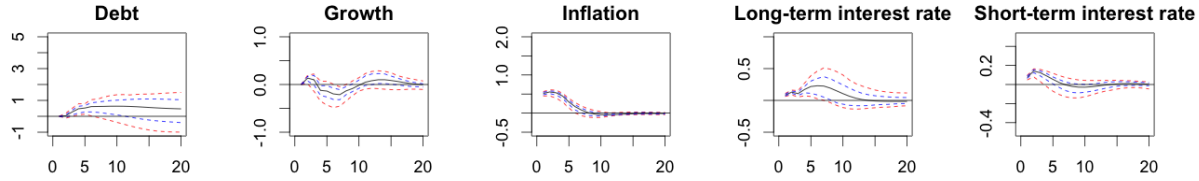
Figure 7: Complete IRFs of the 5-variate model



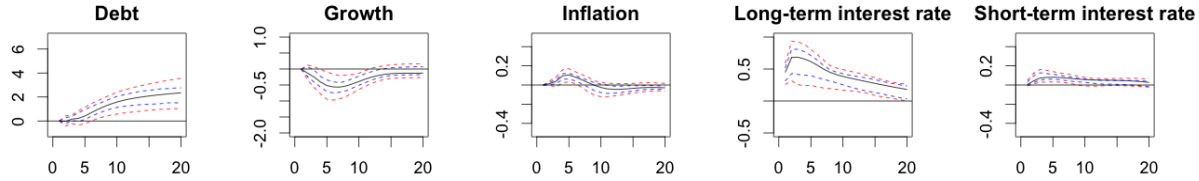
(a) Reactions to a debt shock



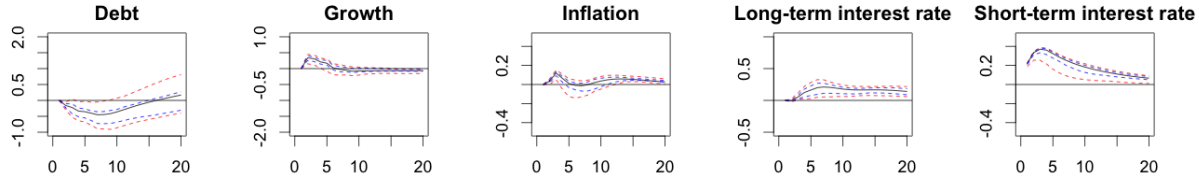
(b) Reactions to a debt shock



(c) Reactions to an inflation shock



(d) Reactions to a long-term interest rate shock

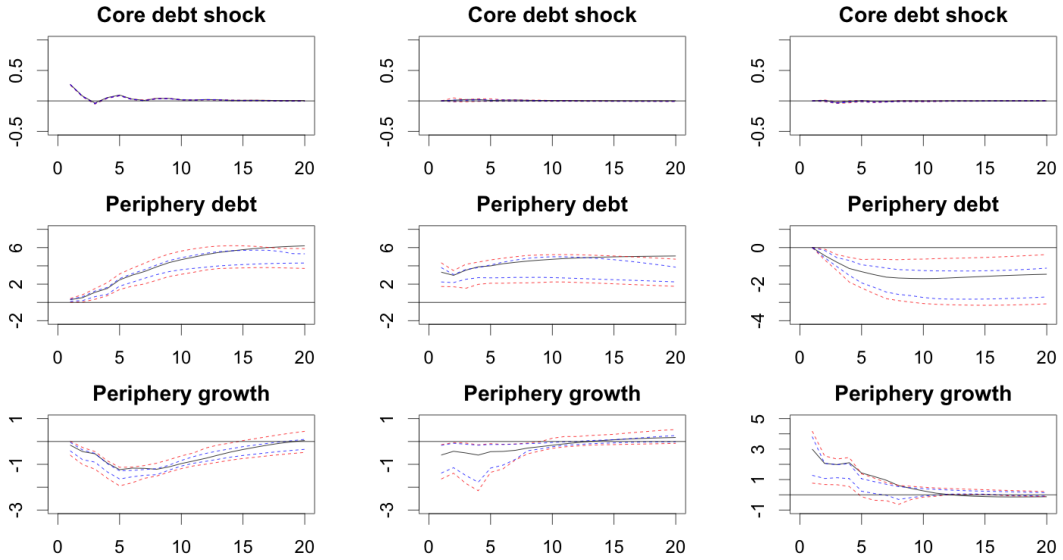


(e) Reactions to a short-term interest rate shock

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

7.3 Complete IRFs of the four spillover models

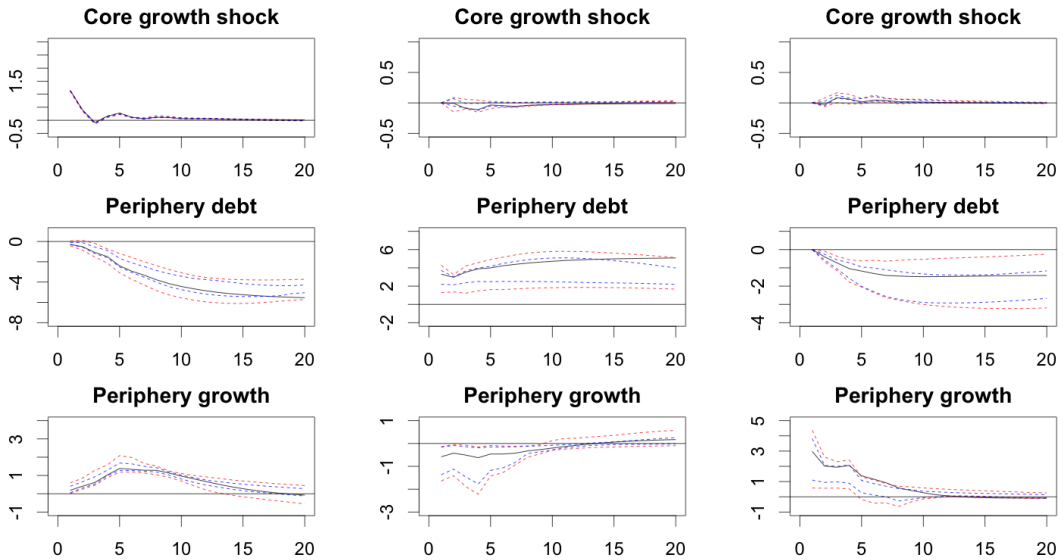
Figure 8: Complete IRFs of debt spillovers from core to periphery countries



(a) Reactions to a debt shock in the core countries (b) Reactions to a debt shock in the periphery countries (c) Reactions to a growth shock in the periphery countries

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

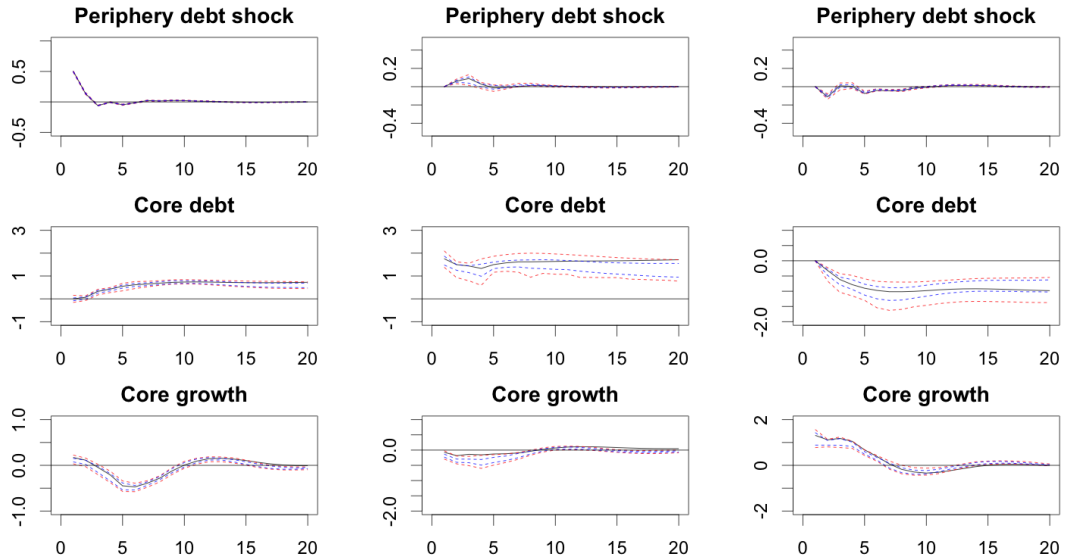
Figure 9: Complete IRFs of growth spillovers from core to periphery countries



(a) Reactions to a growth shock in the core countries (b) Reactions to a debt shock in the periphery countries (c) Reactions to a growth shock in the periphery countries

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

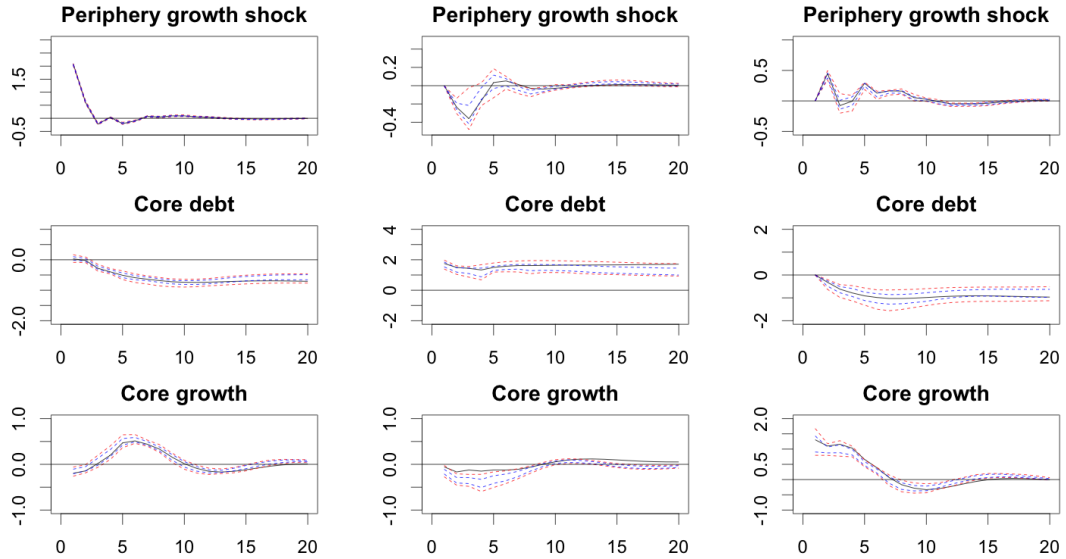
Figure 10: Complete IRFs of debt spillovers from periphery to core countries



(a) Reactions to a debt shock in the periphery countries (b) Reactions to a debt shock in the core countries (c) Reactions to a growth shock in the core countries

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

Figure 11: Complete IRFs of growth spillovers from periphery to core countries

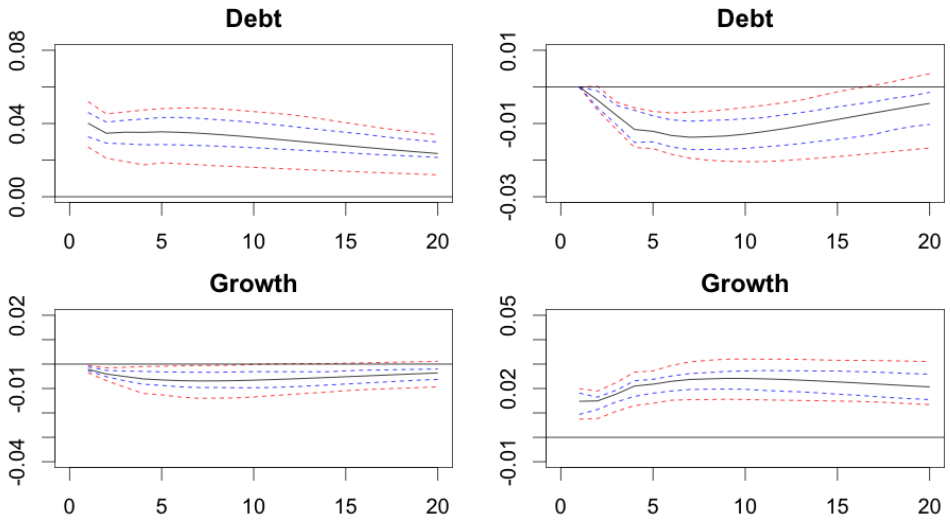


(a) Reactions to a growth shock in the periphery countries (b) Reactions to a debt shock in the core countries (c) Reactions to a growth shock in the core countries

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

7.4 IRFs with logged variables

Figure 12: Logged variables: IRFs of debt and GDP

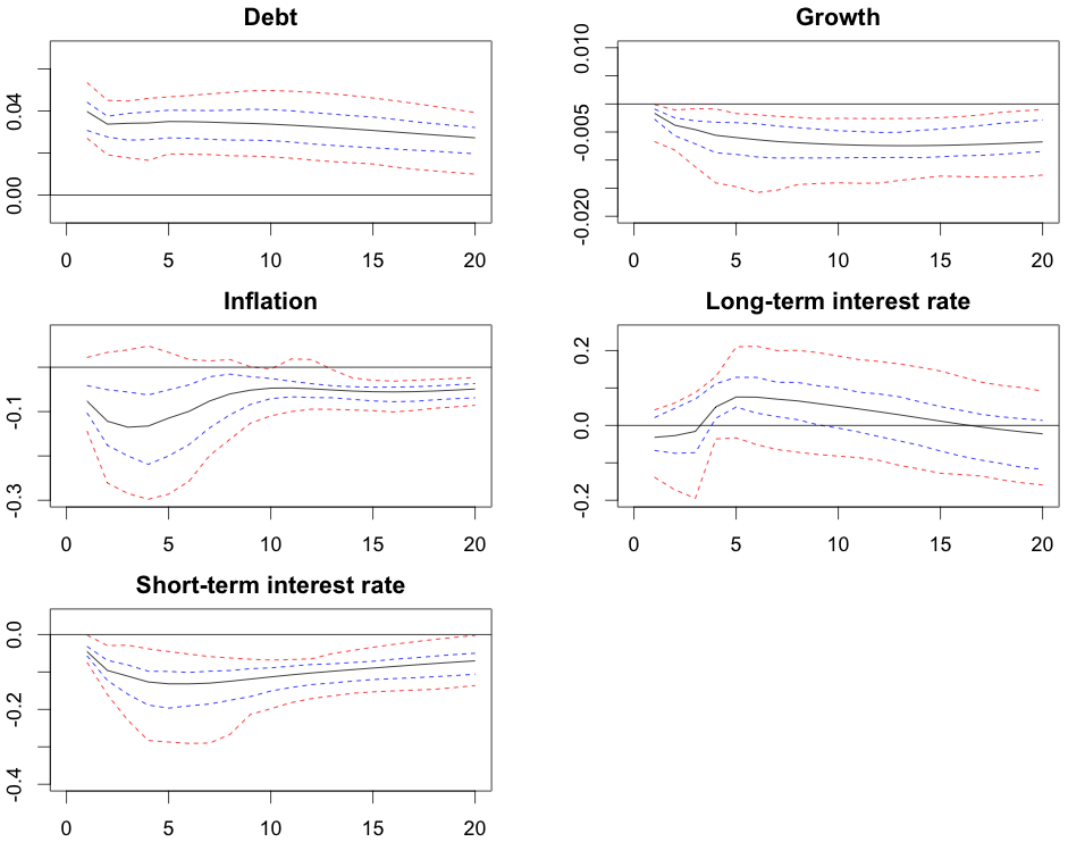


(a) Logged variables: Reactions to a debt shock

(b) Logged variables: Reactions to a GDP shock

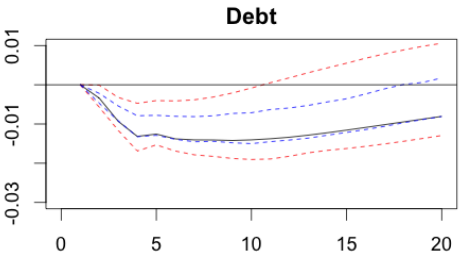
Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

Figure 13: Logged variables: IRFs to a debt shock

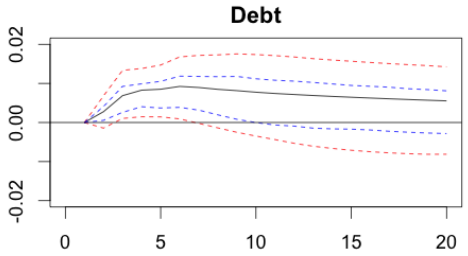


Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

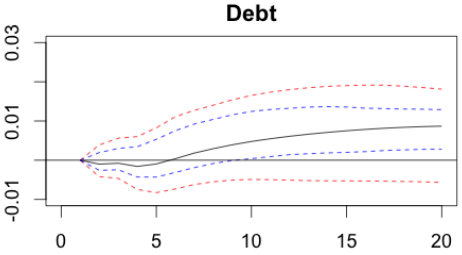
Figure 14: Logged variables: IRFs of debt



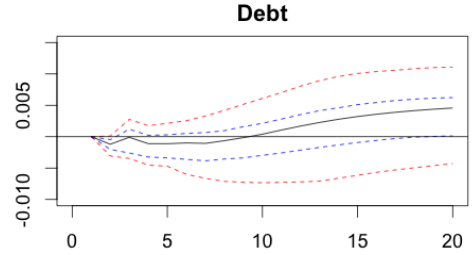
(a) Logged variables: Reaction to a growth shock



(b) Logged variables: Reaction to a inflation shock



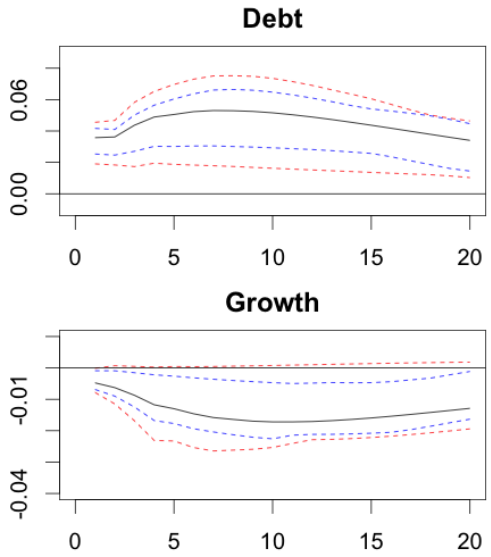
(c) Logged variables: Reaction to a long-term interest rate shock



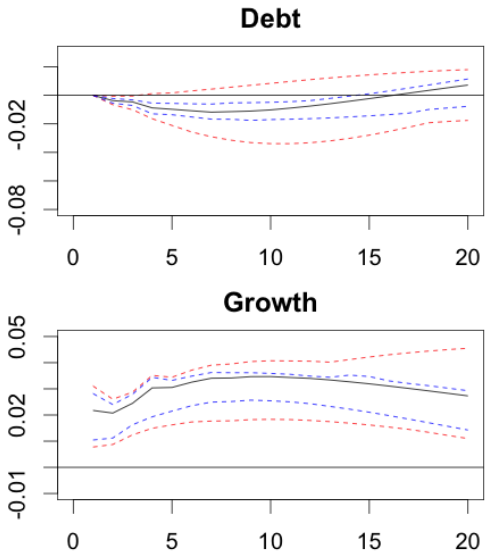
(d) Logged variables: Reaction to a short-term interest rate shock

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

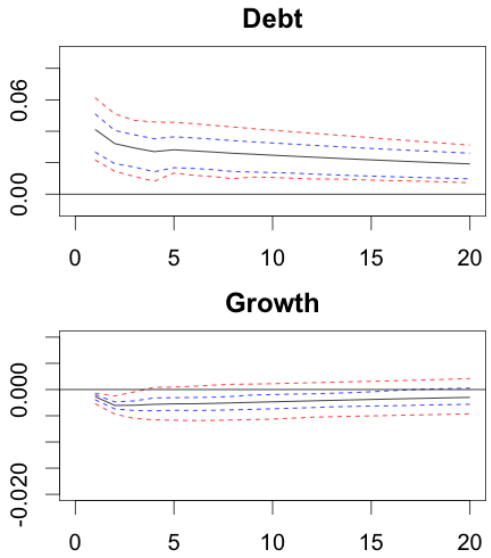
Figure 15: Logged variables: IRFs of periphery and core countries separately



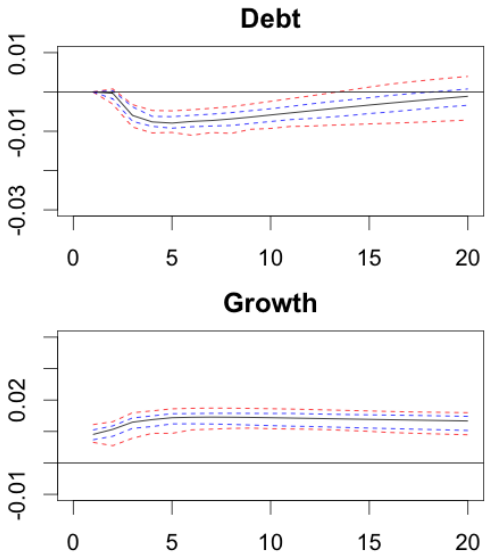
(a) Logged variables: Reaction to a debt shock



(b) Logged variables: Reaction to a GDP shock



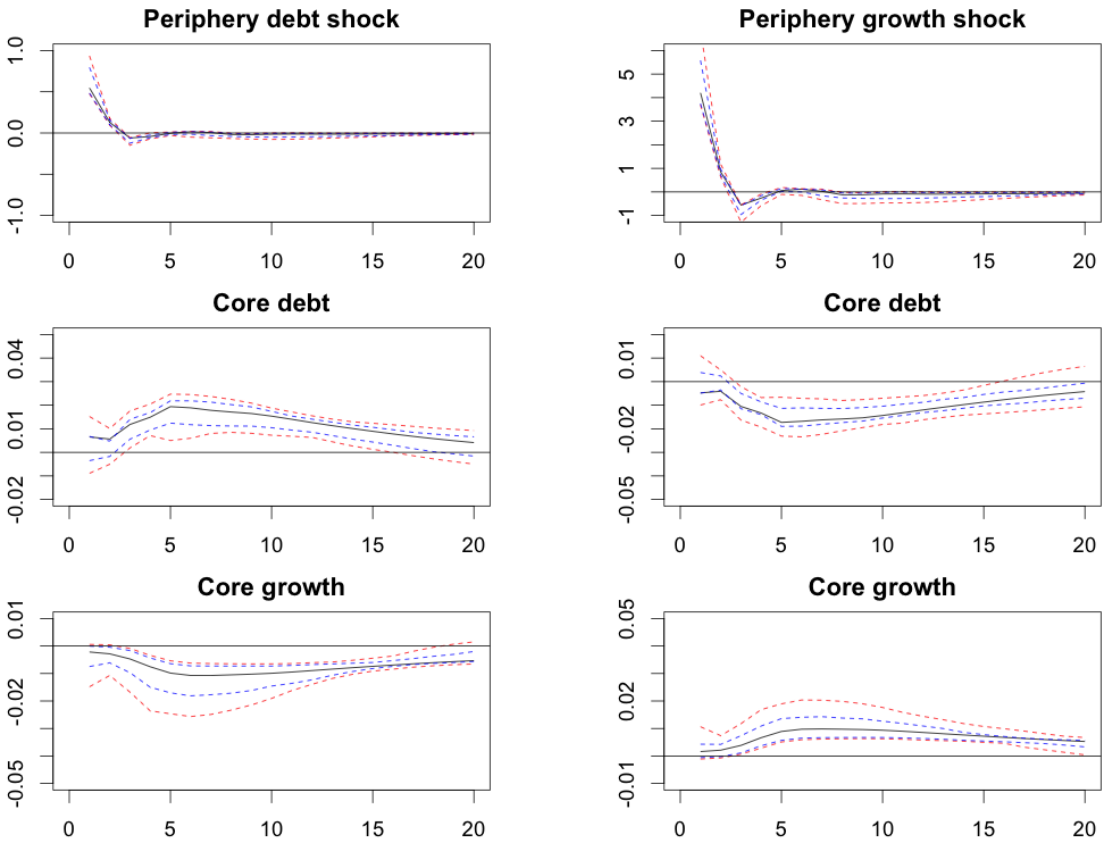
(c) Logged variables: Reaction to a debt shock



(d) Logged variables: Reaction to a GDP shock

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

Figure 16: Logged variables: Spillovers from periphery to core countries

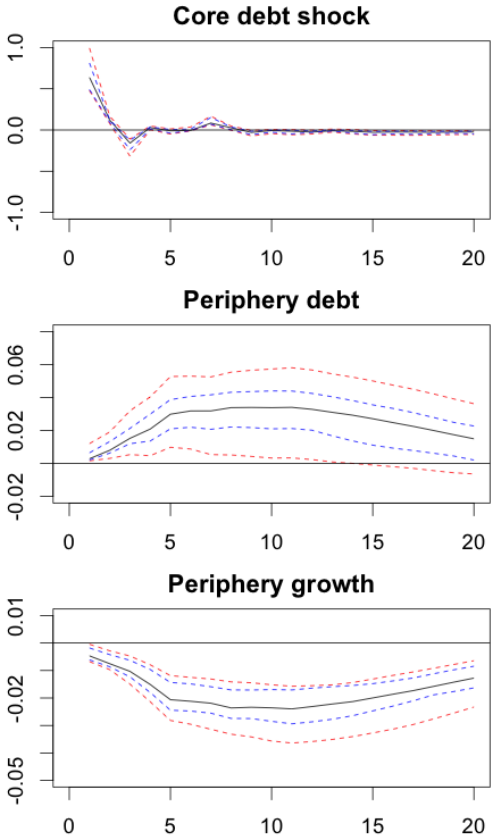


(a) Logged variables:
Reaction to a debt shock in the core countries

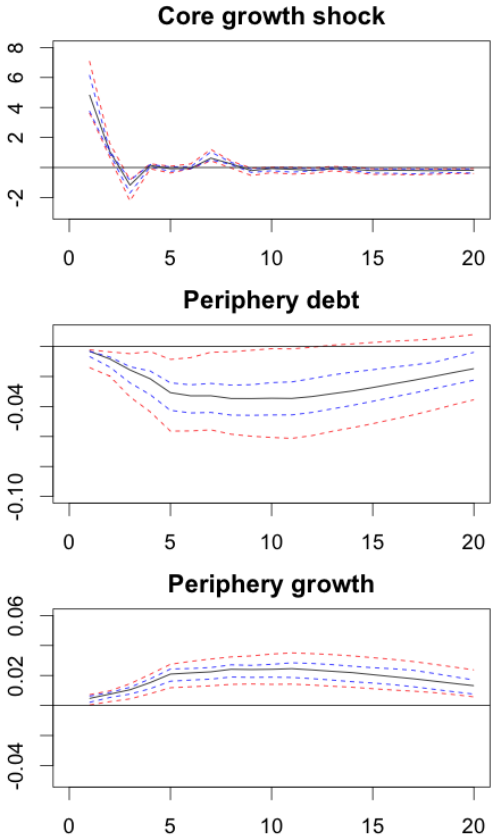
(b) Logged variables:
Reaction to a growth shock in the core countries

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

Figure 17: Logged variables: Spillovers from core to periphery countries



(a) Logged variables:
Reaction to a debt shock in the periphery countries



(b) Logged variables:
Reaction to a growth shock in the periphery countries

Black solid line: orthogonalized IRF, red dashed lines 95%- and blue dashed lines 68%-confidence bands.

7.5 Detailed data description

Description	Unit	Code	Frequency
General government debt	% of GDP	gov_10q_ggdebt	quarterly
GDP	Current prices, million euro	namq_10_gdp	quarterly
Long-term interest rates	%	irt_lt_mcby_q	quarterly
Short-term interest rates	%	irt_st_q	quarterly
Inflation	% change	prc_hicp_manr	monthly

GDP growth in relation to same quarter last year
For example, the growth rate of the first quarter in 2000 is given by:

$$GDPgrowth_{2000Q1} = \frac{GDP_{2000Q1} - GDP_{1999Q1}}{GDP_{1999Q1}}$$

Quarterly inflation
For example the inflation rate for the first quarter in 2000 is given by:

$$Inflation_{2000Q1} = \frac{Inflation_{2000M1} + Inflation_{2000M2} + Inflation_{2000M3}}{3}$$

The resulting data are thus described as follows:

Description	Unit	Frequency
GDP growth	% change	quarterly
Inflation	% change	quarterly