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PUBLIC DEBT, ECONOMIC GROWTH AND THE REAL INTEREST RATE: A PANEL VAR APPROACH TO EU AND OECD COUNTRIES

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Public Debt, Economic Growth and the Real Interest Rate: A Panel VAR Approach to EU and OECD Countries*

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Abstract

We investigate the causal relationship between the public debt to GDP ratio and economic growth for 31 EU and OECD countries from 1995 to 2013. A number of studies have tackled this problem, but very few make the transmission mechanism explicit in their analysis. We estimate a panel VAR model that incorporates the long-term real interest rate on government bonds as a vehicle to transmit shocks in both the public debt to GDP ratio and economic growth. We find no causal link from the public debt to GDP ratio to the GDP growth rate, irrespective of the levels of public debt. Rather, we find a causal relation from the GDP growth rate to the public debt to GDP ratio. In high-debt countries, the direct negative impact of economic growth on public debt is enhanced by a rise in the long-term real interest rate, which in turn decreases interest-sensitive demand and leads to a further increase in the public debt to GDP ratio.

JEL Classification Number: E43, H63, O47
Keywords: Public debt, Economic growth, Interest rate, Panel VAR, Granger causality

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1. Introduction

The seminal work of Reinhart and Rogoff (2010) finds that public debt overhang has a negative effect on economic growth when the debt to GDP ratio is high. Their study has sparked an empirical investigation into the relationship between public debt and economic growth. A number of studies have examined nonlinear relationships between public debt and economic growth where there exists a threshold beyond which public debt has a negative impact on economic growth. Many studies have found evidence in favor of a nonlinear negative relationship between public debt and growth, but their results are sensitive to the time dimension, country coverage, data frequency and econometric methods applied.[1] Moreover, to the best of our knowledge, no studies convincingly demonstrate a causal link from public debt to economic growth with a transmission mechanism explicitly taken into consideration.

We employ a vector autoregression (VAR) model, an ideal econometric tool, to analyze dynamic interrelations among variables. Based on the VAR model, we test the presence of Granger causality between economic growth, public debt and the long-term real interest rate on government bonds through which a shock in public debt is transmitted to economic growth and vice versa. High levels of public debt cast doubt on the full repayment of the debt and might lead to a higher risk premium and associated higher long-term real interest rates, which in turn has a negative impact on economic growth via a decline in interest-sensitive expenditures.[2]

Specifically, we estimate a panel VAR model developed by Holtz-Eakin et al. (1988). The model describes the dynamic relation among public debt, economic growth and the long-term real interest rate for a panel data set of 31 EU and OECD countries from 1995 to 2013. Interestingly, our sample period covers the recent European sovereign debt crisis.

We find no causal link from the public debt to GDP ratio to the real GDP growth rate, irrespective of the levels of the debt ratio. Rather, we find a causal relation from the GDP growth rate to the level of public debt for countries with both high levels of debt to GDP and those with low levels of debt to GDP. Quantitatively, the impact of the GDP growth

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[1] Égert (2015) finds that nonlinear effects change over time, across countries and economic conditions. Kourtellos et al. (2013) find that higher public debt results in lower growth for countries in low-democracy regimes. Panizza and Prebistero (2014) show that once endogeneity is corrected for the link between public debt and growth disappears. They instrument public debt with the valuation effects brought about by the interaction between currency debt and movements in the exchange rate. See Panizza and Presbitero (2013) for a survey of empirical studies dealing with the relationship between public debt and economic growth.

[2] The channel through which high public debt adversely affects economic growth is stated in Baldacci and Kumar (2010) and Reinhart et al. (2012).

rate on public debt is larger in countries with high levels of debt. This is because the negative effects of growth on public debt are amplified through the interest channel. A negative shock to economic growth initially raises the levels of public debt via an increase in government expenditure to boost the economy and a decrease in tax revenues. In addition to this direct impact of growth on public debt, slowdown in growth raises the long-term real interest rate, possibly due to a lower inflation rate, which in turn reduces growth by decreasing interest-sensitive spending and leads to a further increase in public debt. A rise in the long-term interest rate also increases interest payments on public debt and thus further raises the level of public debt. We find that a one-standard-deviation decrease in the real GDP growth rate raises the ratio of public debt to GDP by 3.24 percent points for high-debt countries but only 1.04 percent points for low-debt countries.

The remainder of the paper is organized as follows. In Section 2 we provide a brief survey of the recent literature on the relationship between public debt and economic growth and present our hypothesis on how public debt affects economic growth. We describe our dataset and present descriptive statistics in Section 3. Section 4 shows our empirical results. The last section presents our conclusions.

2. Magnitude of and Channels through which Public Debt Affects Growth and Related Literature

Reinhart and Rogoff's (2010) seminal paper finds that public debt overhang has a negative effect on economic growth at high levels, often at a ratio of public debt to GDP above 90 percent. The observations with debt to GDP above 90 percent have mean growth rates almost 4 percent lower in advanced countries. Their finding is originally based on descriptive statistics of historical episodes, which has stimulated a number of rigorous econometric studies.

Panizza and Presbitero (2013) survey the recent literature on the links between public debt and economic growth and effectively summarize the empirical studies conducted to date by stating that the relationship between public debt and growth is characterized by large cross-country heterogeneity and may vary over time within countries.

There are many studies that find evidence in favor of the negative nonlinear relationship between public debt and growth. For example, Kumar and Woo (2010) confirm that only high levels of debt (above 90 percent of GDP) exert a significant negative effect on growth. They find that a 10 percent point increase in the initial debt-to-GDP ratio is associated with a slowdown in real per capita GDP growth rate of 0.2 percent points per annum. Cecchetti et al. (2011) also find, in various specifications of growth regressions, that the threshold beyond which government debt has a negative

impact on growth is approximately 85% of GDP. They find that a 10 percent point increase in the debt ratio reduces real GDP growth rate by more than one tenth of 1 percent point. Checherita-Westphal and Rother (2012) find a nonlinear impact of government debt on long-term growth with a turning point at approximately 90–100% of GDP. Baum et al. (2013) suggest that the short-run impact of debt on GDP growth is positive and highly statistically significant but decreases to around zero and then loses significance when the ratio of public debt to GDP reaches approximately 67%. For high debt-to-GDP ratios (above 95%), additional debt has a negative impact on economic activity. They find that a 1 percent point increase in the debt to GDP ratio reduces real GDP growth rate by 0.06 percent point. Afonso and Jalles (2013) find that the threshold value of the debt ratio is 58% of GDP for the Euro area and a slightly larger value of 79% of GDP for emerging countries.

However, some studies emphasize that negative relationships between public debt and growth depends on the countries and the sample period chosen. Kourtellos et al. (2013) find that higher public debt results in lower growth only for countries with low-democracy regimes. Dreger and Reimers (2013) show that the negative impact of the debt to GDP ratio is limited to the euro area and periods of non-sustainable public debt. They further note that the negative debt effect diminishes in industrial countries and that debt exerts a positive impact on economic growth provided that the debt is sustainable. Égert (2015) finds some evidence in favor of a negative nonlinear relationship between public debt and growth. However, he warns that these results are very sensitive to the time period and country studied, the data frequency and assumptions on the minimum number of observations required in each nonlinear regime. He reports that when non-linearity is detected, the negative nonlinear effect starts at much lower levels of public debt (between 20% and 60% of GDP). Eberhardt and Presbitero (2015) find some support for a negative relationship between public debt and long-run growth across countries but no evidence for a similar debt threshold within countries. Panizza and Prebistero (2014) find that a negative link between public debt and growth disappears once they correct for endogeneity by accounting for the valuation effects brought about by the interaction between currency debt and movements in the exchange rate.

Previous empirical studies have mainly focused on detecting a negative relationship between public debt and economic growth, but there are no studies aimed at identifying the channels through which public debt affects economic growth. One channel through which public debt is transmitted to growth is via the long-term interest rate. Reinhart et al. (2012) argue that this interest rate channel works as follows: sufficiently high levels of public debt call into question whether debt will be repaid in full, thus leading to a

higher risk premium and its associated higher long-term real interest rate, which in turn lowers economic growth by decreasing interest-sensitive expenditures on investment and durables. Baldacci and Kumar (2010) confirm this conjecture and find that higher public debt leads to a significant increase in long-term interest rates, with the precise magnitude dependent on initial fiscal, institutional and other structural conditions. Baum et al. (2013) also suggest a nonlinear relationship between public debt and the long-term interest rate and find that additional public debt increases the long-term interest rate above a threshold debt to GDP ratio of approximately 73.8%. However, Checherita-Westphal and Rother (2012) report that the level of the public debt to GDP ratio is not statistically significant in determining long-term interest rates in either linear or quadratic forms.[3] Reinghart and Rogoff (2012) also provide evidence that countries with a public debt overhang do not always experience a sharp rise in real interest rates. Nonetheless, even if a significant positive effect of public debt on the long-term interest rate is detected, it does not necessarily imply that public debt has an adverse impact on economic growth by way of this channel. Rather, we have to show that a higher long-term interest rate decreases the growth rate, which is unquestionably theoretically correct, but is by no means empirically self-evident. Therefore, we have to analyze the causal relations among public debt, economic growth and the long-term real interest rate.

A panel VAR model is a suitable econometric tool to analyze dynamic interactions among the public debt to GDP ratio, the real GDP growth rate and the real long-term interest rate, using cross-country data over time. There have been studies that examine the causal link between public debt and economic growth. Lof and Malinen (2014) estimate a panel VAR model of the real GDP growth rate and growth rate of total gross government debt and conclude that the negative correlation between sovereign debt and economic growth is primarily driven by the impact of growth on sovereign debt rather than vice versa. Puente-Ajovín and Sanso-Navarro (2015) investigate the presence of Granger causality between public debt and growth in 16 OECD countries and find that, with the exception of a few countries, there is a causal link from growth to public debt, not from public debt to growth.

Unfortunately, previous panel VAR studies only analyze the two-variate relationship between public debt and economic growth. In this paper we shed light on the role of long-term interest rates in transmitting a shock in public debt into growth and vice versa by examining the tri-variate panel VAR model of public debt, economic growth and the long-

[3] Checherita-Westphal and Rother (2012) find nonlinear effects of debt on private saving, public investment and Total Factor Productivity and conclude that the channels through which public debt has a nonlinear impact on economic growth are precisely by those.

term real interest rate, using cross-country panel data.

3. Data

Our sample includes 27 EU countries and 4 OECD countries (Australia, Canada, Japan and the United States).[4] The sample period covers the years of 1995 to 2013. This selection of countries and range of sample years offsets some of the critique that previous studies incurred. The 31 countries have a stable democracy and share common goals of transparency in both fiscal and monetary policy and other essential institutions. The sample years include economic variation, with economic prosperity (the 1990s) on the one hand, and the worldwide financial crisis (2007-2013) on the other, but do not contain shifts in structural views on the role of government debt. Our sample period is also suitable for analyzing the relationship between public debt and economic growth during the recent European sovereign debt crisis. Specifically, in the Greek crisis of 2015, one of the topics of discussion between the Greek government and the 'Trojka' (the European Commission, the European Central Bank, and the International Monetary Fund) has been the excessive burden of government debt and additional foreign debt on the real GDP growth rate. Similar discussions were held during the Irish, Portuguese, and Spanish rescue plans in the years 2011-2013. We examine the relations among three variables: the real GDP growth rate, the ratio of public debt to GDP and the long-term real interest rates. The real GDP growth rate is calculated as the log difference of real GDP in terms of the 2010 national currency market price. The ratio of public debt to GDP is defined as the gross debt of the general government divided by nominal GDP. The long-term real interest rate is calculated as the nominal long-term (in most cases 10 year) government bonds minus the inflation rate in terms of GDP deflator. The data sources are the Eurostat database and OECD database.

Table 1 shows the mean of the real GDP growth rate, the public debt ratio and the long-term real interest rate for each country in the sample. The public debt ratio varies more widely across countries than the GDP growth rate or the long-term interest rate. The debt to GDP ratio exceeds 100% in five countries: Japan, Greece, Italy, Canada and Belgium, while it is less than 20% in Estonia (6.14%) and Luxembourg (10.81%). The real GDP growth rate ranges from 0.5% (Italy) to 4.41% (Estonia), while the long-term real interest rate ranges from -0.09% (Romania) to 5.13% (Greece).

Figure 1 exhibits a scatter diagram representing the public debt to GDP ratio and the real GDP growth rate. We observe a negative correlation between the public debt ratio and the GDP growth rate. The correlation coefficient is -0.3131, and the null hypothesis

[4] Croatia is not included in our set.

of no correlation is decisively rejected at the 1% significance level. Figure 2 exhibits a scatter diagram representing the public debt to GDP ratio and the long-term real interest rate. We observe a positive correlation between the public debt to GDP ratio and the long-term real interest rate. The correlation coefficient for the whole sample is 0.2352 and the null hypothesis of no correlation is also rejected at the 1% significance level. Note that the correlation coefficient gives no information about the direction of the causal links among the variables, thus, we estimate a panel VAR model to analyze the causal relationships in the next section.

4. Estimation Results

We estimate a panel VAR model using data from 31 countries over the years 1995 to 2013. In applying the VAR model to the panel data, we control for individual heterogeneity by introducing fixed effects. The mean-differencing procedure commonly used in panel analysis would yield biased estimates due to the presence of lagged dependent variables among the explanatory variables. Therefore, following Arellano and Bover (1995), we use forward-mean differencing, commonly known as the Helmert procedure, to eliminate fixed effects. The virtue of this procedure is that we can use untransformed lagged regressors as instruments. Indeed, we use the variables lagged by one and two years. The model is estimated by the System Generalized Methods of Moments (SGMM).[5]

The optimal lag order is chosen by the three model selection criteria for SGMM models proposed by Andrew and Lu (2001). Three criteria are analogous to the Akaike information criteria (AIC), the Bayesian information criteria (BIC) and the Hannan-Quinn information criteria (HQIC). We choose the lag length as one. In estimating a panel VAR model, we include time dummies as exogenous variables to account for aggregate macro shocks.

(1) Two-variate case

First, we estimate a two-variate panel VAR model of the debt-to-GDP ratio and real GDP growth rate for the whole sample (Case 1). The ordering of the variables is GDP growth rate and the debt-to-GDP ratio.[6] Table 2 shows the Wald statistics to test Granger causality, whether the stability condition of the panel VAR model is satisfied, and the

[5] We use the Stata program originally developed by Love and Zicchino (2006) and extended by Abrigo and Love (2015).

[6] Estimation results remain unaltered by a change in the ordering of the variables.

Hansen test statistics of overidentifying restrictions.[7] We find Granger causality from the real GDP growth rate to the public debt to GDP ratio but not vice versa. Figure 3 depicts the impulse responses to a one standard deviation shock to the real GDP growth rate and the debt to GDP ratio together with the associated 90 percent confidence intervals.[8] The debt to GDP ratio is lowered by 1.45 percent points one year after a positive shock to the real GDP growth rate.

Some might argue that the failure to detect the impact of public debt on economic growth is due to misspecification of the model. Many studies find a threshold above which public debt exerts a negative impact on economic growth and below which public debt has no effect on economic growth. To account for the differential effects of public debt on economic growth, we split our sample countries by the mean of the debt-to-GDP ratio into two groups: a high-public-debt group and a low-public-debt group. The high-public-debt group consists of 16 countries, and the low-public-debt group consists of 15 countries.[9] The two-variate panel VAR model is estimated separately for the high-public-debt group (Case 2) and the low-public-debt group (Case 3). Table 2 shows that there is no causal link from public debt to economic growth for the high-public-debt group, however, we do observe a weak causal link from the public debt to GDP ratio to economic growth in the low-public-debt group. We observe Granger causality from economic growth to public debt for both the high- and low-public-debt groups. Figures 4 and 5 depict the impulse responses for both groups. The impact of economic growth on public debt is larger for the high-debt group. The debt-to-GDP ratio is lowered by 2.17 percent points two years after a positive shock to GDP growth rate for the high-debt group, while the counterpart is 1.50% for the low-debt group. The impact of the debt-to-GDP ratio on economic growth is quite small for the low-debt group. The GDP growth rate is lowered by 0.19 percent points three years after a one-standard-deviation positive shock to the debt-to-GDP ratio.

(2) Tri-variate case

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[7] Note that a VAR model is stable if all moduli of the eigenvalue of the estimated models are strictly less than unity. See Hamilton (1994) pp. 260-261.

[8] Confidence intervals are estimated from 2,000 Monte Carlo simulations from the estimated panel VAR model.

[9] The countries in the high-public-debt group are Belgium, Germany, Ireland, Greece, Spain, France, Italy, Cyprus, Hungary, Malta, the Netherlands, Austria, Portugal, Canada, Japan and the United States. Those in the low public debt group are Australia, Bulgaria, Czech Republic, Denmark, Estonia, Latvia, Lithuania, Luxembourg, Poland, Romania, Slovak Republic, Slovenia, Finland, Sweden and United Kingdom.

Next we estimate a tri-variate panel VAR model of the debt-to-GDP ratio, the real GDP growth rate and the long-term real interest rate for the whole sample (Case 4). The ordering of the variables is the real GDP growth rate, the debt-to-GDP ratio and the long-term real interest rate.[10] Table 3 shows various test statistics of the estimated tri-variate panel VAR model.

Even if the model is extended to incorporate the possible impact of public debt on economic growth via the long-term real interest rate, we cannot detect a causal link from public debt to economic growth. There is no direct impact of the debt-to-GDP ratio on the real GDP growth rate. Moreover, we cannot find indirect effects of public debt on economic growth as we do not detect Granger causality either from the debt-to-GDP ratio to the long-term real interest rate or from the long-term real interest rate to the GDP growth rate.

In contrast, we still find a causal link from economic growth to the public debt to GDP ratio. Additionally, we find a causal link from economic growth to the long-term real interest rate. A rise in the GDP growth rate leads to a fall in the long-term interest rate, possibly by way of a rise in the inflation rate.

Figure 6 depicts the impulse responses for the tri-variate case. The debt-to-GDP ratio is lowered by 1.34 percent points two years after a positive shock to the GDP growth rate. The impact of economic growth on public debt when the interest rate is endogenized is quantitatively similar to the two-variate case (Case 1). The long-term interest rate decreases by 1.03 percent points one year after a positive shock to the real GDP growth rate.

We estimate a tri-variate panel VAR model separately for the high-public-debt group (Case 5) and low-public-debt group (Case 6). We observe several common causal links among the variables for both groups in Table 3. First, there is a direct causal link from economic growth to public debt. Second, there is no causal link from public debt to economic growth, irrespective of the levels of debt. Third, an increase in the real GDP growth rate lowers the long-term real interest rate. Moreover, we uncover additional causal links among the variables for the high-public-debt group. One of these additional links is a causal link from the long-term real interest rate to economic growth. This implies that economic activities are sensitive to a change in the long-term real interest rate in the high-public-debt group.[11] We also find a causal link from the long-term real

[10] The estimation results remain essentially unaltered by changing the ordering of the variables.

[11] We also observe a causal link from the long-term real interest rate to economic growth for the low-public-debt group, but it turns out that the effect of the interest rate on

interest rate to the debt-to-GDP ratio. A rise in the long-term real interest rate increases interest payments on public debt and thus raises the debt-to-GDP ratio.

We now summarize the channel through which a negative shock to real GDP growth rate is transmitted to a rise in public debt. For low-debt countries, we observe only the direct link from the real growth rate to public debt. That is to say, a negative shock to the real growth rate raises the levels of public debt via an increase in government expenditure and a decrease in tax revenues. For high-debt countries, an initial negative impact of economic growth on public debt is further amplified through the interest channel. In other words, slowdown in the growth rate raises the long-term real interest rate, possibly due to a lower inflation rate, which in turn reduces the real growth rate by decreasing interest-sensitive demand and leads to a further increase in public debt. A rise in the long-term real interest rate also increases interest payments on public debt and further raises the level of public debt.

Figure 7 schematically compares the transmission mechanisms from economic growth to public debt between high-debt countries and low-debt countries. Quantitatively speaking, the impact of the real growth rate on public debt is much larger for high-debt countries. Figures 8 and 9 show the impulse responses for high- and low-debt countries, respectively. The debt-to-GDP ratio is lowered by 1.04 percent points three years after a positive shock to GDP growth rate for low-debt countries, while the debt-to-GDP ratio is lowered by 3.24 percent points four years after a positive shock to GDP growth rate for high-debt countries. In high-debt countries, the impact of economic growth on the debt-to-GDP ratio is persistent, and the debt-to-GDP ratio is still 2.27 percent points lower ten years after the positive shock to economic growth. In high-debt countries, the debt-to-GDP ratio increases by 3.12 percent points six years after a positive shock to the long-term interest rate.

Finally, we make a quantitative evaluation of the extent to which the long-term interest rate amplifies the shock to GDP growth rate by comparing the pattern of the impulse responses under an endogenous interest rate with the pattern of responses under an exogenous interest rate (Case 7). Figure 10 shows the impulse responses when the interest rate is exogenous. The debt-to-GDP ratio decreases only by 1.86 percent points two years after a shock to GDP growth rate, which is 1.38 percent points smaller than the case of an endogenous interest rate.

5. Concluding Remarks

In this paper we find a causal link from economic growth to the public debt by

economic growth is positive, contrary to the theoretical prediction.

estimating a panel VAR model that accounts for the interest channel through which a shock to economic growth is transmitted to the public debt and vice versa for EU and OECD countries from 1995-2013. However, we fail to find a reverse causality from public debt to economic growth. Our findings remain valid even if we split the sample countries into a high-public-debt group and a low-public-debt group. Our findings show that the long-term real interest rate plays a vital role in transmitting a shock in economic growth to public debt for high-public-debt countries.

Although we could not detect a causal link from public debt to economic growth even for high-debt countries, public debt might be accumulated for many years once a negative shock hits the GDP growth rate. This accumulation is due to a rise in the real interest rate, which in turn decreases interest-sensitive demand and further increases public debt. Rapid accumulation of public debt might start to adversely affect the economic growth if the financial market perceives the level of public debt as 'unsustainable', and the long-term real interest rate responds more sensitively to the levels of public debt. In fact, the long-term interest rate in Greece rose sharply during 2011 and 2012 in response to a rise in the debt-to-GDP ratio. In contrast, the long-term interest rate in Japan stayed around zero despite soaring government debt.[12]

It is important to investigate why the long-term interest rate in one country stays at quite a low level in spite of large public debt, while it sharply rises in another country under the same circumstances. This essentially is asking what factors determine a 'sustainable' level of public debt.[13] [14] Solving this problem will provide a promising platform for designing an economic policy to stabilize economies despite mounting public debt.

[12] The simple correlation coefficient between the nominal interest rate of 10-year government bond and the debt-to-GDP ratio during 1995 to 2013 is 0.479 and -0.805 for Greece and Japan, respectively.

[13] Many academic researchers warn that the current debt level in Japan is unsustainable. For example, see Dekle (2003), Doi and Ihori (2009), Doi, Hoshi and Okimoto (2011), Ito, Watanabe and Yabu (2011), Sakuragawa and Hosono (2011) and Hoshi and Ito (2012). Broda and Weinstein (2005) argue that the ratio of government debt to GDP would be stabilized by an increase in tax rates.

[14] The countries with enormous public debt can still maintain decent economic growth since they possess high growth potentials, such as high productivity. In fact, quite a few countries in the high public debt group have attained high TFP growth rates.

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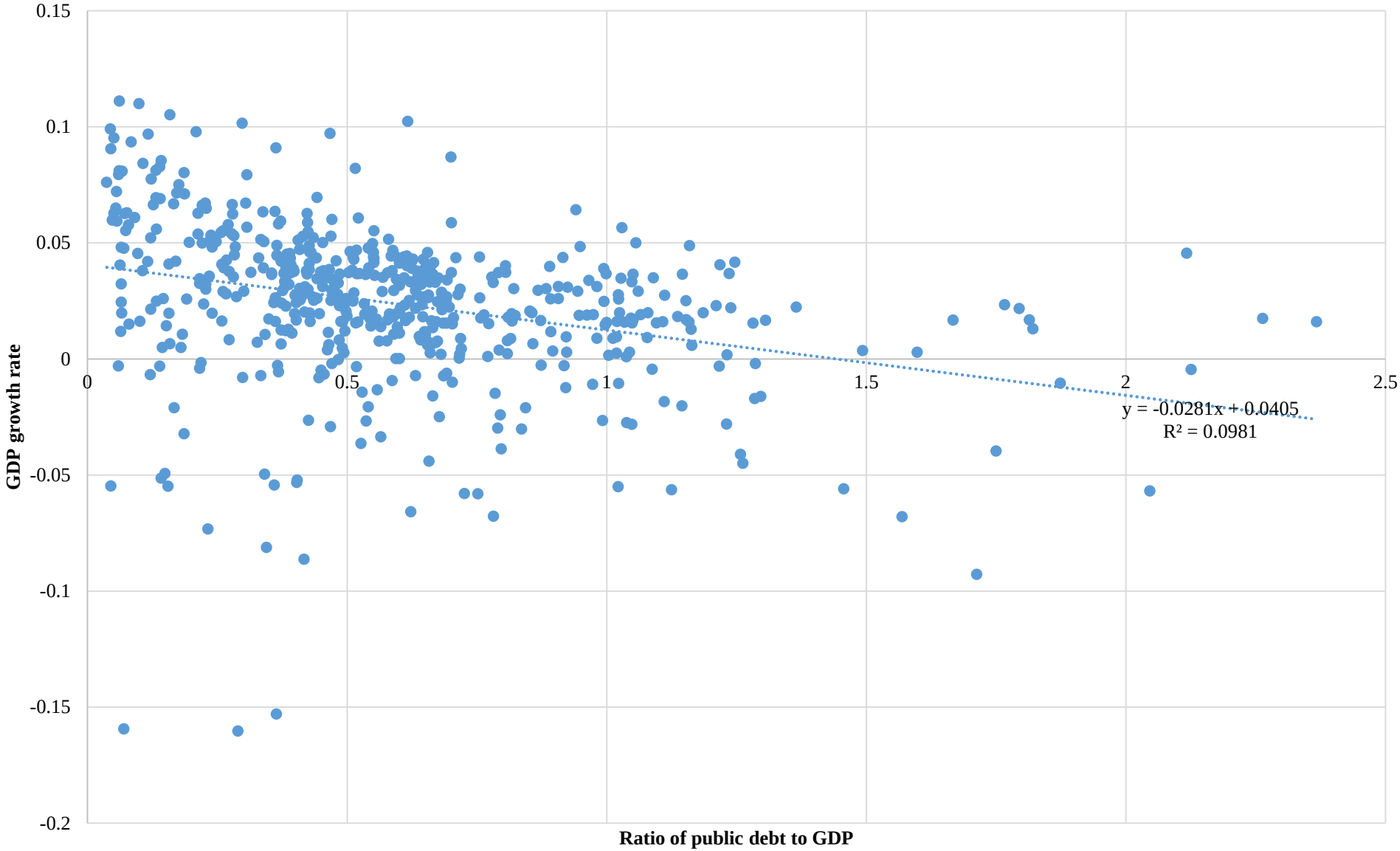
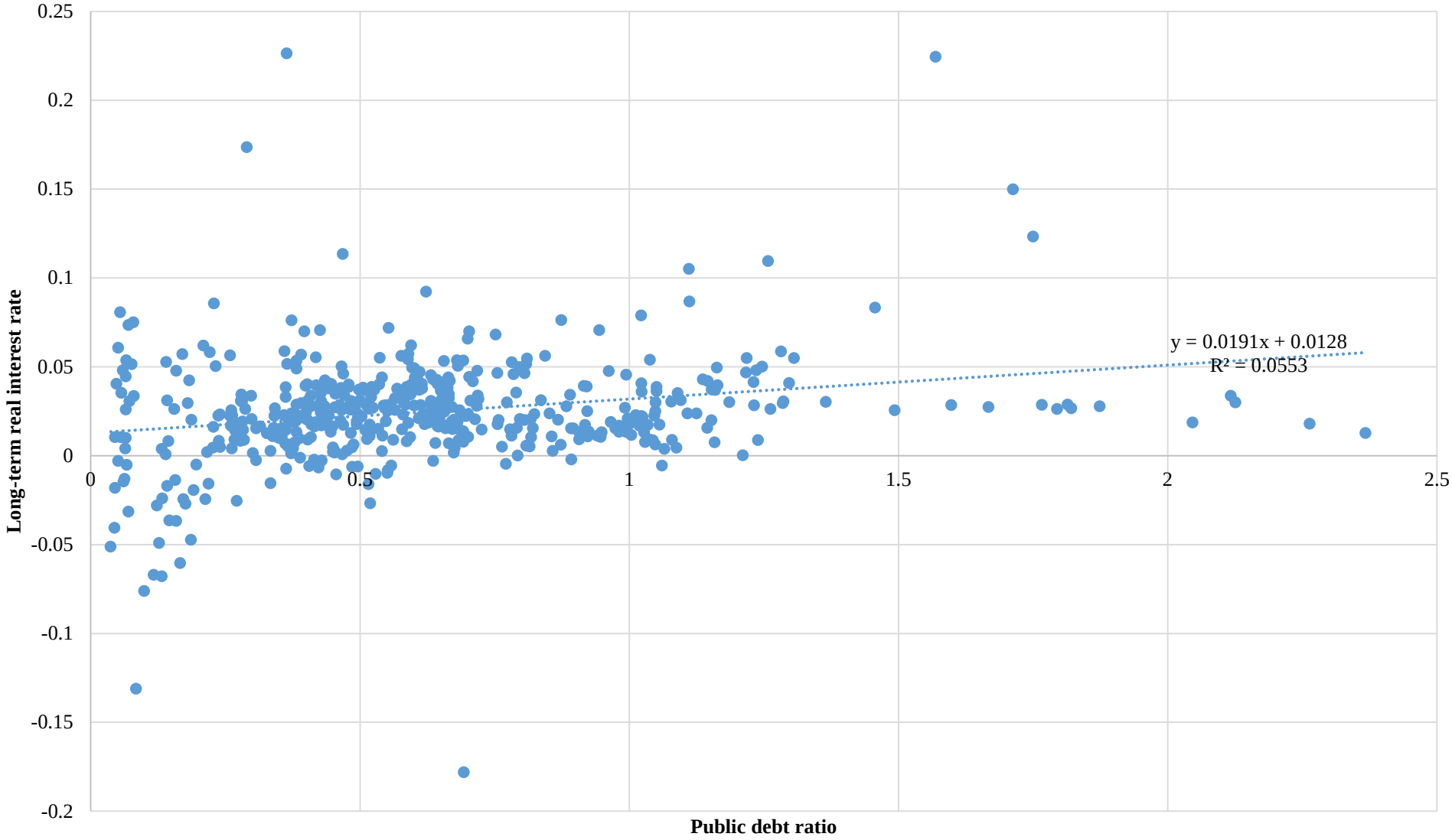
Figure 1　Scatter Diagram of Public Debt Ratio and GDP Growth Rate

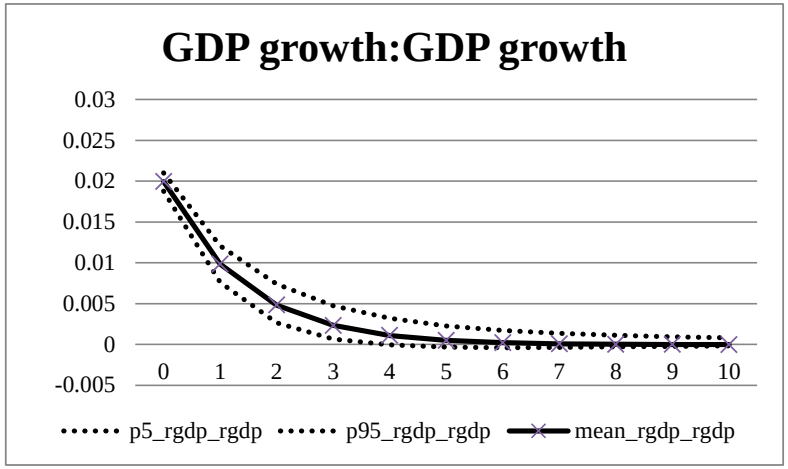


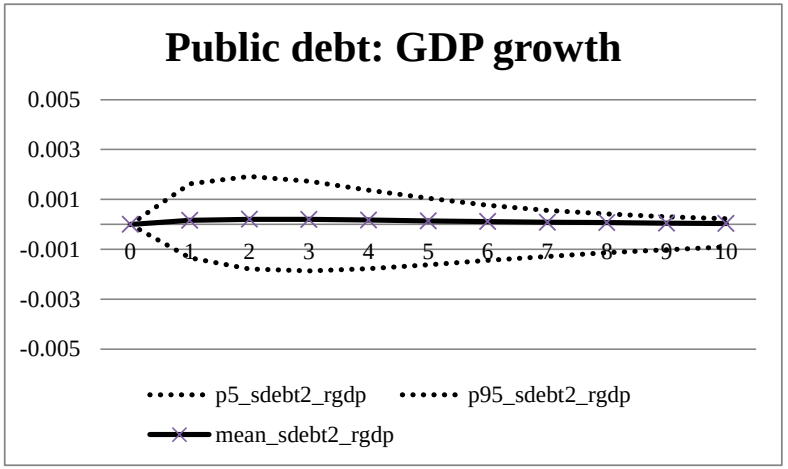
Data source: Eurostat and OECD data base

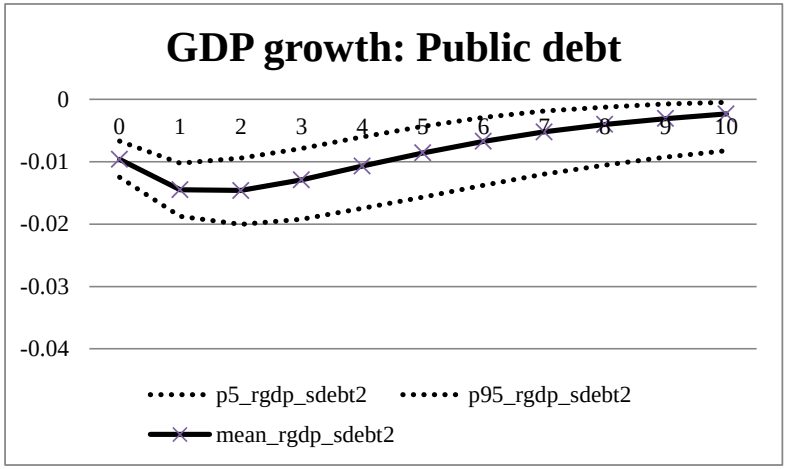
Figure 2 Scatter Diagram of Public Debt Ratio and Long-term Real Interest Rate

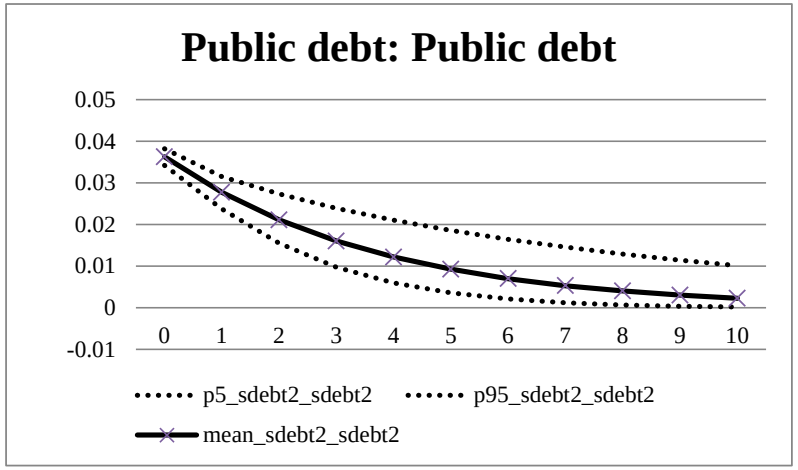


Data source: Eurostat and OECD data base



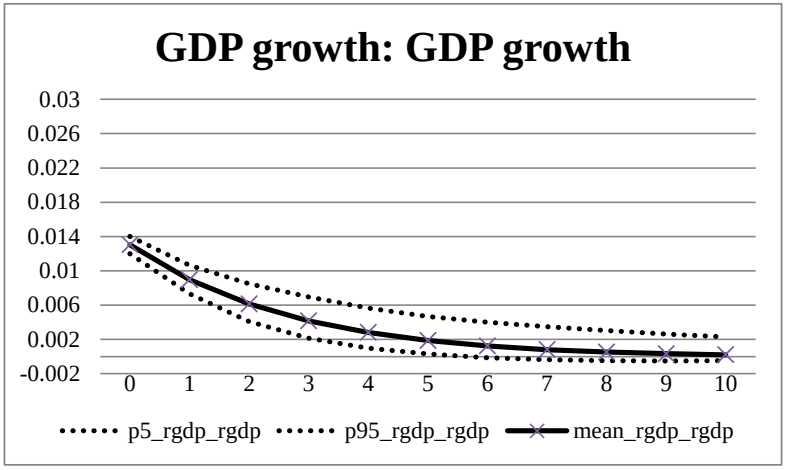


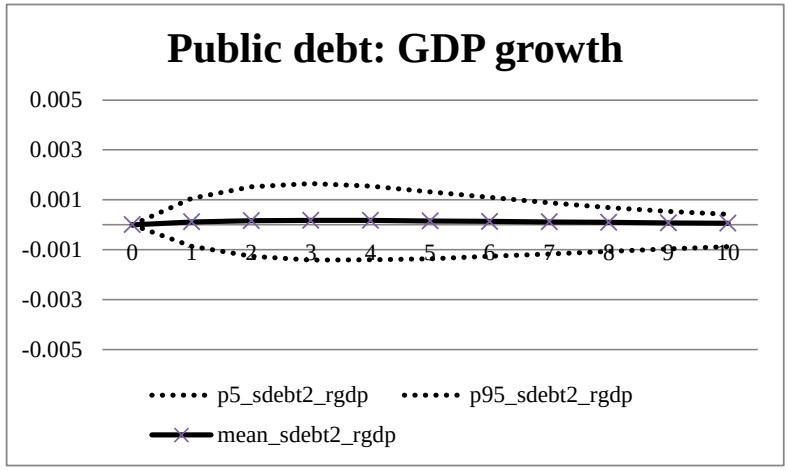


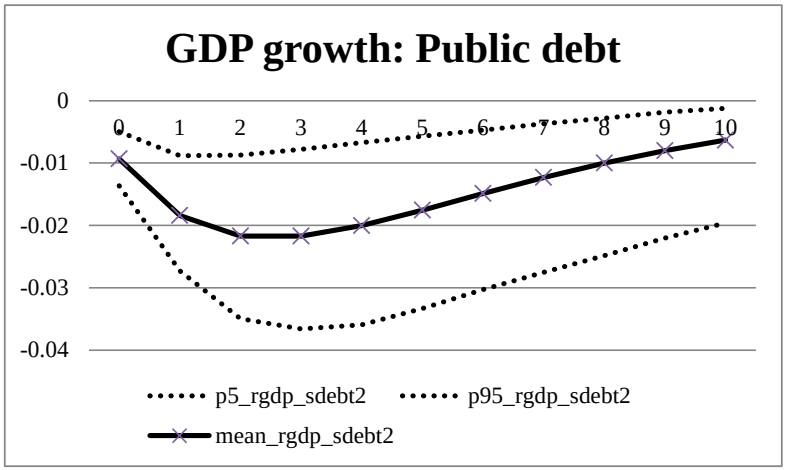


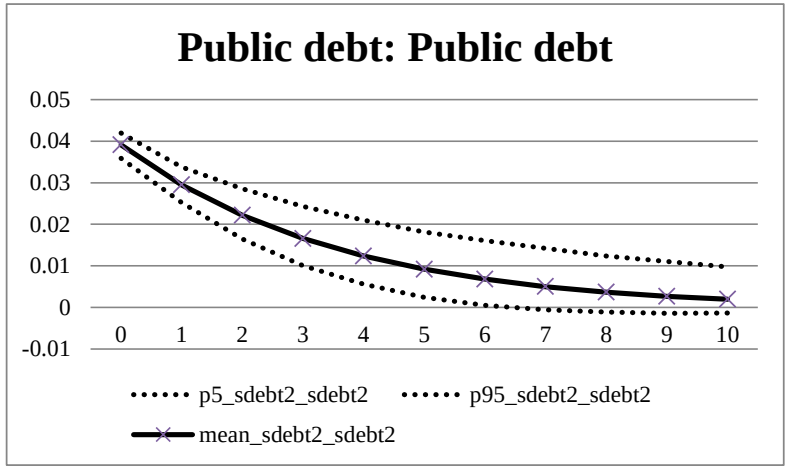
Notes: impulse variable: response variable

Figure 3 Impulse Responses: Basic Two-variate Case



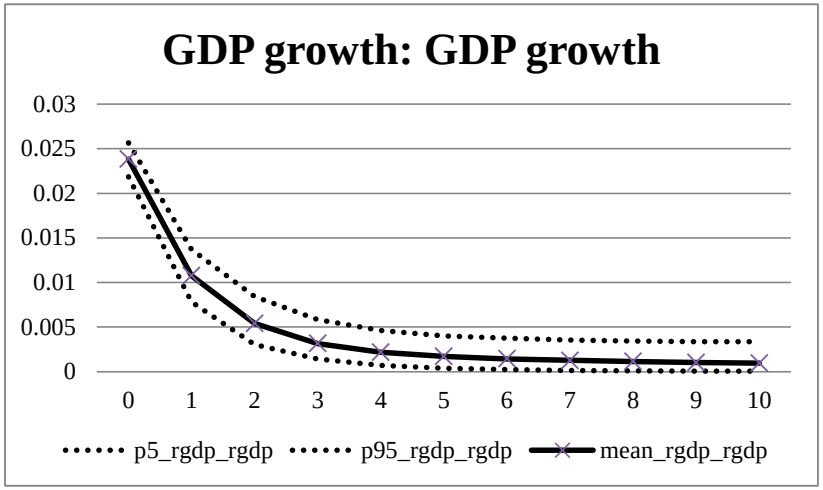


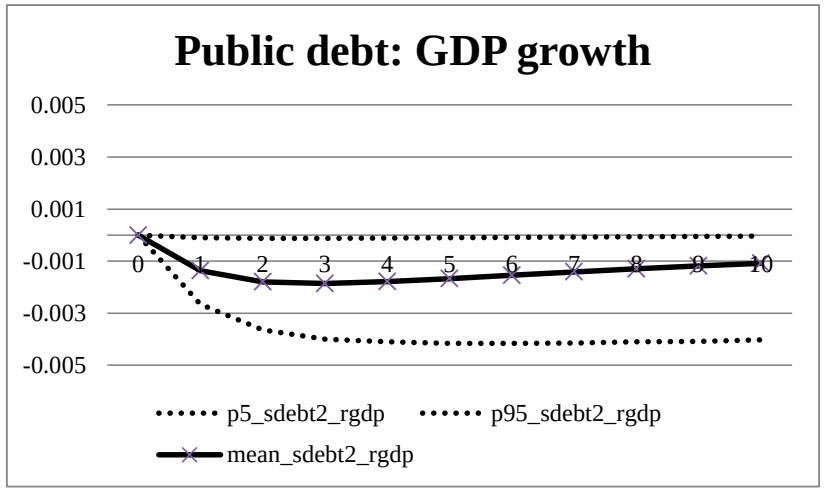


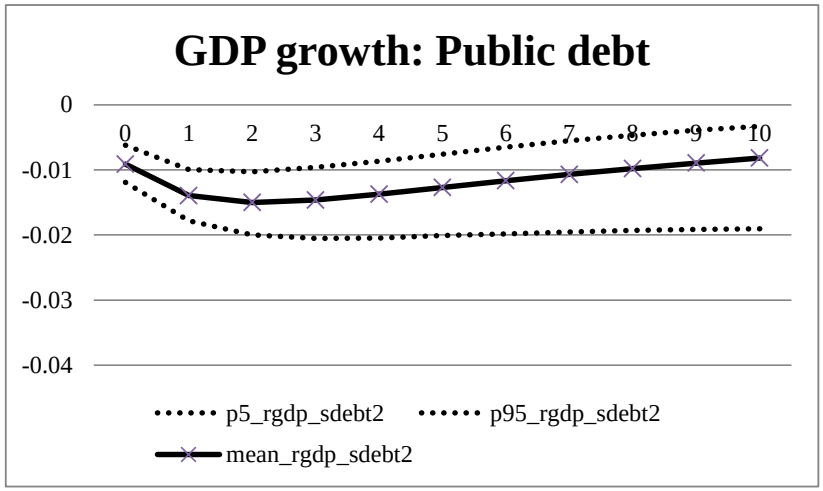


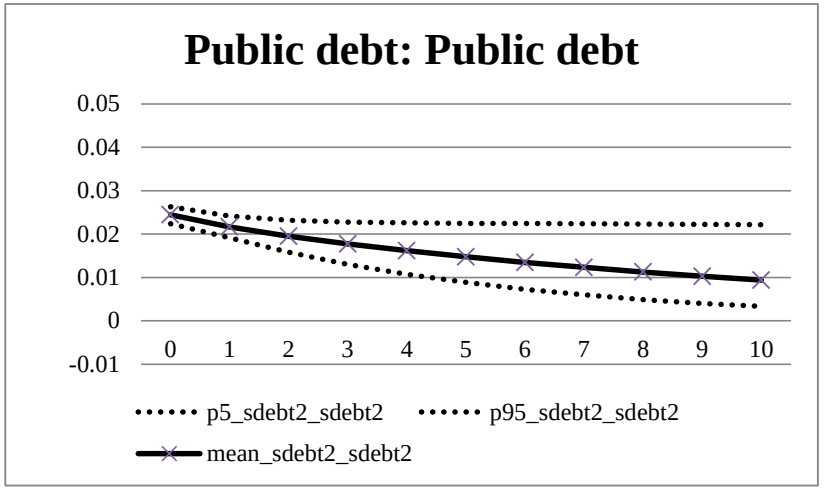
Notes: impulse variable: response variable

Figure 4 Impulse Responses: Two-variate Case for High Debt Countries



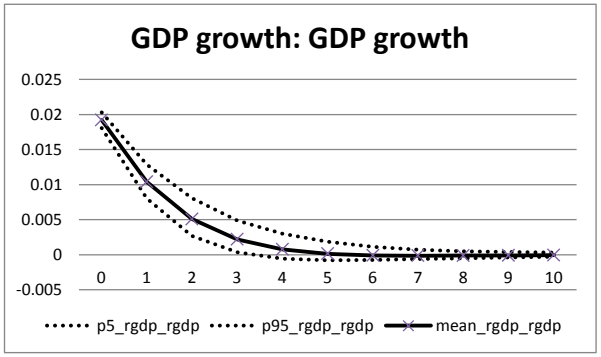


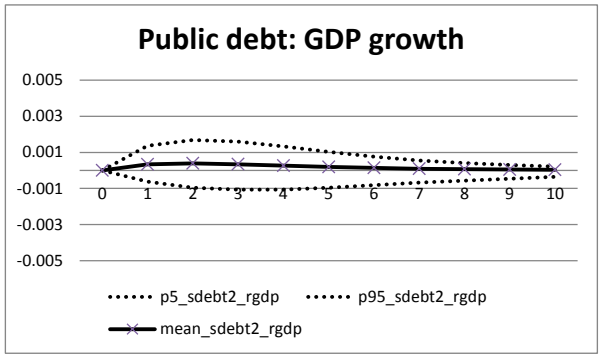


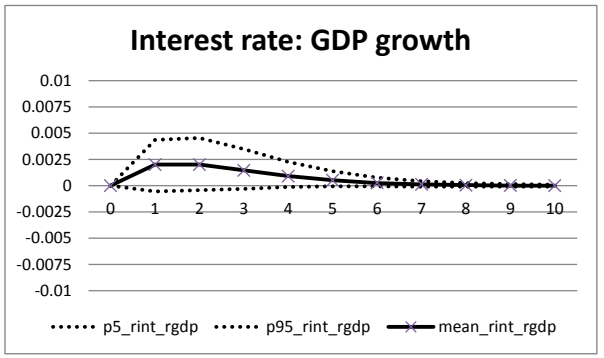


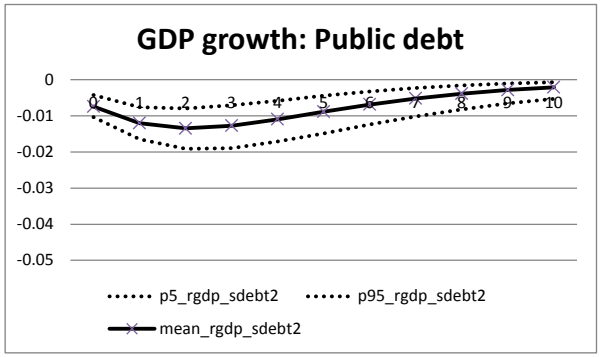
Notes: impulse variable: response variable

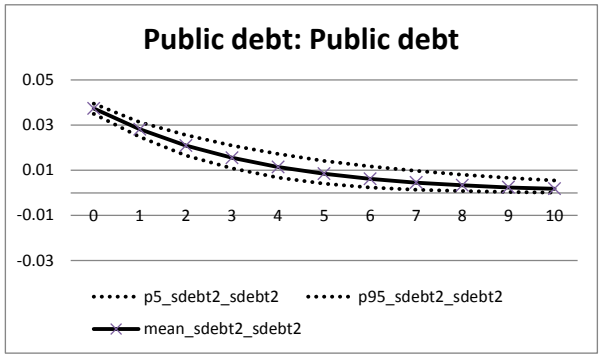
Figure 5 Impulse Responses: Two-variate Case for Low Debt Countries

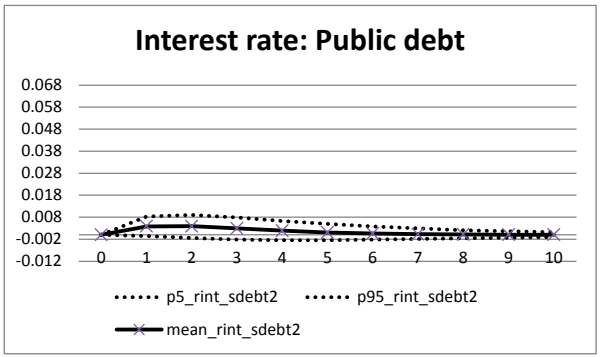


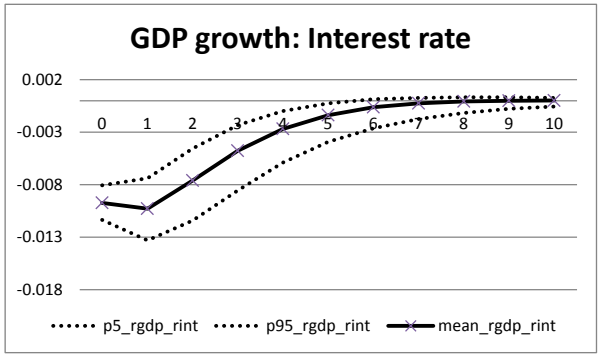


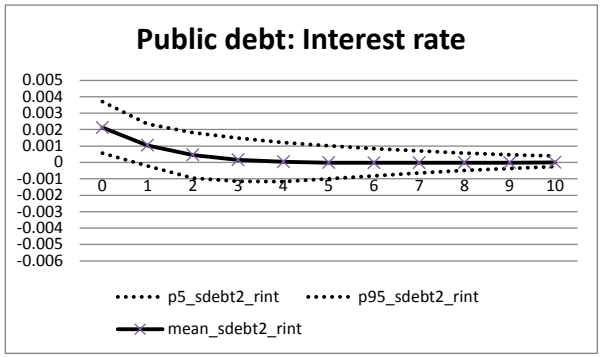


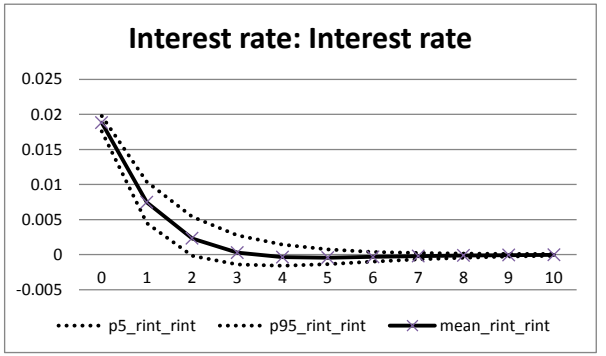










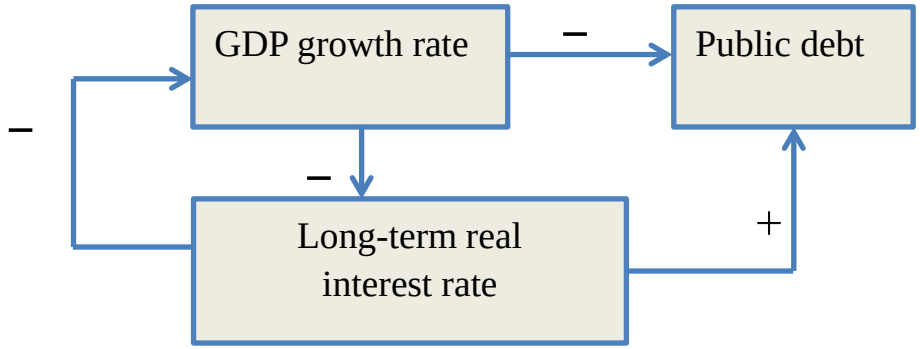


Notes: impulse variable: response variable

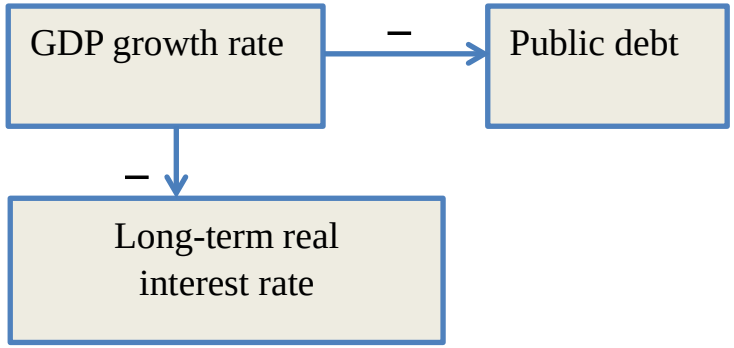
Figure 6 Impulse Responses: Basic Three-variate Case

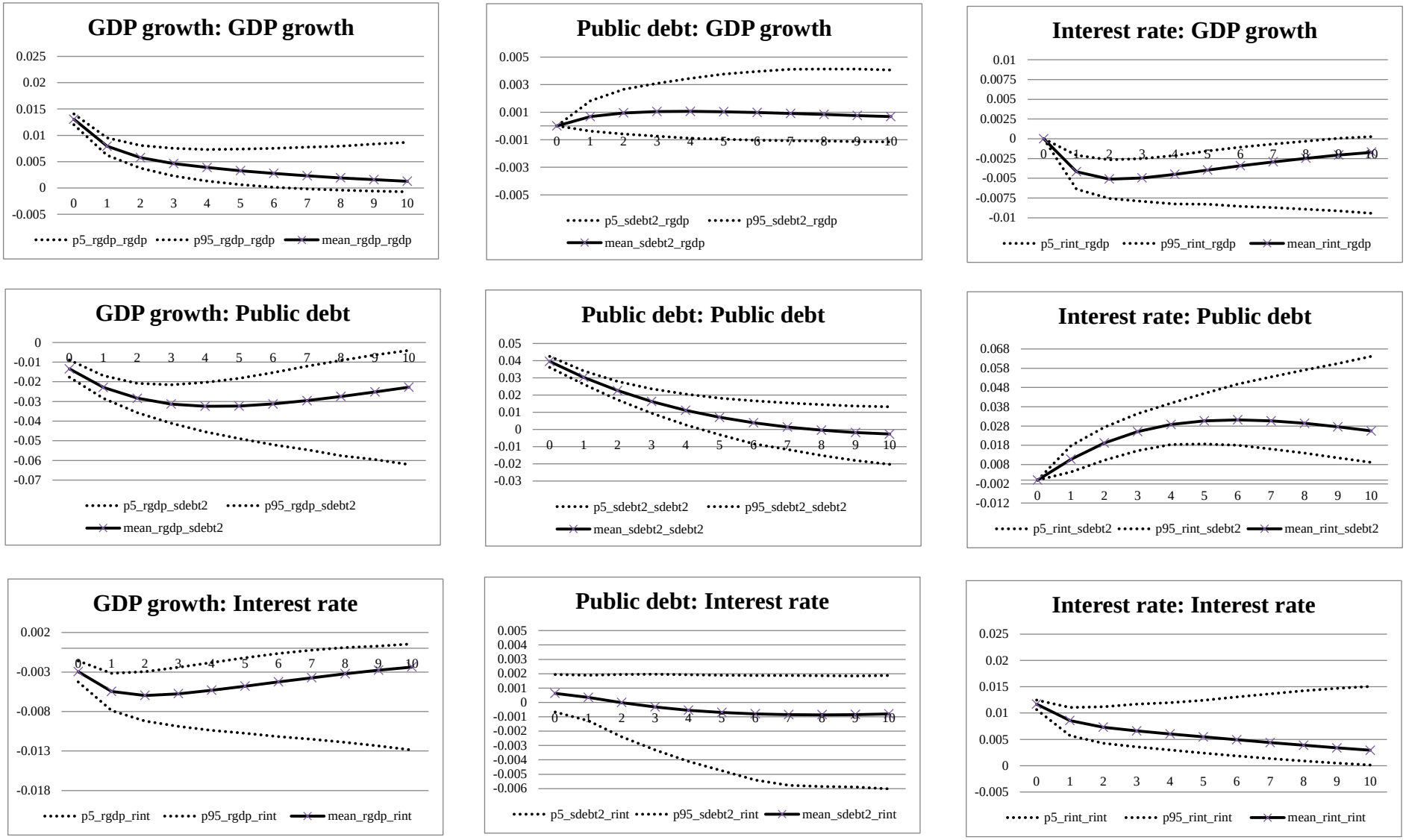
Figure 7 Causal Relationship among the Public Debt, Economic Growth and Interest Rate: Schematic Illustration

1) High debt countries



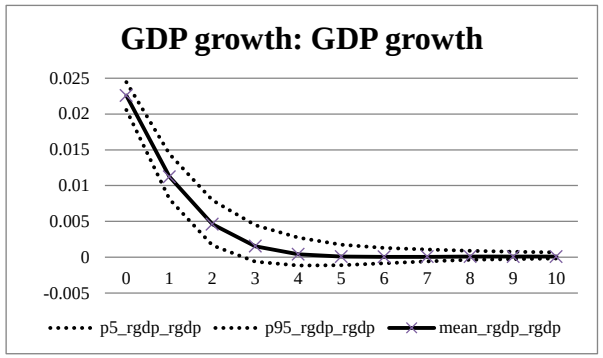
2) Low debt countries

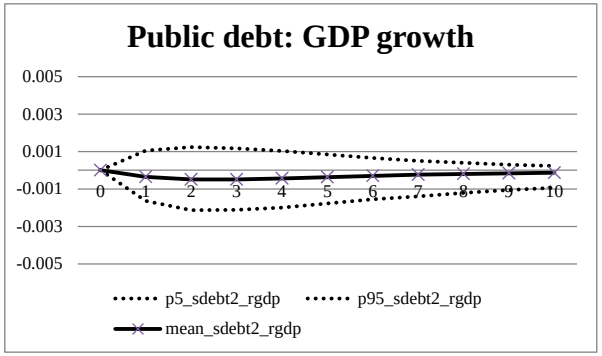


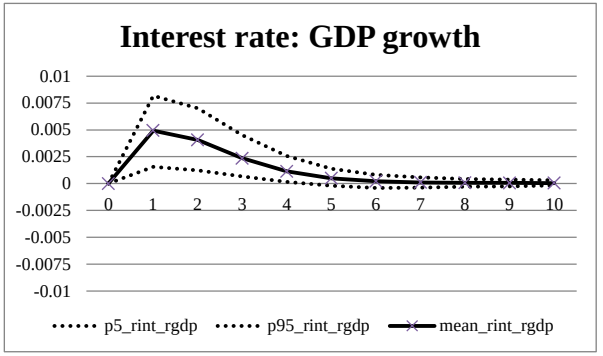


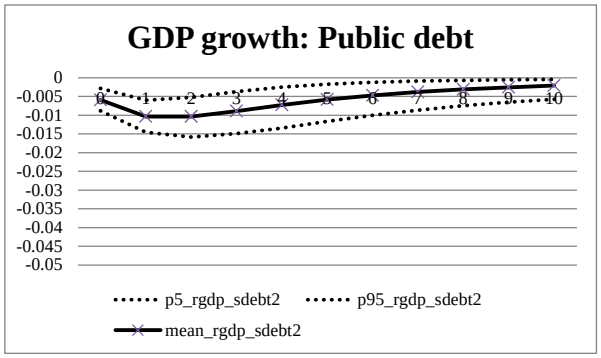
Notes: impulse variable: response variable

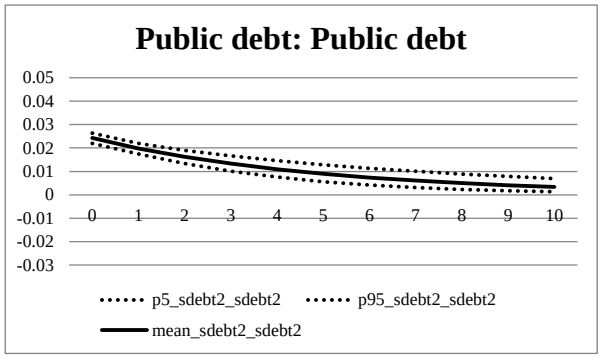
Figure 8 Impulse Responses: Three-variate Case for High Debt Countries

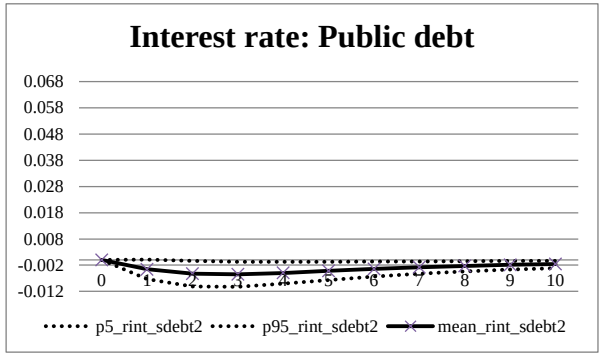


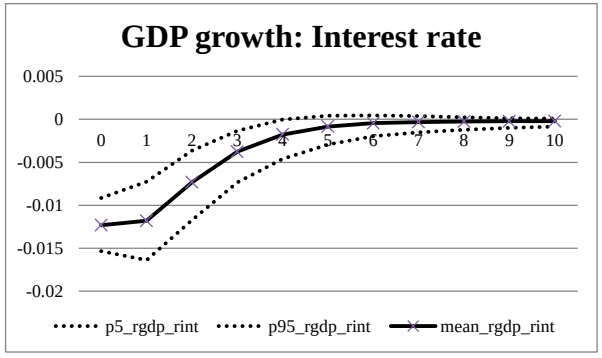


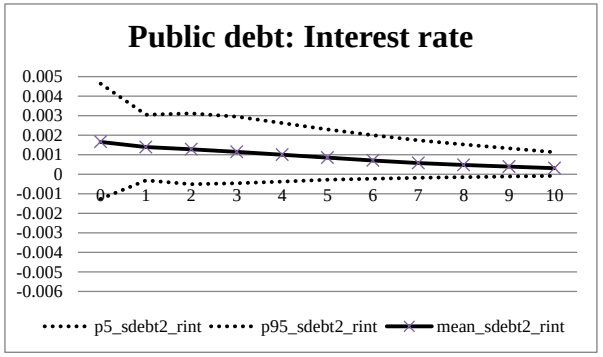


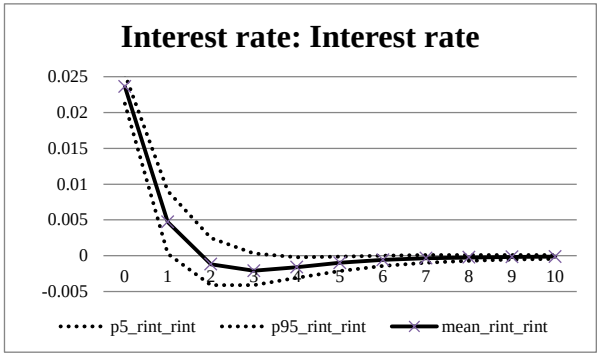






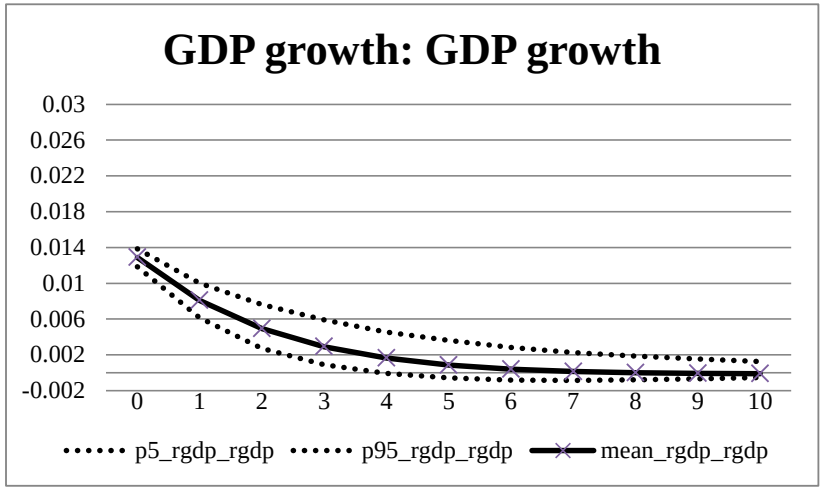


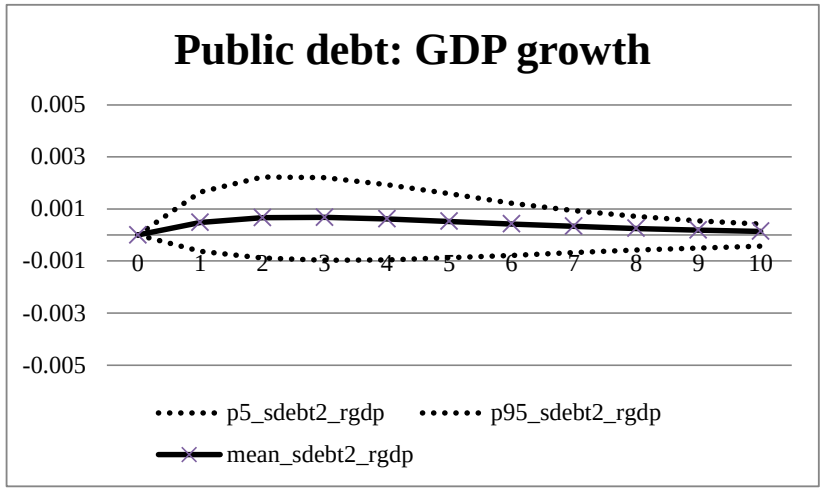


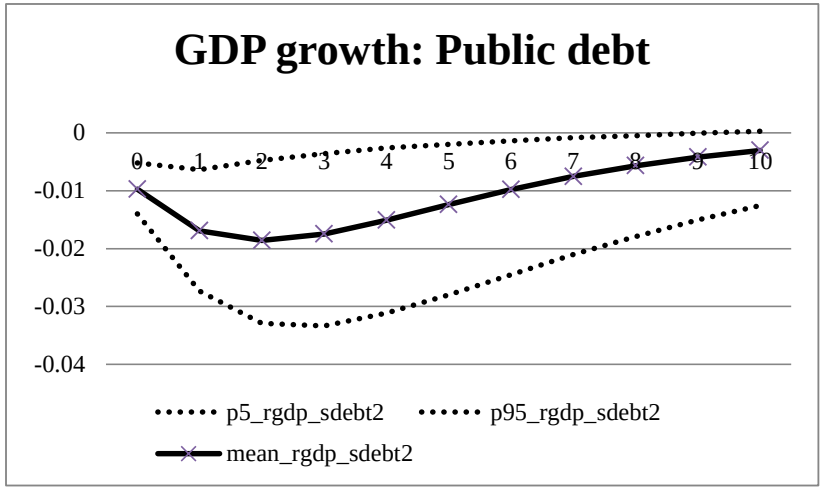


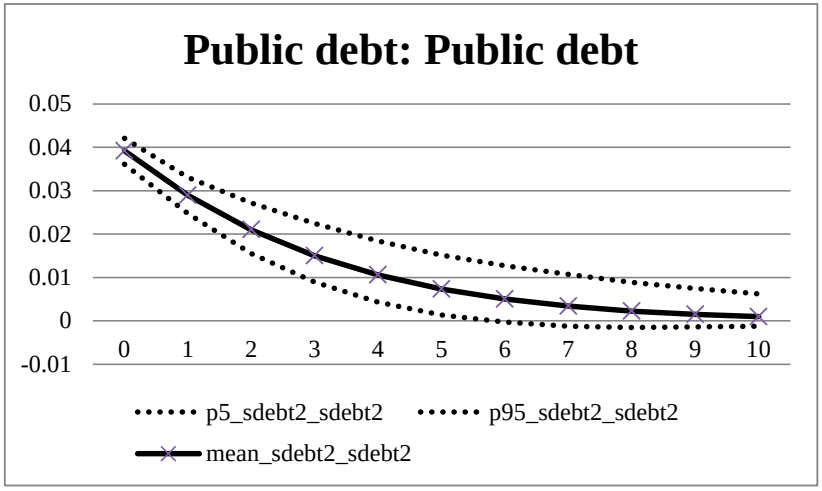
Notes: impulse variable: response variable

Figure 9 Impulse Responses: Three-variate Case for Low Debt Countries









Notes: impulse variable: response variable

Figure 10 Impulse Responses: Two-variate Case for High Debt Countries with Interest Rate Exogenous

Table 1 Summary Statistics by Country

(%)

		Public debt ratio	GDP growth rate	Long-term real interest rate
1	Australia	42.49	3.21	2.70
2	Austria	70.18	1.88	2.75
3	Belgium	105.71	1.74	2.57
4	Bulgaria	39.24	2.23	-0.07
5	Canada	105.84	2.52	2.35
6	Cyprus	60.07	2.28	2.96
7	Czech Republic	26.47	2.25	2.63
8	Denmark	47.96	1.21	2.10
9	Estonia	6.14	4.41	2.24
10	Finland	44.93	2.30	2.51
11	France	68.24	1.61	2.75
12	Germany	65.54	1.25	3.00
13	Greece	112.14	0.87	5.13
14	Hungary	67.19	2.03	2.62
15	Ireland	57.36	4.05	2.78
16	Italy	109.56	0.50	2.81
17	Japan	166.07	0.81	2.57
18	Latvia	20.02	4.30	0.68
19	Lithuania	25.31	4.39	2.47
20	Luxembourg	10.81	3.36	1.22
21	Malta	61.33	2.12	2.15
22	Netherlands	57.05	1.82	2.11
23	Poland	45.79	4.00	3.54
24	Portugal	72.61	1.10	3.17
25	Romania	21.04	2.56	-0.09
26	Slovak Republic	38.87	3.83	2.19
27	Slovenia	30.58	2.45	2.57
28	Spain	57.16	2.11	2.44
29	Sweden	49.49	2.33	2.75
30	United Kingdom	52.34	2.03	2.30
31	United States	85.50	2.41	2.42

Data source: EuroStat, OECD Database

Table 2 Various Test Statistics of Panel VAR Model: Two-variate Case

	Excluded variables	Granger causality Wald statistics	Stability condition	Hansen's test statistics of Overidentifying restrictions
Case 1	GDP growth equation			
	debt-to-GDP ratio	0.034 (0.854)		
	Debt-to-GDP ratio equation		satisfied	5.898
	GDP growth rate	9.886 (0.002)		(0.207)
Case 2 High debt Countries	GDP growth equation			
	debt-to-GDP ratio	0.038 (0.846)		3.458
	Debt-to-GDP ratio equation		satisfied	(0.484)
	GDP growth rate	4.018 (0.045)		
Case 3 Low debt countries	GDP growth equation			
	debt-to-GDP ratio	3.053 (0.081)		3.611
	Debt-to-GDP ratio equation		satisfied	(0.461)
	GDP growth rate	9.546 (0.002)		

Notes: The values in parenthesis are p-value.

Table 3 Various Test Statistics of Panel VAR Model: Three-variate Case

	Excluded variables	Granger causality Wald statistics	Stability condition	Hansen's test statistics of Overidentifying restrictions
Case 4	<u>GDP growth equation</u>			
	debt-to-GDP ratio	0.027 (0.869)		
	long-term interest rate	1.697 (0.193)		
	<u>Debt-to-GDP ratio equation</u>			
	GDP growth rate	3.548 (0.060)	satisfied	7.549 (0.580)
	long-term interest rate	1.958 (0.162)		
	<u>Long-term interest rate equation</u>			
	GDP growth rate	13.655 (0.000)		
	debt-to-GDP ratio	0.073 (0.788)		
Case 5 High debt Countries	<u>GDP growth equation</u>			
	debt-to-GDP ratio	1.885 (0.170)		
	long-term interest rate	10.013 (0.002)		
	<u>Debt-to-GDP ratio equation</u>			
	GDP growth rate	12.483 (0.000)	satisfied	9.518 (0.391)
	long-term interest rate	6.316 (0.012)		
	<u>Long-term interest rate equation</u>			
	GDP growth rate	6.687 (0.010)		
	debt-to-GDP ratio	0.020 (0.887)		

Table 3 (continued) Various Test Statistics of Panel VAR Model: Three-variate Case

	Excluded variables	Granger causality Wald statistics	Stability condition	Hansen's test statistics of Overidentifying restrictions
Case 6	GDP growth equation			
Low debt	debt-to-GDP ratio	1.029 (0.310)		
Countries	long-term interest rate	5.629 (0.018)		
	Debt-to-GDP ratio equation			
	GDP growth rate	8.955 (0.003)	satisfied	10.870 (0.285)
	long-term interest rate	2.437 (0.119)		
	Long-term interest rate equation			
	GDP growth rate	8.219 (0.004)		
	debt-to-GDP ratio	1.452 (0.228)		
Case 7	GDP growth equation			
High debt countries	debt-to-GDP ratio	0.492 (0.483)		
(long-term interest	Debt-to-GDP ratio equation		satisfied	1.817 (0.769)
rate exogenous)	GDP growth rate	2.582 (0.108)		

Notes: The values in parenthesis are p-value.