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Tracing the Effects of Fiscal Policy on the Greek Macroeconomy:
A Structural VAR Analysis

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Abstract

This paper contributes towards extending previous work done on the estimation of the real effects of fiscal-policy shocks within the context of the Greek economy and, in so doing, focuses on the reaction of private consumption and investment. Special attention is also paid to the determination of the theoretical framework that best describes the properties of the data. Identification is achieved using the SVAR methodology of Blanchard & Perotti (2002), which – among others- involves the calculation of the output elasticities of the fiscal variables included in the analysis. The most up-to-date values of certain subcomponents of the aforementioned elasticities have been taken into account, several aspects of the Greek tax-code have been considered, and econometric estimation of the remaining parts has been conducted. These elements can be thought of as additional aspects of the contribution of this thesis and are relatively uncommon among other papers following the same methodology. No firm theoretical conclusions can be drawn from the results obtained, since these are either inconclusive or statistically insignificant. In particular, private consumption is found to be positively affected by shocks in government wages, whereas it drops after a shock in government spending on goods and services. I also find a significant crowding-out effect of taxes on private investment; a one-euro increase in taxes results in a more-than-one-euro decrease in investment. All other impulse-response relationships studied have not yielded statistically significant results.

Keywords: Structural Vector Autoregressions (SVAR), fiscal policy, fiscal multipliers, real effects
JEL: E62; H30; H50

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List of Abbreviations and Names

Institutions, Datasets & Data Properties

EC	European Commission
ECB	European Central Bank
ESM	European Stability Mechanism
EU-28	European Union, 28 Member States
IMF	International Monetary Fund
ESA1995	European System of Accounts, 1995
ESA2010	European System of Accounts, 2010
GSIS	General Secretary of Information Systems - Ministry of Finance, Greece
LFS	Labour Force Survey
NACER2	Statistical Classification of Economic Activities in the European Community (NACE), Rev. 2 (2008)
OECD	Organisation for Economic Co-operation and Development

Sectors, Types of Economic Activity & Types of Transactions

OQ	Public administration, defence, education, human health and social work activities
PAY	Paid
REC	Received
S1	Total economy
S11	Non-financial corporations
S12	Financial corporations
S13	General Government
S14_S15	Households and Non-profit institutions serving households
NPISH	Non-profit institutions serving households

Indicators

Sector Account Components

B1GM	Gross domestic product at market prices
B2_B3G	Gross operating surplus and mixed income
B3G	Mixed Income
D1	Compensation of employees
D2	Taxes on production and imports
D21	Taxes on products
D29	Other taxes on production
D3	Subsidies
D31	Subsidies on products
D39	Other subsidies on production
D4	Property income

D41	Interest
D42_TO_D45	Distributed income of corporations; reinvested earnings on direct foreign investment; property income attributed to insurance policy holders; rents
D5	Current taxes on income and wealth, etc.
D61	Social contributions
D6311_D63121_D63131	Social transfers in kind
D7	Other current transfers
D8	Adjustment for the change in net equity of households in pension funds reserves
D91	Capital taxes
D92_D99	Other capital transfers and investment grants
P2	Intermediate consumption
P3	Final consumption expenditure
P5	Gross capital formation
P51	Gross fixed capital formation
P52_P53	Changes in inventories and acquisitions less disposals of valuables

Government Account Components

D6311_D63121_D63131	Social transfers in kind = expenditure on products supplied to households via market producers
P11_P12_P131	Market output, output for own final use and payments for other non-market output

Labour Force Survey

U	Unemployment; working-age population, ages 15-64

Quarterly National Accounts: Price Indices

PCH_PRE_CPI05_NAC	Gross Domestic Product in current prices; Price index - percentage change over previous period, based on 2005=100 and national currency

Other

D11_OQ	Gross wages and salaries; public administration, defence, education, human health and social work activities

Macroeconomic Variables

GDP	Gross Domestic Product
GDPD	GDP deflator
GMI	Gross Mixed Income
GOS	Gross Operating Surplus
PRC	Private Consumption
PRI	Private Investment
PRW	Private Wages

Fiscal Variables

CIT	Corporate Income Taxes
GE	Government Expenditure
NCR	Current (Government) Revenue, Net of current transfers
GSGS	Government Spending of Goods and Services
GTRANS	Government Transfers
INDT	Indirect Taxes
NONCYCL	Government Revenue net of transfers; Non-cyclical component
PIT	Personal Income Taxes
PW	Public Wages
SC	Social Contributions
UNEMB	Unemployment Benefits
INCB	Income-related Benefits

Suffixes in front of variable names visible in tables and equations

d-	variable in first-differences, or in year-on-year growth rates (depending on specification, please refer to text)
L1.-	first lag of variable
L2.-	second lag of variable
R-	variable expressed in real terms
Δ-	difference operator (annual growth rates)

Dummy

GC	Greek-Crisis dummy

Econometric Terms

ARIMA	Auto-Regressive Integrated Moving Average (model)
EC	Error-Correction
ERS	Elliott-Rothenberg-Watson test
FIML	Full Information Maximum Likelihood
GLS	Generalised Least Squares
MLE	Maximum Likelihood Estimator
(S)IRF	(Structural) Impulse-Response Function
SBIC	Schwarz's Bayesian Information Criterion
SEM	Simultaneous Equations Model
SVAR	Structural Vector Autoregression

Other

CA	Cyclically Adjusted
EA	Euro-Area
EAP	Economic Adjustment Programme
EMU	European Monetary Union
G20	Group of Twenty
IBC	Intertemporal Budget Constraint

MPC	Marginal Propensity to Consume
RBC	Real Business Cycle
ZLB	Zero Lower Bound

1. Introduction

It has been argued that "[…] [o]ne of the few positive effects of the recent financial crisis has been the revival of interest in the short-run macroeconomic effects of government spending and tax changes" (Ramey, 2011b, p.673). Indeed, when interest rates in the US and the UK reached the zero lower bound in late 2008 and early 2009 respectively, policymakers realized that there was little monetary policy alone could do to stimulate the economy; there was also need for fiscal stimulus.

Already in April 2009, the Group of Twenty (G20 (2009)) decided to undertake a fiscal expansion that was estimated to amount to 5 trillion US dollars by the end of 2010. What was striking, though, was the fact that there was no consensus to be reached among several prominent economists, when it came to determining the size, composition and persistence of this set of policy measures. Almost a year later, leaders and specialists became confronted with yet another issue that soon caused considerable controversy; as a sovereign debt crisis gradually began to unfold and to substantially affect several members of the European Monetary Union (EMU), austerity packages started coming into force over the subsequent years, heating even more the debate about the sign and magnitude of fiscal multipliers.

To make matters worse, a paper by Blanchard & Leigh (2013, abstract) recently stressed that "…in advanced economies, stronger planned fiscal consolidation has been associated with lower growth than expected…A natural interpretation is that fiscal multipliers were substantially higher than implicitly assumed by forecasters". Nevertheless, forecasters alone are not the only ones to blame: there is little analytical modelling can do, when there is no agreement on the possible effects of (largely) unexpected changes in fiscal policy on a theoretical basis. As one would expect, different theoretical models imply different assumptions, which –in turn- determine the final impact of government spending or revenue increases on the real economy.

In fact, what most economists tend to agree upon is that "…we know relatively little about the effects of fiscal policy shocks. We are not even sure about the direction of the responses of some variables, let alone the magnitude of those responses" (Beetsma, 2008, p. 1). But researchers' frustration goes beyond that; there have been times, when empirical results have remained inconclusive or have even appeared to be inconsistent with popular strands of the literature, such as neoclassical and Neo-Keynesian theory.

Tracing the reasons behind this, still unsolved, problem is as important as is identifying the problem itself. Is the absence of consensus due to a lack of interest in the topic over the years

preceding the crisis? Not really. Fiscal policy has been at the core of economic theory, even before becoming the centre of attention of other groups of stakeholders, such as journalists, polling companies or other non-specialists. Is it because government expenditure and revenue are too multifaceted? Definitely, at least in part. But what seems to be of even greater importance is the fact that the effects of fiscal policy seem to be quite dependent on the time and country under examination, as well as on the specific circumstances prevailing both in the domestic and international economy. This has been exemplified by the fact that the use of a given method in different time- and place- contexts has not always given the same results. What one may conclude, then, is that even widely-agreed-upon stylized facts concerning the reaction of the macroeconomy to fiscal policy shocks cannot be taken for granted. This reaction would be expected to change, as economies around the world change, and new channels influencing it would be expected to emerge over time.

The aim of this paper is to contribute towards extending current knowledge about fiscal multipliers by identifying some of the channels between the fiscal and macroeconomic sector of a specific economy (Greece) and over a specific period of time (2000Q1 – 2013Q3) and suggesting relative theoretical explanations that are able to best describe these channels. This aim is served by the use of a Structural Vector Autoregression (SVAR) that follows the methodology developed by Blanchard & Perotti (2002).

In particular, this thesis extends previous work done by Tagkalakis (2013), by further disaggregating GDP into its two main components i.e. private consumption and private investment, and studying the reaction of these components to fiscal policy shocks. Furthermore, the values for the output elasticity of taxes has been updated, taking into account the new values estimated by Price et al (2014).

I find that positive shocks in public wages positively affect private consumption, while positive shocks of government purchases of goods and services affect it negatively. Investment is found to be particularly sensitive to tax increases, given that a large crowding-out effect has been observed. However, no firm conclusions could be drawn on the dynamics inherent in the other combinations of fiscal and macroeconomic variables used in this paper.

The rest of this paper is organised as follows: **Section 2** provides an overview of the theoretical background. **Section 3** motivates the choice of topic and setting, while **section 4** outlines the relative research questions. **Section 5** illustrates the data collection and pretesting processes. **Section 6** touches upon methodological issues, while **section 7** presents the results. **Section 8**

has been devoted to robustness analysis, while **section 9** discusses the results. **Section 10** concludes.

2. Literature Review

2.1. The Real Effects of Fiscal Policy: A Theoretical Overview

2.1.1 Short-Run Effects: The Traditional Keynesian Perspective

Within the IS-LM- model framework –under the Keynesian model that allows for a flexible interest rate, but also assumes constant prices-, expansionary fiscal policy moves the IS curve upwards, resulting in a higher equilibrium interest rate and in a larger equilibrium income (Beetsma (2008)). ***Figure 1*** has been used to show this movement for illustrative purposes, and has been originally presented in Beetsma (2008):

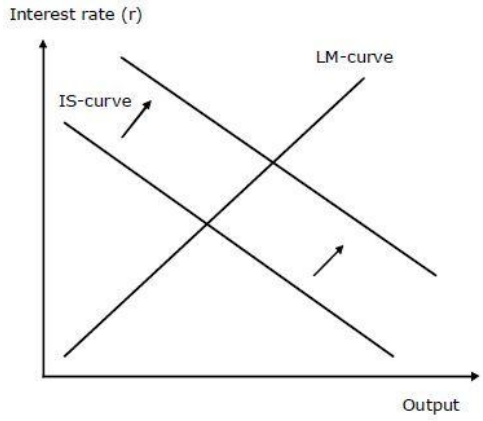

Figure 1 - The IS-LM Model
Source: This figure has been originally presented in Beetsma (2008).

However, since investment is assumed to be decreasing in the interest rate, a higher interest rate may result in a decrease in investment. This last sequence of events is described as the "crowding-out effect" and changes only the total magnitude of the fiscal multiplier, but not its sign (Hemming et al (2002)).

As argued by Hemming et al (2002), the magnitude of the crowding-out effect itself can vary, depending on the determinants of private investment, on the money demand and monetary policy and on the dynamic effects of fiscal policy. That is, the more sensitive investment is to interest rates, the greater the crowding out effect will be. Nevertheless, if the model studied also allows for an accelerator effect and, therefore, depicts investment as being an increasing function in current income, the crowding-out effect will tend to be minimised. Furthermore, a money demand that is relatively less sensitive to interest rates and relatively more sensitive to income, tends to result in smaller multipliers. Last but not least, as far as monetary policy is concerned, a more accommodative monetary policy, i.e. the presence of a monetary authority that does not

decrease interest rates in response to a fiscal expansion, tends to wipe out the crowding-out effect. One then, may conclude that classical Keynesian theory is largely agnostic about the final sign of the impact of a government spending shock on private investment.

Of course, an analysis of the impact of expansionary fiscal policy cannot be complete by only using the IS-LM-model, since its counterpart, the AD-AS-model is equally important. The two models are inextricably linked, given that different short-run IS-LM-equilibria for different prices, give the downward-slopping, long-run AD-curve.

Turning, now, to the AD-AS- model framework, expansionary fiscal policy –i.e. an increase in government spending- moves the AD curve upwards. However, the final impact of a positive fiscal policy shock on output will depend on the shape –and, therefore, the reaction- of the AS curve, which is depicted as an upward-slopping line in the textbook version of the model. This shape is a direct consequence of the fact that the assumption of constant prices is dropped in this long-run model and, instead, prices are believed to be sticky (Beetsma (2008)). Then, an increase in government expenditure will result to temporary increase in output and a permanent increase in the level of prices. ***Figure 2*** presented below has also been originally presented in Beetsma (2008) and illustrates the interaction between the AD and AS curves:

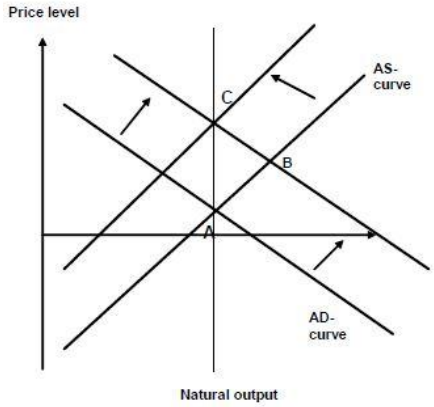

Figure 2 - The AS-AD Model
Source: This figure has been originally presented in Beetsma (2008).

2.1.2 Short-Run Effects: The Neoclassical Perspective

The main assumptions within the standard neoclassical, or Real Business Cycle (RBC), framework are the following (Fontana (2009); Ramey (2011a)):

- The Ricardian equivalence hypothesis holds.[1]

[1] The Ricardian equivalence hypothesis, at least its more modern version, can be considered to be a generalization of the Permanent Income or Lifecycle hypothesis (Seater (1993)). It states that whether an increase in government spending is debt- or tax- financed has no impact on economic activity and output. If the government finances an increase in government spending through bond issuance, there will be a drop in current taxes, but also an increase in future taxes, since the government will have to pay the debt back. At the same time, agents will be the ones buying

- All goods and factors are perfectly competitive.
- Prices are perfectly flexible.
- The production function has constant returns to scale.
- The utility function is separable in consumption and leisure.
- Agents are forward-looking and may smooth out consumption by borrowing and lending freely at the capital market (there are no credit constraints).
- The intertemporal budget constraint is binding for the government.
- The labour supply function is increasing in government spending and the consumption function is decreasing in government spending.

An increase in government consumption, temporary or permanent, will result in an increase of the present discounted values of future taxes of exactly the same magnitude, under the intertemporal government budget constraint. In turn, and since the Ricardian equivalence hypothesis holds, individuals will consider themselves to be relatively poorer (negative wealth effect) and will reduce both the consumption of goods and services and leisure –i.e. they will start working more-, thus increasing the labour supply. However, the increase in labour supply will cause a decline in real wages, given the fact that there is no shift of the labour demand curve. The resulting increase in employment –if sufficiently persistent, and if financed by lump-sum taxes- will increase the expected return to capital and, therefore, positively affect investment and output. According to the same model, an increase in government spending is less effective in increasing output –i.e. the multiplier is smaller, even negative-, when the former is temporary and when it is financed by a raise in distortionary taxes (Fontana (2009); Ramey (2011a)).

Another model that is very close to the one just presented above, but also allows for debt-financed tax cuts and government spending increases, as well as for case when the Ricardian equivalence does not hold, is the one analysed in Fatás & Mihov (2001). In their analysis, they discuss four policy experiments that provide useful insights of the effects of fiscal policy. In the first one (Case 1), an increase in government spending is financed by lump-sum taxes, while distortionary taxation balances the spending increase in the second experiment (Case 2).[2] In contrast with the two previous cases, both the third and the fourth policy experiments assume that a given tax-cut (Case 3) or an increase in spending (Case 4) is not financed by either a

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the bonds and being less taxed in the short-term, while receiving interest payments and being more taxed in the longer term. Therefore, since lifetime outflows will equal inflows, the lifetime constraint will remain constant and rational agents will consider the present discounted value of the government's future taxes to be equal with the present value of the debt.

[2] Since taxes in this experiment are distortionary, "…the Ricardian equivalence hypothesis may not hold and therefore the timing of taxes may matter" (Fatás & Mihov, 2001, p.14)

simultaneous increase in spending or an increase in taxes respectively, but materialises through the realisation of deficits instead.

The findings derived from the policy experiments conducted by Fatás & Mihov (2001) can be summarized in ***Table 1*** as follows:

	Effect on Output	Effect on Consumption	Effect on Investment	Effect on Wages
Case 1	(+) Larger, the more elastic the labour supply is	(-)	(?) Depends on labour elasticity and marginal product of capital	(-)
Case 2	(-)	(-)	(-)	(+) When labour elasticity is relatively high
Case 3	(+) Larger, the more elastic the labour supply is	(-)	(+)	(-)
Case 4	(?) Depends on labour supply elasticity, persistence of debt	(-)	(?) Depends on labour supply elasticity, persistence of debt	(-)

Table 1 – Summary of Results in Fatás & Mihov (2001)
Source: Created by the author.

Finally, other models within the neoclassical framework assume a utility function is non-separable in consumption and leisure (Fontana (2009)). Then, a negative wealth effect still becomes evident after an increase in government expenditure, but - given the fact that there is substitutability between consumption and leisure- the marginal utility of consumption increases and, therefore, consumption also increases. All other variables behave as they usually do in the standard neoclassical model.

2.1.3 Short-Run Effects: Fiscal Policy and Investment (a q-Type Model)

Another channel that connects fiscal policy with wages and profits –and, therefore, investment- is highlighted under the q-theory-of-investment framework. The basic assumptions of the model, as presented by Alesina et. al (2002), are presented below:

- Capital becomes productive immediately.
- The price of investment goods relative to the output price is unity.
- Investment expenditures at time t are fully tax deductible.
- The investment rate is related to the shadow value of capital, λ_t which equals the present discounted value of the marginal product of capital.

- The marginal product (or profitability) of capital is a decreasing function of the capital-labour ratio, which, from the first-order conditions for labour, is an increasing function of the real compensation of labour.

In an economy with a perfectly competitive labour market and lump-sum taxation, an increase in government employment leads to an increase in private real wages and a decrease in private investment. This is due to a negative wealth effect; since both consumption and leisure are normal goods, an increase in labour supply is observed. However, the latter is not enough, so as to completely offset the increased government labour demand. Therefore, private employment and the marginal product of capital decrease, leading to higher real private wages, lower profits and lower investment.

Similarly, in an economy with a unionised labour market –specifically, with private wages set by a monopoly union and government wages exogenously set by the government-, an increase in either government employment or government wages also leads to an increase in private real wages and a decrease in private investment. Here, however, this effect is caused by the fact that either the probability of getting employed within the public sector (if not already employed there) –after an increase in government employment- or the income of public workers –after an increase in government wages- is increased. Under both scenarios, "…the reservation utility of the union members goes up and the wage demanded by the union for private sector workers increases, reducing profits and investment" (Alesina et al, 2002, p.573).[3] Finally, when there is an increase in income taxes or social security contributions, profits and investment, once again, fall due to the fact that "…the burden of labour taxes is borne in part by the firm…" (Alesina et. al, 2002, p.574). That is, private sector employers have to pay a higher pre-tax wage, regardless of the fact that workers receive a lower after-tax wage.

2.1.4 Short-Run Effects: The Neo-Keynesian Perspective

Models in the Neo-Keynesian (or New-Consensus) vein follow a similar structure with the neoclassical ones and embrace, at least to some degree, the Ricardian equivalence hypothesis. However, they also introduce some additional Keynesian features, the most common of which are nominal rigidities and monopolistically competitive firms in the good market. These models try to explain the simultaneous increase in consumption, the real wage, as well as productivity, which has been often identified following a government shock. A representative example of a

[3] Reservation utility is defined as: "The minimum level of utility that must be guaranteed by a contract to make it acceptable to an agent" (Oxford Reference, 2015).

Neo-Keynesian model is presented by Christiano, Eichenbaum & Rebelo (2011). There, an increase in government consumption increases total demand and employment, but also increases the discounted value of future taxes, since an intertemporal budget constraint binds the government. Nonetheless, -according to the Ricardian equivalence hypothesis- this increase will mean that individuals will perceive themselves to be relatively poorer and, therefore, will start saving more, consuming less and working more. From the aspect of firms, the government consumption increase decreases the mark-up (i.e. the price over marginal cost charged by firms), due to price stickiness. Consequently, labour demand will also increase, since they will continue hiring workers, provided that the marginal cost is smaller than or equal to the price of the goods produced. As a final result, real wages will also rise, leading to an increase in the marginal utility of consumption. Nevertheless, the model does not clearly predict whether this increase will be enough to set off the previous decrease in private consumption. It may, then, be concluded that the overall effect of a government consumption increase on private consumption is ambiguous and can be either positive or negative, depending on the specification of the model.

Models developed in the more recent literature extend and modify standard Neo-Keynesian models, in an effort to overcome some of their limitations. One such modification has been the abandonment of the Ricardian equivalence hypothesis. The main argument against Ricardian equivalence have been that the lifetime of any given agent is uncertain –there are both a positive probability that the agent will live over to the next period and a positive probability that the agent will die over the current period-.[4] In addition, since capital markets are not perfect, individuals may actually be facing liquidity constraints over their lifetime, such as credit rationing. In the model developed by Galí, Lopez-Salido and Vallés, individuals' behaviour is not homogeneous, since there are both individuals that behave in accordance with the Ricardian equivalence hypothesis and individuals that do not (Fontana (2009)). The latter are known as "the rule-of-thumb" consumers and actually face credit constraints over their lifetime, which deter them from borrowing or lending freely. That is, in these models, there is a proportion of individuals – at least 50%, in the Galí, Lopez-Salido and Vallés model- that consumes all of their current income in each period. Moreover, employment is demand determined, so that agents are always willing to supply as many hours as firms need. Therefore, when labour demand is, again, increased after an increase in government consumption due to the assumptions of monopolistic competition and nominal price rigidities, the subsequent increase in real wages will lead to a greater consumption of goods and services by the "rule-of-thumb" consumers. As a result, the extended or enriched

[4] For a concise overview of the criticism against the Ricardian equivalence hypothesis, please see Seater (1993).

New-Keynesian model predicts a clear-cut increase in both real wages and private consumption and, therefore, an "unambiguously positive" (Fontana, 2009, p.593) overall effect on output.

In ***Table 2*** I now summarise the theoretical effects of an increase in government spending on labour supply, labour demand, labour, output, real wages and consumption, as predicted under the different analysis frameworks that have been presented so far (with the exception of the q-type model).

	L^S	L^D	L	Y	w	C
Standard neoclassical	↑	=	↑	↑	↓	↓
Enriched neoclassical	↑	=	↑	↑	?	↑
Standard Neo-Keynesian	↑	↑	↑	↑	↑	?
Enriched Neo-Keynesian	↑	↑	↑	↑	↑	↑

Table 2 – Summarised Predictions of Main Theoretical Models

Source: Reproduced from Fontana (2009), who provides a similar table on the effects predicted by the Neo-Keynesian and neoclassical models.

2.1.5 Fiscal Policy and the Business Cycle

Distinguishing between the effects of fiscal policy in recessions and expansions is as important as is trying to provide a theoretical justification behind those effects. A seminal paper to this end has been the one by Auerbach & Gorodnichenko (2012), where the impact of fiscal policy shocks in the U.S. economy (with a sample covering the years 1947-2008) is traced using a regime-switching SVAR that is able to make a distinction between the two states of the business cycle. What they find, is that government spending multipliers are much larger in recessions than in expansions. This result also extends to several subcomponents of government expenditure used as further experiments. Interestingly enough, controlling for the share of fiscal policy shocks predicted by forecasters does not influence their main finding; to the contrary, it makes the multipliers even larger in recessions and even smaller in expansions.

2.1.6 Fiscal Policy, Trigger Points and Expectations

Regardless of the model that may better describe the effects of fiscal policy on different macroeconomic variables and in a specific context (place and time), no model discussed so far incorporates the possibility of changes in the direction of these effects. As Perotti (1999) argues, a neoclassical model may predict a decrease in private consumption following a positive government spending shock, but it will always do so. This is also the case with a Keynesian model; its theoretical predictions will always be the same. However, in the model developed by

Perotti (1999), the correlation between private consumption and government spending (or tax revenue) is allowed to switch from being positive and Keynesian (or negative and Keynesian) in good times into being negative and non-Keynesian (or positive and non-Keynesian) in bad times. Bad times are characterized by a high present discounted value of future expenditure or a large value of initial debt or a high expected taxation in the future. The logic behind the model can essentially be summarized as follows: Agents living in the economy expect large tax hikes to materialize, if the debt-to-GDP ratio were to reach a given threshold. However, should a consolidation happen before that, agents would know that the expected massive tax hike could be prevented and, therefore, the negative wealth effect would not become present in the economy. The main conclusion of this paper is that initial conditions, such as the initial debt-to-GDP ratio, may affect, to a smaller or greater extent, the effects of fiscal policy shocks on private consumption and that "…in times of fiscal stress the economy's response to fiscal shocks changes qualitatively" (Perotti, 1999, p.1400).

2.2. The Importance of Government-Expenditure Disaggregation

Special attention has been paid by several authors to the distinction among the different components of government expenditure, and especially between the wage and non-wage component of government consumption.

Finn (1998) argues that there are two main reasons substantiating the argument that the further disaggregation of government spending is important. Firstly, she points out that both government employment and spending on goods and services components amount to a significant share of government expenditure and should, thus, be considered separately. Second, she stresses the fact that RBC-models predict different macroeconomic impacts for each of these shocks, mainly due to the "sectoral employment reallocations occurring with shocks to government employment but not with shocks to government purchases" (Finn, 1998, p. 636). In the model developed by Finn (1998) herself (which is a RBC model), a shock in government purchases on goods and services is procyclical, since it increases output, while a shock in government employment is countercyclical, since it decreases output, and a shock in government investment is acyclical.

Fatás & Mihov (2001) also decompose government spending into the wage, non-wage and investment components as a robustness check, arguing that "by creating different incentives the three main expenditure components … should exert different impacts on macroeconomic variables" (Fatás & Mihov, 2001, p. 10). They find that the government wage component has the largest effect on private consumption. Alesina et al (2002) analyse a model, where government

wages and employment put upward pressure on private wages, profits and investment and increased taxes or transfers negatively affect labour supply in the private sector. Finally, Marattin & Salotti (2011) also decompose government consumption into a wage and a non-wage component, in order to study whether these have different effects on private consumption and investment of a panel of 14 economies-members of the European Union. They find evidence showing that government wages have a more substantial effect on private consumption and private investment than the non-wage component.

2.3. Measuring the Real Effects of Fiscal Policy in Practice

The effects of both spending and tax shocks have been extensively studied in the literature, and there is a wide variety of methodologies applied and tools used to achieve this. However, what all authors have been unanimously interested in is the sign (positive or negative) and magnitude (less or greater than one) of the fiscal multiplier (both for expenditure and revenue). This is because the combination of the magnitude and sign of fiscal multipliers can be very informative about the behaviour of macroeconomic variables in response to fiscal shocks and about whether this behaviour conforms to one or more theoretical models of interest. A positive multiplier of a magnitude greater than one, for example, would signal that a given fiscal expansion has standard Keynesian effects, while one of a magnitude less than one (even negative) would imply the presence of either stronger or weaker crowding out effects, or that the macroeconomic variables affected follow neoclassical theory in their behaviour.

In general, it has been argued that these multipliers are "…a nebulous concept that depends very much on the type of government spending, its persistence, and how it is financed" (Ramey, 2011a, p. 673). Therefore, before continuing with the presentation of some seminal papers in the field, I first focus on the theoretical and applied definition of fiscal multipliers.

2.3.1. Measuring Fiscal Multipliers – Theory and Practice

As long as the theoretical background concerning multipliers is concerned, it is worth pointing out that "…all of the theories hinge fundamentally on the effect of government spending on equilibrium hours worked, and how those hours translate to output" (Ramey, 2011a, p. 674).

The Keynesian model in its simplest form –i.e. assuming an accommodative monetary policy that keeps the interest rate constant, in a closed economy- measures the government spending multiplier (in terms of output) as:[5]

$$\frac{\Delta Y}{\Delta G} = \frac{1}{1 - MPC}$$

[5] The two formulas presented further below have been reproduced from Ramey (2011b).

where Y denotes output (GDP), G denotes government expenditure, MPC is the marginal propensity to consume or "…the responsiveness of consumption to current income" (Hemming et. al, 2002, p.5), and Δ is the first-difference operator.
At the same time, the tax multiplier is given by:

$$\frac{\Delta Y}{\Delta T} = -\frac{MPC}{1-MPC}$$

where, again, Y and MPC are output and the marginal propensity to consume respectively, T stands for government revenue, and Δ is the first-difference operator.

Observing the two formulas presented above, it is evident that:

- The magnitude of the multiplier positively depends on the magnitude of the marginal propensity to consume (MPC). The higher the latter is, the smaller the denominators of both types of multipliers and the larger the numerator of the tax-multiplier will be.
- The multipliers for a spending increase ($\Delta G > 0$) is always greater than unity. This follows from the fact that the MPC is always assumed to be greater than zero and less than one.
- The multiplier is greater in magnitude for a spending increase, than for a tax cut, since the MPC is always less than one.

What is less evident by visual inspection, but is a condicio sine qua non in standard Keynesian models is that the multiplier for a spending increase or tax cut is positive, while the multiplier for a tax increase or spending cut is negative. This, in turn, means that there is a positive correlation between movements in government spending/revenue and movements in, for instance, GDP.
In general, the exact magnitude of these multipliers will also depend on the following factors:

- The magnitude of the propensity to consume.
- Whether the economy is open or closed (Ramey (2011b); Hemming et. al (2002))

Then, the marginal propensity to import has also to be taken into account and it results in a lower multiplier:

$$\frac{\Delta Y}{\Delta G} = \frac{1}{1-MPC+MPI}$$

where MPI is the marginal propensity to import. Of course, a larger marginal propensity to import will result in relatively smaller multiplier than a smaller one.

Furthermore, in an open economy with flexible prices, floating exchange rate and perfect capital mobility -or, otherwise, under the framework of the Mundell-Fleming model-, an increased interest rate due to a spending increase results in a capital inflow, that then appreciates both the nominal and the real exchange rate. However, an appreciation of the exchange rate worsens the trade balance of the economy, and ends up wiping out the positive effects of the spending increase.

- Whether the economy is undergoing a recession or an expansion (Parker (2011); Auerbach & Gorodnichenko (2012)).

Fiscal policy is more efficient -that is, the multiplier is larger- in recessions, when there are slack resources in the economy and prices are inflexible. The latter assumption is translated into a horizontal AS curve and therefore the economy behaves as in the original Keynesian model. Since there is both unused capital and unused labour in the capital and labour markets, an increase in government spending will not affect the interest rate and wages, which, instead, will remain constant. Therefore, an increase in government spending will lead to an increase in output, but not in prices. Given the fact that the increased output will mean an increased use of labour, current income and, therefore, consumption will also become larger, something that will result in a further increase of output.

The opposite happens –that is, fiscal policy is less efficient and the multiplier is smaller-, when the economy is undergoing an expansion. In that case, markets clear, prices are flexible, and the AS curve is steeply upward slopping. Therefore, the economy behaves as predicted by the neoclassical model. Thus, a (positive) shock in aggregate demand (which is a result of the increase in government spending) will affect (increase) the prices of both capital and labour, as well as the commodity prices, but the crowding-out effect in private investment and consumption will also be significant.

The spending multiplier –in terms of hours worked- within the standard neoclassical framework is given by:[6]

$$\frac{dn}{dg} = \underbrace{\frac{\partial h}{\partial g}}_{static\ effect} + \underbrace{\frac{\partial h}{\partial k'}\frac{\partial k'}{\partial g}}_{dynamic\ effect}$$

where n stands for hours worked (or labour supply), g denotes government spending, k' is the capital stock of next period, $h(k, k' + g)$ is the function that gives optimum labour supply, and $\frac{\partial h}{\partial g} = \frac{\partial h}{\partial k'}$ due to the fact that g and k' enter symmetrically in h.

[6] The formula for the fiscal multiplier has been reproduced from Ramey (2011b).

The dynamics between the static and dynamic effect are the ones that eventually give the sign and size of the multiplier, and those depend on whether the increase in government spending is temporary or permanent and on whether it is financed with distortionary or lump-sum taxes. Temporary increases financed with distortionary taxation give the smallest (even significantly negative) multipliers, whereas permanent and financed-with-lump-sum-taxes increases give the largest (just below one) multipliers (Ramey (2011b)).

Finally, standard Neo-Keynesian models also allow for a wide range of possible values for the government spending multiplier, although these never become negative. The spending multiplier with respect to output is given, in this model, by:[7]

$$\frac{dY_t}{dG_t} = \frac{1}{g}\frac{\hat{Y}_t}{\hat{G}_t} = 1 + \frac{1-g}{g}\frac{\hat{C}_t}{\hat{G}_t}$$

where Y_t is output, G_t stands for government spending, C_t is consumption, g denotes the share of spending relative to output and $\hat{Y}_t$, $\hat{G}_t$ and $\hat{C}_t$ are the log-linear approximations of the deviation of Y_t, G_t and C_t respectively from their steady state.

Christiano, Eichenbaum & Rebelo (2011) have recalculated the aforementioned multiplier for several possible values of the parameters used in the model specification, and some of their findings have been summarised below:

- The value is greater than one, whenever the marginal utility of consumption is not independent of hours worked.
- The stickier the prices are, the larger the magnitude of the multiplier is.
- The less rapid is the increase of interest rates by the monetary authority in response to an increase in government spending, the greater the value of the multiplier is.

In practice, though, whenever the effects of fiscal policy on output and its components are not traced through the use of general-equilibrium models, fiscal multipliers are quantified as ratios of the difference in output (GDP) to the difference in government spending or government expenditure (both expressed in monetary units). In order to obtain values that can be used in the calculation of the fiscal multipliers of interest, researchers have to properly identify the fiscal shocks that can have an impact on GDP and its subcomponents. Such an identification is

[7] The formula giving the fiscal multiplier within the Neo-Keynesian framework has been reproduced from Christiano, Eichenbaum & Rebelo (2011).

possible through the use of Structural Vector Autoregressions (SVARs); the Structural Impulse Response Functions (SIRFs) of the system can provide estimates of the values in question. **Appendix G. The Logic behind IRFs and SIRFs** briefly discusses the concept of Impulse Response Functions (IRFs).

2.3.2. Some Results of Other SVAR Analyses

Papers serving an aim similar to the one of this thesis can be grouped in four categories, based on the analytical method used (Perotti (2004)).[8]

First, there are studies implementing the "narrative" approach, as developed by Ramey & Shapiro (1998) and extended by Edelberg et al (1998), using a dummy variable to identify three main exogenous fiscal shocks: the onset of the Korean War, the Vietnam war and the Reagan military build-up. Second, papers following the tradition of Mountford & Uhlig (2009) use the "sign restriction" approach. As its name suggests, the signs of the impact responses of the other variables in the system (usually representing a business, monetary and fiscal shock) are restricted, while leaving the one of output to be freely determined by the model.

A third alternative that has been widely used for the identification of fiscal policy shocks is the well-known Choleski decomposition, which assumes a recursive causal ordering among the endogenous variables of the system. Finally, under the Blanchard & Perotti (2002) framework, detailed institutional information concerning the tax system of the economy in focus, as well as information about the timing of tax collection, is considered and incorporated in the model.

In ***Table 3*** and ***Table 4*** that follow, the results of a selective number of papers are outlined. Since the Blanchard & Perotti (2002) methodology is the one used in this thesis (for reasons presented in the following section), I have only considered papers within the same vein, in order to increase comparability. The first table shows the effects on GDP, consumption, investment and employment of a spending shock, while the second depicts the effects of a tax shock. The values of the (cumulative) spending and tax multipliers are also reported, relative to the reference value of 1. Since tax multipliers have been found to be negative by all papers, their absolute value is reported instead.

[8] Very concise descriptions of the four alternatives described in the text can be found in Caldara & Kamps (2008), Caldara & Kamps (2012) and Perotti (2004). I have used these papers to briefly outline these four methods.

	Method	Country	GDP	Private Consumption	Private Investment	Private Employment	Spending Multiplier
Blanchard & Perotti (2002)	B&P	U.S.	(+)	(+)	(-)	N/A	>1
Giordano et. al (2007)	B&P	Italy	(+)	(+)	(+)	(+)	>1
De Castro & Hernandez de Cos (2008)	B&P	Spain	(+) in the short term, (-) in the long term	(+) in the short term, (-) in the long term	(+) in the short term, (-) in the long term	N/A	>1
Coutinho Pereira & Wemans (2013)	B&P	Portugal	Insignificant in the short term, (+) in the long term	(+) but insignificant	(+) but insignificant	N/A	Statistically insignif.
Tagkalakis (2013)	B&P	Greece	(+)	N/A	N/A	(+)	| |>1

Table 3 – Summary of Empirical Results, Impulse: Government Spending

Note: Effects of a positive shock in government spending. The symbol | | denotes absolute value.

Source: Created by the author.

	Method	Country	GDP	Private Consumption	Private Investment	Private Employment	Tax Multiplier
Blanchard & Perotti (2002)	B&P	U.S.	(-)	(-)	(-)	N/A	| |<1
Giordano et. al (2007)	B&P	Italy	negligible	negligible	negligible	negligible	| |<1
De Castro & Hernandez de Cos (2008)	B&P	Spain	Insignificant in the short term, (-) in the medium term	(+) in the short term, (-) in the medium term	Insignificant in the short term, (-) in the medium term	N/A	N/A
Coutinho Pereira & Wemans (2013)	B&P	Portugal	(-)	(-), but insignificant	Absence of response	N/A	Statistically insignif.
Tagkalakis (2013)	B&P	Greece	(-)	N/A	N/A	(-) on impact, (+)subsequently	| |>1

Table 4 - Summary of Empirical Results, Impulse: Taxes

Note: Effects of a positive shock in tax revenue. The symbol | | denotes absolute value.

Source: Created by the author.

3. Motivation & Contribution

After having looked at the main strands of theoretical literature studying the effects of fiscal policy on output and its components, it has become apparent that there is significant discrepancy among them. Different theories may predict different paths of the reaction of these variables, both in terms of sign (positive, negative) and in terms of magnitude (fiscal multipliers smaller or greater than one). Even in the case where two theories may agree on the sign or magnitude of the response, they may still disagree on the chain of events leading to that response. Unfortunately, the wide disagreement just described above, leaves no space for unanimity among economists, in a period when the latter has been needed the most.

Indeed, since the outburst of the financial and economic crisis in 2008, there have been numerous occasions on which fiscal measures and their possible effects on the real sector had to be determined, within the context of either fiscal stimulus or fiscal adjustment packages. Initially, policymakers around the world deemed fiscal stimulus to be necessary, in an attempt to jumpstart the contracting economy. Nonetheless, there was no consensus among profligate economists about the synthesis of these packages or their expected impact. Still, the American Recovery and Reinvestment Plan and the European Economic Recovery Plan came into force in early 2009 and late 2008 respectively, predicting stimuli amounting to 787$ billion in the U.S. (Congressional Budgetary Office (2011)) and €200 billion in the EU (European Commission (2014a)).

However, problems within the fiscal sectors of some Member States of the EMU became apparent soon afterwards. Once again, economists were asked to determine the most suitable measures, in order to help countries clean up their public finances, while providing them with financial and technical assistance. The so-called Economic Adjustment Programmes (EAPs) started to be implemented over the following years, first in Greece and subsequently in Ireland, Portugal and Cyprus, involving a considerable amount of fiscal consolidation. The adjustment in the public sector has aimed at considerably reducing the debt-to-GDP ratio of the countries involved, and has constituted of a variety of measures, including significant reductions in the government wage bill, intermediate consumption and investment, as well as tax increases.

What has been alarming, though, is that the economic conditions prevalent in those economies have further deteriorated over the same period. As ***Figures 3 - 8*** on the next page suggest, GDP per capita and actual individual consumption per capita have decreased, while the gap between the country-specific values and the EU-28 average has widened. Both working-age-population and youth unemployment rates have significantly increased, and the share of people at the risk of

poverty or social exclusion, as well as the share of those experiencing severe material deprivation have also risen.

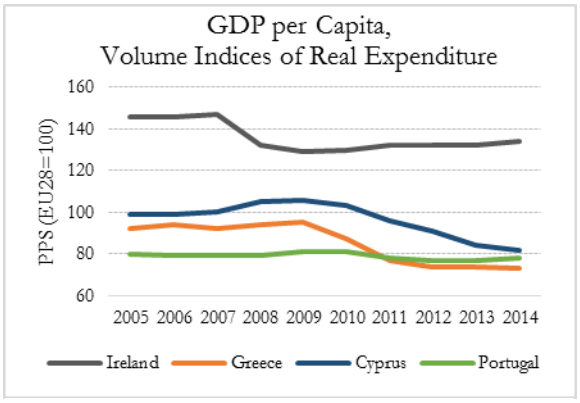

Figure 3 - *GDP per Capita, Volume Indices of Real Expenditure*

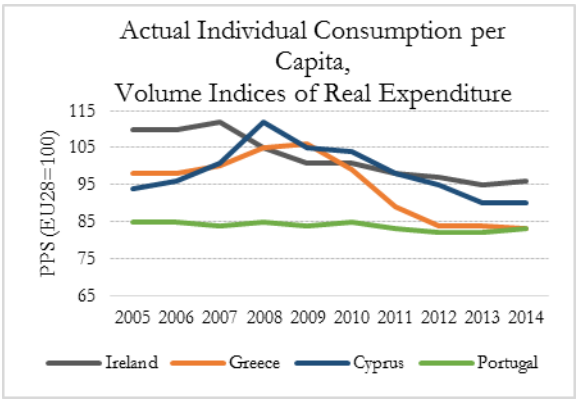

Figure 4 - *Actual Individual Consumption per Capita, Volume Indices of Real Expenditure*

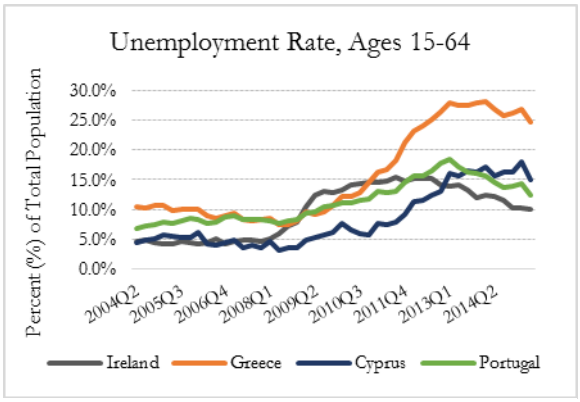

Figure 5 - *Unemployment Rate, Ages 15-64*

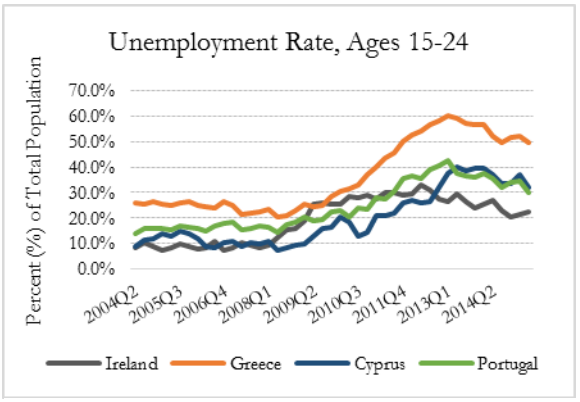

Figure 6 - *Unemployment Rate, Ages 15-64*

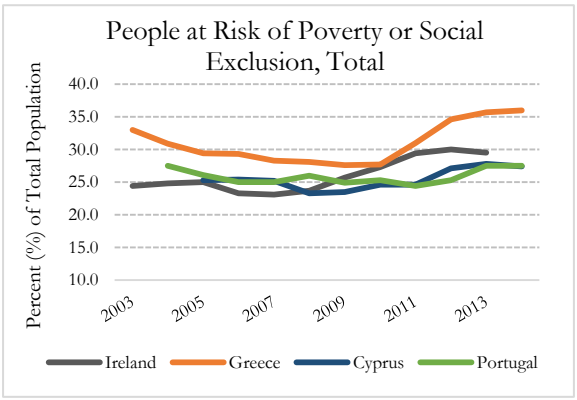

Figure 7 - *People at Risk of Poverty or Social Exclusion, Total*

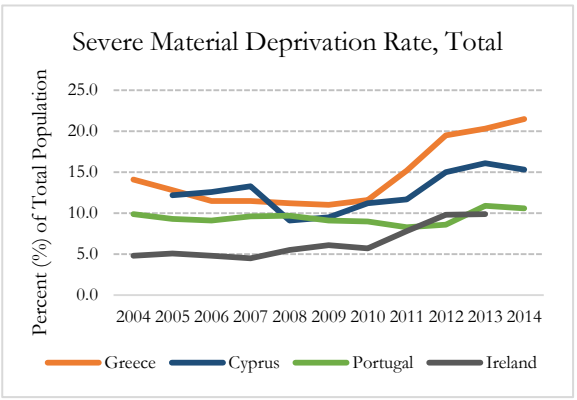

Figure 8 - *Severe Material Deprivation Rate, Total*

Figures 3 – 8 - Socioeconomic Conditions in Cyprus, Greece, Ireland and Portugal

Note: The two unemployment rates are reported on a quarterly basis, whereas the remaining four indicators are reported on a yearly basis. GDP per capita and actual individual consumption per capita are expressed in PPS (EU28=100), i.e. in Purchase Power Standard with the EU28 serving as the reference country. The unemployment rate for ages 15-24 is expressed as a percentage share with respect to total population aged 15-24, while the remaining three indicators are expressed in percentage shares of total population. Note that the vertical axes in most of the graphs have been truncated for greater clarity in the presentation of the data.
Source: Created by the author. All data has been collected from Eurostat.

But then, could there be a causal link between these two phenomena: fiscal consolidation programmes on the one side and the deterioration of socioeconomic conditions on the other? If that were the case, it would mean that negative shocks in government expenditure (i.e. spending cuts) and positive shocks in government revenue (i.e. tax increases) may have economic and, therefore, social, consequences on the real sectors of those economies. Hence, tracing -given the properties of the data- the effects of fiscal policy shocks on output and its components can be of crucial importance for both policymakers and stakeholders.

The aim of this paper is to contribute towards extending the current knowledge about the effects of fiscal policy on the real side of the economy and, in specific on output and its components. It tries to achieve this aim by using the Structural Vector Autoregression (SVAR) methodology developed by Blanchard & Perotti (2002) as its main analytical tool, and by focusing on the Greek economy (over the period 2000-2013) as the setting in which this tool can be applied.

As already presented in **subsection 2.3.2**, one mainly encounters four alternatives, when searching for an appropriate method to use, in order to identify fiscal policy shocks and their effects: the "narrative", the "sign-restriction", the Choleski ordering and the Blanchard & Perotti (2002) approaches. Each one of them has its own advantages and disadvantages.

On the one hand, there is no doubt that the three episodes identified by the "narrative" approach are purely exogenous; it would be unrealistic to attribute sudden increases in the military spending to fluctuations of output (Perotti (2004)). On the other hand, given that all these episodes reflect war preparations, it would be hard to apply this method to countries such as Greece, since Greece has not been involved to systematic war operations since the Second World War

The main advantage of sign restrictions is that whether the fiscal policy shocks are anticipated or not by the private sector plays no importance (Perotti (2004)). However, their design is such that they exclude potential "non-Keynesian" effects of spending and tax shocks on output, and that they may also overestimate the tax multiplier relative to the spending one (Perotti (2004); Caldara & Kamps (2012)). This has been considered to be a very important disadvantage, since "non-Keynesian" effects may be present in countries undergoing severe economic and fiscal crises, such as Greece.

As for the Choleski decomposition, its advantages and disadvantages are quite well known. While it is a method very easy to implement, it requires identifying restrictions concerning the causal

ordering of the variables that are very often hard to base on solid grounds of economic theory. However, as presented in **subsection 8.3**, it has been also used as a way to check the robustness of the results.

The fourth and last alternative at one's disposal is the one used in this thesis, i.e. the Blanchard & Perotti (2002) methodology. I consider the main advantage of this method to be the fact that it accounts for differences in tax systems among countries, thus trying to a greater extend to match the data. Another advantage, especially relative to the "sign restriction" approach, is that it does not exclude any "non-Keynesian" effects prior to identification. However, it shares some of the disadvantages of the Choleski decomposition, since some assumptions about causal ordering are required, and it can be hard to impose them, in case there is evidence for bi-directional causality between the variables. Whatever the case, one should not forget that by choosing this method, I have obtained a tool allowing identification; choosing any of the alternatives would have had its own disadvantages.

Apart from the fact that Greece has been one of the countries experiencing severe macroeconomic crises and being subject to fiscal adjustment, its selection as the economy in focus of this thesis has also been based on the current state of knowledge concerning the effects of fiscal policy shocks. Surprisingly, there is a research void, as far as the real effects of fiscal policy in Greece over the period 2000-present are concerned. To the best of my knowledge, while there are a couple of studies performing such an analysis using either theoretical models –for instance, Papageorgiou (2012)- or growth equations –for instance, Angelopoulos & Philipopoulos (2007) and Tagkalakis (2014)-, only Tagkalakis (2013) focuses on the post-2000 period using the Blanchard & Perotti (2002) approach. Nonetheless, he does not decompose GDP further and instead focuses on the impact on unemployment. Consequently, a large piece of information is lost; as must have already become evident from the previous section of this paper, different theories may predict similar effects of fiscal policy on output, but different ones on consumption and investment. In addition, the value of the output elasticity of taxes used by Tagkalakis (2013) is relatively outdated, since it is based on the one calculated by Girouard & Andrè (2005).

Finally, two reasons have dictated the choice of the period 2000-2013 as the setting of this study. The first and more obvious one is that Greek quarterly data on fiscal and macroeconomic variables are not available for earlier years. As for the second, I agree with Tagkalakis (2013, p. 26) in that "Greece became part of the euro area on 1st January 2001 but its euro entry was

already decided in 2000, therefore we start our data set in 2000 because expectations for a euro area entry were already formed".

The contribution of this thesis is three-fold. First, it extends the work done by Tagkalakis (2013), by further disaggregating output in private consumption and investment. Second, it uses up-to-date values of certain subcomponents of the output elasticities of the different fiscal variables, taken from the most recent paper of OECD calculating those (i.e. Price et al (2014)). Special attention is paid to aspects directly related to other parts of the aforementioned elasticities that are usually taken for granted in papers using the Blanchard &Perotti (2002) methodology. These include the consideration of several aspects of the Greek tax-code, as well as econometric estimation. It should be noted that, to the best of my knowledge, it is the first time that such a detailed analysis on output elasticities is conducted on the sample under examination. Finally, it also focuses on testing for cointegration based on specific theoretical grounds and exploring the direction of causality between government spending and government revenue, an analysis that – to the best of my knowledge- has not been conducted on the sample studied.

4. Research Questions

To better serve the aim of this thesis, I pose and am interested in answering, the following research questions:

1) How sensitive, if at all, is the real sector of the Greek economy - as represented by GDP, private investment and private consumption- to fiscal policy shocks?
2) Which of the main theoretical strands of the literature (i.e. traditional Keynesian, neoclassical, and Neo-Keynesian) can best explain these macroeconomic effects, if any, and to what extend?

5. Data Description and Pretesting

In order to analyse the effects of fiscal-policy shocks in Greece, I have used data reported on a quarterly basis and covering the time period 2000Q1 – 2013Q3, which has resulted in a dataset length of 55 observations in total. As will be explained in **subsection 6.2**, using quarterly data is crucial for the identification scheme used in this paper, since we can then assume that potential endogeneity channels are eradicated. All time series have been retrieved from Eurostat's database and include indicators taken from quarterly, non-financial Sectoral Accounts and Accounts of General Government, as well as from the quarterly results of Eurostat's Labour Force Survey (LFS).

Before any further tests or transformations could be conducted on the data available, seasonal adjustment was necessary. Greece is one of the few countries included in Eurostat's database that has a very limited range of seasonally adjusted indicators, and seasonally adjusted series are either much shorter than the non-seasonally adjusted ones or non-existent. To this end, the X-13-ARIMA-SEATS method for seasonal adjustment –as provided by the *Eviews* software for statistical analysis- has been applied whenever there has been evidence substantiating the presence of stable or moving seasonality.

After seasonality had been removed from the data, I defined the main macroeconomic and fiscal variables used in the analysis conducted in the following chapters. These include the ***Gross Domestic Product (GDP)***, ***Current (Government) Revenue net of current transfers (NCR)*** –as well as some subcategories-, ***Government Expenditure (GE)*** –as well as some subcategories-, ***Private Consumption (PRC)*** and ***Private Investment (PRI)***, among others. All variables have been transformed in logarithms and expressed in real terms. Moreover, they have been expressed as differences between each period t and the corresponding period t-4, a transformation that translates into year-over-year growth rates and results in four observations less for each variable, or, 51 observations available for econometric estimation.[9]

I have also tested all variables for the presence of a unit root using the Elliott-Rothenberg-Stock (ERS) test, both before and after their final transformation in growth rates. All original variables in logarithmic and real terms have been found to be integrated of order one, and in specific to be random walks with drift. Expressing them in year-over-year growth rates has not resulted in stationarity –again, tested using the ERS test-, but this has not caused any concerns about inference from the coefficients of the different reduced-form VARs or construction of the structural Impulse Response Functions (IRFs) used in this paper, since the stability condition for all VAR-specifications has been fulfilled and convergence of the coefficients is guaranteed.[10]

While a transformation in first-differences is the first alternative to come in mind when one uses series that are integrated of order one (or first-difference stationary), the annual growth rates have been considered to be much preferable in this case. As will be explained later, it has been decided to include only a limited number of lags –actually, the Schwarz's Bayesian Information Criterion (SBIC) has chosen only one, when given a maximum number of four lags - in the VAR-

[9] The econometric estimation of the different elasticities is an exception, since 54 observations are available in that case. This stems from the fact that the elasticity-elated variables have been transformed in first differences, something that leads to only one observation getting lost because of the transformation. Of course, the definition of within-quarter elasticities means that potential use of annual growth rates would be useless or even harmful for the purposes of the analysis.

[10] Please see the results from Postestimation tests in **Appendix E. Reduced-Form-VAR Postestimation Tests** for more details.

specifications of this paper, given the short length of the series used in the analysis. Having only one lag in the model, and first differences, would mean that the series in the model would be affected by shocks that have occurred in the previous two quarters (they would be affected by shocks occurring only in the previous quarter, if they were in levels, but inserting the variables in first-differences gives one quarter more). However, with annual growth rates and one lag, variables can be affected by shocks having occurred even five quarters (i.e. more than one year) ago. I am of the opinion that the latter transformation can better capture the system's dynamics, since I would expect that the effects of fiscal policy on the macroeconomy should become apparent to a full extend five quarters after the initial shock, even in the presence of lags in their transmission.

Appendix A. List of Main Variables presents the definitions of the main variables of interest, while **Appendix B. The Data, Seasonal Adjustment and Pretesting** provides more detailed information concerning the different data sources, aspects of the seasonal adjustment process, as well as the transformation of the variables and the subsequently performed unit-root tests.

Before proceeding with the description of the identification scheme used in this paper, it would be very interesting to summarise (***Table 5*** and ***Table 6***) some descriptive statistics calculated for the seasonally adjusted, untransformed data.[11]

	Government Expenditure (as a share of GDP)		**Net Current Revenue (as a share of GDP)**	
	Pre-Crisis	***Crisis***	***Pre-Crisis***	***Crisis***
Min	0,1813	0,2105	0,3453	0,3604
Max	0,2724	0,2403	0,3915	0,4083
Mean	0,2237	0,2243	0,3666	0,3838
Std. Dev	0,0227	0,0115	0,0132	0,0148
Obs	40	15	40	15

Table 5 – Descriptive Statistics (Main Fiscal Variables)
Source: Author's own calculations.

	Private Consumption (as a share of GDP)		**Private Investment (as a share of GDP)**	
	Pre-Crisis	***Crisis***	***Pre-Crisis***	***Crisis***
Min	0,6621	0,6880	0,1622	0,1008
Max	0,7398	0,7231	0,2440	0,1675
Mean	0,7010	0,7046	0,1897	0,1283
Std. Dev	0,0225	0,0109	0,0175	0,0206
Obs	40	15	40	15

Table 6 – Descriptive Statistics (Main Macroeconomic Variables)
Source: Author's own calculations.

[11] In other words before expressing the variables in logarithmic and real terms.

Although there do not seem to be any significant changes in the behaviour of government spending, an upward movement of the minimum and maximum values, as well as the mean of taxes can be observed. On the macroeconomic side, and in contrast to private consumption, private investment appears to have become more volatile after the outburst of the crisis, while decreasing significantly in terms of its range and mean.

6. Methodology

6.1 The VAR Model

The benchmark, or baseline, VAR specification is a trivariate, first-order system (i.e. the longest lag-length included, for all variables, is unity), which includes ***Government Expenditure (GE)***, ***Current (Government) Expenditure net of current transfers (NCR)*** and ***Gross Domestic Product (GDP)***.[12] GE is defined as the sum of government spending on goods and services, compensation of civil servants and public investment, while NCR is defined as the difference between current revenue and current transfers. All variables have been seasonally adjusted (as described already in **Section 5**), and have been expressed in logarithmic and real terms –the latter transformation being conducted through the use of the ***GDP Deflator (GDPD)*** -. They enter the model in differences between period t and period t-4.

Turning to other specifications used in the analysis, I have decided to further disaggregate both government expenditure and GDP, and, thus, to include different components of both variables. In particular, I have also incorporated ***Public Wages (PW)*** and ***Government Spending on Good and Services (GSGS)*** on the government expenditure side, as well as ***Private Consumption (PRC)*** and ***Private Investment (PRI)*** on the macroeconomic side. The further breakdown of government expenditure has been considered to be of utmost importance, taking into consideration the miscellaneous theoretical models that predict different effects caused by different components of government expenditure.[13] Drawing a distinction between private consumption and investment is of equally high importance, since different theories may predict similar effects of fiscal policy on GDP as a whole, while predicting effects of the opposite sign for consumption and investment.[14] Given the relatively small size of the sample, I have not included more than three variables in each specified VAR model, but instead have chosen to alternate –and, thus, have different combinations of- the different expenditure and

[12] Please see more details in the following subsection of this paper on the criterion for the determination of the lag length.
[13] Please refer to **subsection 2.2.** for more details.
[14] For example, a positive shock in government expenditure would be expected to increase consumption in Keynesian models, while being expected to decrease it in neoclassical models.

macroeconomic variables. However, regardless of the expenditure variable used in each model, I have always included the NCR variable, so as to control for potential correlation between government expenditure and government revenue.

In total, nine different VAR models have been used in this paper, and these are presented in ***Table 7*** below. For convenience, each VAR has been given a code name (as seen in the first column of the following table), which I accordingly use when referring to it.

	Variables Included	Number of lags	Other Options
VAR1	ΔRGE - ΔRNCR – ΔRGDP	1	dfk - small
VAR2	ΔRGSGS - ΔRNCR – ΔRGDP	1	dfk - small
VAR3	ΔRPW - ΔRNCR – ΔRGDP	1	dfk - small
VAR4	ΔRGE - ΔRNCR – ΔRPRC	1	dfk - small
VAR5	ΔRGE - ΔRNCR – ΔRPRI	1	dfk - small
VAR6	ΔRGSGS - ΔRNCR – ΔRPRC	1	dfk - small
VAR7	ΔRGSGS - ΔRNCR – ΔRPRI	1	dfk - small
VAR8	ΔRPW - ΔRNCR – ΔRPRC	1	dfk - small
VAR9	ΔRPW - ΔRNCR – ΔRPRI	1	dfk - small

Table 7 – VAR Specifications

Note: The "dfk" and "small" options in Stata correct the degrees of freedom and the t and F statistics accordingly, when the model is fitted on small samples.

Source: Created by the author.

The specifications VAR1-VAR3 have been run, in order to better be able to evaluate where the results of this paper stand, in comparison to other papers analysing the same topic and using the same methodology. The others, are the main focus of the analysis and extend the work done by Tagkalakis (2013).

Finally, deterministic regressors (i.e. exogenous variables) have also been included in the model. These consist of a constant, as well as ***Public Investment (PI)***, ***working-age unemployment (U)*** (also in first-difference of logarithms) and a ***dummy controlling for the Greek (Debt) Crisis (GC) and its fourth lag***, and their inclusion can be based on different grounds.

As far as public investment is concerned, it has been included as an exogenous variable whenever the VAR specification contains as an endogenous variable a subcomponent of government revenue (i.e. government spending on goods and services and public wages). This has been done to control for potential correlation between the two main categories of government expenditure, i.e. government consumption (which includes government purchases of goods and services and public wages) and public investment. One would expect, that in case the government would need

to either increase or cut government expenditure, it would have to decide whether to do this via its spending on consumption, investment or both.

Turning to unemployment, it has been considered to be a very important variable, both with respect to its behaviour over the time period studied and with respect to theories linking it to the effects of fiscal policy. Both working-wage and youth unemployment rates became approximately double in magnitude over the period 2000-2013, with the former increasing from 12,5% in 2000Q1 to 27,4% in 2013Q3 and the latter skyrocketing from 30,9% to 57,1% in the respective quarters. Taking into account that unemployment directly leads to a decrease in both personal and family incomes –even in the presence of unemployment benefits-, it becomes obvious that higher levels of unemployment may result to lower levels of private consumption.[15] Therefore, one interested in studying the effects of shocks in fiscal policy on private consumption, should also control for unemployment. From an economic-theory perspective, both Keynesian and neoclassical theories connect this variable to the effect of a given increase in government spending. On the one side, Keynesian theory predicts larger effects of expansionary fiscal policy when the degree of slack in the economy is higher and prices are stickier. Unemployment can be considered to be a measure of such slack. On the other side, neoclassical theory argues that the labour supply function is increasing in government spending and that, therefore, the elasticity of labour supply plays a key role in determining the impact of government spending increases on consumption and output. Since unemployment mirrors the relationship between labour demand and supply, it can also be used to control for potential negative wealth effects that may affect the number of hours worked and, hence, employment.

As for the Greek-Crisis dummy, its inclusion has been deemed to be necessary for several reasons. Firstly, by visually inspecting the series for government expenditure, I have observed that it exhibits a structural break (break in trend) in the first quarter of 2010 and starts to persistently decline in later quarters. More importantly, though, the dummy in question controls for the fact that the first sets of austerity measures were announced by the Greek government in February and March 2010, before the official agreement for financial support with the IMF, the EC and the ECB was reached or even officially requested. In this, my definition of the Greek-crisis dummy differs from the one used by Tagkalakis (2013) –accordingly called "Economic-Adjustment-Programme (EAP) dummy"- in that the dummy takes the value of 1 for the first time in the first quarter of 2010, and not in the second. Tagkalakis's (2013) rationale for his

[15] An unemployed person in Greece receives 360 euros per month in the form of an unemployment benefit, an amount that accounts for approximately 55% of the minimum wage of 683,76 euros per month, as legislated by the government since March 2012 (see also Manpower Employment Organisation (2015), for more details.

choice is that the agreement and first implementation of the EAP in the second quarter of 2010 resulted in Greece being cut-off from financial markets and in the pursuit of several labour reforms from then onwards. I, nevertheless, argue that any further austerity measures implemented after the public announcement of the financial-support agreement between Greece and its creditors may have been anticipated by the private sector. Indicative of the widely-held expectations that the agreement for financial support would eventually result in decreases in disposable income was the fact that only three days after its official announcement, a massive protest was organized in the centre of Athens, attracting more than 150.000 individuals and following a two-day strike with an unusually high participation of employees in both private and public sectors.[16] As will be further explained in the subsection explaining the identification scheme of Blanchard & Perotti (2002), one of the crucial assumptions endorsed is that fiscal shocks are unanticipated. As a final remark, I should point out that the dummy of interest also controls for the continuous increase in the long-term interest rate on Greek bonds starting in late 2009, as well as the increasing difficulty of the Greek government to borrow at a reasonable cost in the financial markets.

Another natural candidate that could serve as an exogenous variable is the long-term nominal interest rate. This type of interest rate is very often included in similar specifications, since it is considered to be closely related to private consumption and investment.[17] I, thus, decided to also include the ten-year nominal interest rate of government bonds in the VAR model after transforming it in first-differences (in levels). However, all coefficients on interest rate were statistically insignificant and, consequently, the latter has not been included in the final version of the specification used in this paper.

In mathematical terms, the primitive system representing the baseline specification –or the system in a structural form-, can be expressed as the system of equations presented below. All deterministic regressors, with the exception of the constant, have been suppressed, so as to serve the aim of notational convenience.

$$\Delta GE_t = b_{10} - b_{12}\Delta NCR_t - b_{13}\Delta GDP_t + \gamma_{11}\Delta GE_{t-1} + \gamma_{12}\Delta NCR_{t-1} + \gamma_{13}\Delta GDP_{t-1} + \varepsilon_{\Delta GE,t} \quad (6.1)$$

$$\Delta NCR_t = b_{20} - b_{21}\Delta GE_t - b_{23}\Delta GDP_t + \gamma_{21}\Delta GE_{t-1} + \gamma_{22}\Delta NCR_{t-1} + \gamma_{23}\Delta GDP_{t-1} + \varepsilon_{\Delta GR,t} \quad (6.2)$$

$$\Delta GDP_t = b_{30} - b_{31}\Delta GE_t - b_{32}\Delta NCR_t + \gamma_{31}\Delta GE_{t-1} + \gamma_{32}\Delta NCR_{t-1} + \gamma_{33}\Delta GDP_{t-1} + \varepsilon_{\Delta GDP,t} \quad (6.3)$$

[16] Please refer to Kokkaliari & Phoskolos (2010), for more details.

[17] For instance, Giordano et al (2007) and de Castro & Hernández de Cos (2008) use similar arguments when they include the long-term interest rate in their specifications, instead of the short-term one.

All variables are expressed in annual growth rates (shown here by the Δ-operator) and the disturbance terms $\varepsilon_{\Delta GE,t}, \varepsilon_{\Delta GR,t}, \varepsilon_{\Delta GDP,t}$ are assumed to be mutually uncorrelated, zero-mean, White-Noise processes. Consequently, the structural shocks exhibit the following properties:

$$E(\varepsilon_t) = E\begin{bmatrix} \varepsilon_{\Delta GE,t} \\ \varepsilon_{\Delta NCR,t} \\ \varepsilon_{\Delta GDP,t} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} = 0_{3\times 1}$$

$$E(\varepsilon_t \varepsilon_t') = E\begin{bmatrix} \varepsilon_{\Delta GE,t}^2 & \varepsilon_{\Delta GE,t}\varepsilon_{\Delta NCR,t} & \varepsilon_{\Delta GE,t}\varepsilon_{\Delta GDP,t} \\ \varepsilon_{\Delta NCR,t}\varepsilon_{\Delta GE,t} & \varepsilon_{\Delta NCR,t}^2 & \varepsilon_{\Delta NCR,t}\varepsilon_{\Delta GDP,t} \\ \varepsilon_{\Delta GDP,t}\varepsilon_{\Delta GE,t} & \varepsilon_{\Delta GDP,t}\varepsilon_{\Delta NCR,t} & \varepsilon_{\Delta GDP,t}^2 \end{bmatrix} = \begin{bmatrix} \sigma_{\Delta GE}^2 & 0 & 0 \\ 0 & \sigma_{\Delta NCR}^2 & 0 \\ 0 & 0 & \sigma_{\Delta GDP}^2 \end{bmatrix} \equiv \Sigma_\varepsilon$$

It is of interest to estimate the following unknown parameters:

$$\theta = (b_{10}, b_{20}, b_{30}, b_{12}, b_{13}, b_{21}, b_{23}, b_{31}, b_{32}, \gamma_{11}, \gamma_{12}, \gamma_{13}, \gamma_{21}, \gamma_{22}, \gamma_{23}, \gamma_{31}, \gamma_{32}, \gamma_{33}, \sigma_{\Delta GE}^2, \sigma_{\Delta NCR}^2, \sigma_{\Delta GDP}^2)'.$$

However, the structural-form just presented above would not give us unbiased and consistent estimates of the unknown parameters of interest, since all variables have a contemporaneous effect on each other (endogeneity problem). As a result, we need to derive the reduced-form of the system, which instead will give us estimates that are both unbiased and consistent. This is derived as follows, after writing our structural-form system in the compact form:

$$\begin{cases} \Delta GE_t + b_{12}\Delta NCR_t + b_{13}\Delta GDP_t = b_{10} + \gamma_{11}\Delta GE_{t-1} + \gamma_{12}\Delta NCR_{t-1} + \gamma_{13}\Delta GDP_{t-1} + \varepsilon_{\Delta GE,t} \\ b_{21}\Delta GE_t + \Delta NCR_t + b_{23}\Delta GDP_t = b_{20} + \gamma_{21}\Delta GE_{t-1} + \gamma_{22}\Delta NCR_{t-1} + \gamma_{23}\Delta GDP_{t-1} + \varepsilon_{\Delta GR,t} \\ b_{31}\Delta GE_t + b_{32}\Delta NCR_t + \Delta GDP_t = b_{30} + \gamma_{31}\Delta GE_{t-1} + \gamma_{32}\Delta NCR_{t-1} + \gamma_{33}\Delta GDP_{t-1} + \varepsilon_{\Delta GDP,t} \end{cases} \Leftrightarrow$$

$$\Leftrightarrow \begin{bmatrix} 1 & b_{12} & b_{13} \\ b_{21} & 1 & b_{23} \\ b_{31} & b_{32} & 1 \end{bmatrix} \begin{bmatrix} \Delta GE_t \\ \Delta NCR_t \\ \Delta GDP_t \end{bmatrix} = \begin{bmatrix} b_{10} \\ b_{20} \\ b_{30} \end{bmatrix} + \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} \end{bmatrix} \begin{bmatrix} \Delta GE_{t-1} \\ \Delta NCR_{t-1} \\ \Delta GDP_{t-1} \end{bmatrix} + \begin{bmatrix} \varepsilon_{\Delta GE,t} \\ \varepsilon_{\Delta NCR,t} \\ \varepsilon_{\Delta GDP,t} \end{bmatrix} \Rightarrow$$

$$\Rightarrow BY_t = \Gamma_0 + \Gamma_1 Y_{t-1} + \varepsilon_t \xrightarrow{\text{premultiplication by the inverse of B}}$$
$$\Rightarrow B^{-1}BY_t = B^{-1}\Gamma_0 + B^{-1}\Gamma_1 Y_{t-1} + B^{-1}\varepsilon_t \Rightarrow$$
$$\Rightarrow Y_t = A_0 + A_1 Y_{t-1} + e_t$$

where

$$Y_t = \begin{bmatrix} \Delta GE_t \\ \Delta NCR_t \\ \Delta GDP_t \end{bmatrix},\ Y_{t-1} = \begin{bmatrix} \Delta GE_{t-1} \\ \Delta NCR_{t-1} \\ \Delta GDP_{t-1} \end{bmatrix}$$

$$\mathrm{A}_0 = B^{-1}\Gamma_0 = \begin{bmatrix} a_{10} \\ a_{20} \\ a_{30} \end{bmatrix},\ \mathrm{A}_1 = B^{-1}\Gamma_1 = \begin{bmatrix} \alpha_{11} & \alpha_{12} & \alpha_{13} \\ \alpha_{21} & \alpha_{22} & \alpha_{23} \\ \alpha_{31} & \alpha_{32} & \alpha_{33} \end{bmatrix},\ \text{and}\ e_t = B^{-1}\varepsilon_t = \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix}$$

The properties of the new disturbance terms will be as follows:

$$E(e_t) = E\begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix} = 0_{3\times 1} \quad \text{and}$$

$$E(e_t e_t') = E\begin{bmatrix} e_{1t}^2 & e_{1t}e_{2t} & e_{1t}e_{3t} \\ e_{2t}e_{1t} & e_{2t}^2 & e_{2t}e_{3t} \\ e_{3t}e_{1t} & e_{3t}e_{2t} & e_{3t}^2 \end{bmatrix} = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & \sigma_2^2 & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & \sigma_3^2 \end{bmatrix} \equiv \Sigma_e = B^{-1}\Sigma_\varepsilon B^{-1\prime},$$

where $\sigma_{12} = \sigma_{21}$, $\sigma_{13} = \sigma_{31}$ and $\sigma_{23} = \sigma_{32}$.

The reduced-form of the baseline specification can also be written in terms of lag polynomials, as follows:

$$\boldsymbol{Y_t = D(L)Y_{t\text{-}1} + e_t}$$

where $D(L)$ is an autoregressive polynomial in lag-operator L.

An important issue inherent in every VAR specification is the determination of the lag-length of the variables included in the model, so that these adequately capture both the dynamics of the system and all serial correlation in the data. The system dynamics can only be captured by a number of lags that is not too small, but, then again, special attention should be given to the possibility that the degrees of freedom of the model might be eroded very quickly. For instance, in a 3x3 system, and without taking into account the parameters on exogenous or deterministic regressors, every lag added will erode 3 more degrees of freedom. As for serial correlation, the different residual series of the model obtained after estimation should resemble the properties of White-Noise series and be serially uncorrelated. However, if –after fitting the model to the data-

remaining serial correlation is detected, one has to consider higher-order models, until the no-remaining-serial-correlation condition is satisfied. Still, one should also be very careful with the degrees of freedom available in the estimation: sometimes one may face a trade-off between remaining serial correlation and many lost degrees of freedom, with the latter potentially resulting into insignificant estimates of many of the parameters.

I have based my decision for the selection of the lag-order of the model on Schwarz's Bayesian Information Criterion (SBIC), since this criterion is inclined to select more parsimonious models –given the fact that it has a larger penalty-term incorporated in the formula calculating the statistic for each lag-, and is also believed, as argued by Ivanov & Kilian (2005), to be more accurate in samples containing less than 120 observations. For almost all specifications, the SBIC criterion has selected a first-order VAR model, when using a maximum number of two lags as an option.[18] There have been, however, three specifications (i.e. all specifications including PRC), where the SBIC originally selected 0 lags. Including no lags in the model, however, means that the time path of a variable in a given period t is not affected by any realisations of the other variables in the past. Under this scenario, VAR-analysis makes no particular contribution, given that it only reproduces the behaviour of the variables already observed in the data. Therefore, and with the aim of consistency, I have decided to use 1 lag in all VAR specifications.[19] I have then tested –among other postestimation tests ran- for the existence of remaining serial correlation in each of the residuals (using a maximum lag-order of 4 lags as an option) and most of the time have been able to reject the null of no remaining serial correlation at the 5% level. However, adding a second lag did not eliminate the issue and, hence, I have decided to use one lag instead. For a summary of the tests conducted after fitting each of the reduced-form VAR specifications, please refer to **Appendix E. Reduced-Form-VAR Postestimation Tests**. I now turn to the identification scheme used and present its logic and properties in detail.

6.2 The Identification Scheme

The tool enabling the identification of the impact of fiscal policy shocks on the macroeconomy is the method developed by Blanchard & Perotti (2002). This approach mainly relies on institutional information and takes advantage of the lags present in the decisions related to and the implementation of fiscal policy.

[18] I did not use a larger number of lags as an option when using the *varsoc* command in *Stata* (i.e. the one calculating values for all the information criteria available), given the fact that the sample was quite small (51 observations) and that the degrees of freedom available would not permit the use of more than two lags in total.
[19] After all, all other information criteria point towards the use of one lag, when given a maximum of two lags.

The procedure followed can be thought of as constituting of three steps and having the relationship between the reduced-form and structural-form residuals as its starting point. In particular, the reduced-form residuals $e_{\Delta GE,t}$ and $e_{\Delta NCR,t}$ are considered to be a linear combination of three distinct effects:

1) The so-called ***automatic response*** of expenditure/taxes to unanticipated changes in output. In this case, currently applied fiscal-policy rules are taken as given and do not change. For example, this category would include an unanticipated increase in taxes, due to a sudden increase in GDP, but for constant tax rates.
2) The so-called ***systematic discretionary response*** of policymakers to changes in output. Such responses actually imply changes in fiscal policy rules, as a result of changes in output. For example, policymakers might have to reduce the current tax rates, after realizing that the economy has entered a contraction.
3) ***Random discretionary shocks***. These shocks represent the structural-form innovation of each fiscal variable and are considered to be uncorrelated with the structural-form innovations of the other variables. In fact, the methodology in use has been built, in order for these shocks to be identified.

Therefore, and keeping in mind the different distinctions of effects just described, we may proceed to the first step of the identification scheme, by decomposing the two reduced-form disturbances of government expenditure and taxes as follows:

$$e_{\Delta GE,t} = \eta_{GE,GDP} e_{\Delta GDP,t} + \lambda_{12} \varepsilon_{\Delta NCR,t} + \varepsilon_{\Delta GE,t} \quad (6.4)$$

$$e_{\Delta NCR,t} = \eta_{NCR,GDP} e_{\Delta GDP,t} + \lambda_{21} \varepsilon_{\Delta GE,t} + \varepsilon_{\Delta NCR,t} \quad (6.5)$$

The coefficients $\eta_{GE,GDP}$ and $\eta_{NCR,GDP}$ capture the two first types of responses of taxes/expenditure described above, that is the automatic response of taxes/expenditure and the discretionary response of policymakers to unanticipated changes in output.

A potential problem when trying to disentangle the automatic from the discretionary response of fiscal variables to changes in output is endogeneity, since a shock in either of the fiscal variables may be correlated with a shock in GDP; as output may be affected by fiscal policy, fiscal policy can be affected by output. But then, what is really the factor that eliminates these endogeneity channels and isolates the one response from the other? Blanchard & Perotti (2002) argue that the assumption that is crucial for identification is that "…it takes policymakers and legislatures more than a quarter to learn about a GDP shock, decide what fiscal measures, if any, to take in

response, pass these measures through the legislature and actually implement them" (Blanchard & Perotti, 2002, p. 1334).

In particular, the fact that the data used is reported on a quarterly basis is assumed to eradicate the discretionary response of government spending and revenue to unanticipated changes in output. This is due to the existence of ***decision and implementation lags*** that are inherent in the practice of fiscal policy. In other words, it takes more than a quarter for policymakers to:

a) realise the changes that have occurred in the economy,
b) decide to implement new measures and, then,
c) transform the new measures into laws and acts, before implementing them.

As a result, the aforementioned coefficients capture only the automatic response of taxes and expenditure to unanticipated changes in output. Put differently, they can be characterized as the automatic stabilisers built-in in modern tax systems and mathematically correspond to the elasticities of government expenditure to GDP and of taxes to GDP, respectively. The calculation of these elasticities relies on information concerning the characteristics and design of the tax code of a given economy, as well as on miscellaneous assumptions implied by economic theory. A detailed description of the estimation –or determination- of these elasticities is presented in **subsection 6.3**.

What is crucial to understand at this point is that the ***decision lags*** are practically the ones that eliminate potential endogeneity channels. However, the ***implementation lags*** might cause a problem similar to the one the other lags solve; delays in the implementation of fiscal policy could mean that the private sector might have anticipated the fiscal measures eventually brought into force. Of course, anticipation with respect to fiscal policy shocks might bias the reaction of GDP, private consumption and investment. As mentioned already in **subsection 6.1**, special care has been taken, in order to ensure that the fiscal policy shocks captured by the model are not anticipated by the private sector.

Once the elasticities of government expenditure and taxes with respect to output have been determined, one can continue with the second step of the Blanchard & Perotti methodology. This includes the construction of the so-called ***Cyclically Adjusted (CA)*** reduced-form residuals of government expenditure and taxes, which are defined as follows:

$$e^{CA}_{\Delta GE,t} = e_{\Delta GE,t} - \eta_{GE,GDP} e_{\Delta GDP,t} = \lambda_{12}\varepsilon_{\Delta NCR,t} + \varepsilon_{\Delta GE,t} \tag{6.6}$$

$$e^{CA}_{\Delta NCR,t} = e_{\Delta NCR,t} - \eta_{NCR,GDP} e_{\Delta GDP,t} = \lambda_{21}\varepsilon_{\Delta GE,t} + \varepsilon_{\Delta NCR,t} \tag{6.7}$$

As a reminder, it is worth mentioning here that, by this stage, one already knows $e_{\Delta GE,t}$, $e_{\Delta GDP,t}$, $e_{\Delta NCR,t}$, $\eta_{GE,GDP}$, $\eta_{NCR,GDP}$. That is, one is supposed to already have retrieved $e_{\Delta GE,t}$, $e_{\Delta GDP,t}$, $e_{\Delta NCR,t}$ after running the reduced-form VAR described earlier, and is also supposed to have exogenously determined the elasticities $\eta_{GE,GDP}$, $\eta_{NCR,GDP}$, based on certain assumptions and information. Therefore, one may find $e^{CA}_{\Delta GE,t}$, $e^{CA}_{\Delta NCR,t}$ by just doing simple algebraic operations. The constructed $e^{CA}_{\Delta GE,t}$, $e^{CA}_{\Delta NCR,t}$ have the nice property that, while being possibly correlated with each other, they are –by definition- no longer correlated with $e_{\Delta GDP,t}$.

Having determined the CA disturbances for taxes and expenditure, means that one ends up having two equations in four unknowns:

$$e^{CA}_{\Delta GE,t} = \lambda_{12}\varepsilon_{\Delta NCR,t} + \varepsilon_{\Delta GE,t} \tag{6.8}$$

$$e^{CA}_{\Delta NCR,t} = \lambda_{21}\varepsilon_{\Delta GE,t} + \varepsilon_{\Delta NCR,t} \tag{6.9}$$

It is evident, that further steps towards the identification of $\varepsilon_{\Delta NCR,t}$, $\varepsilon_{\Delta GE,t}$ cannot be taken, unless one imposes an identifying restriction that will assign an exogenously determined value on either λ_{12} or λ_{21} (see the end of this subsection for a more detailed explanation). This can only be achieved, by implicitly imposing a causal ordering or exclusion restriction between the two fiscal variables of interest: one can either assume that government spending is causally prior to taxes – i.e. that government expenditure "comes first"-, or that taxes are causally prior to government expenditure –i.e. taxes "come first"-. Assuming the former implies that taxes have no contemporaneous effect on government expenditure and that, therefore, $\lambda_{12} = 0$. Similarly, assuming the latter implies that government expenditure has no contemporaneous effect on taxes and that, therefore, $\lambda_{21} = 0$.

As one would expect, whether the causal relationship runs from government expenditure to government revenue, or vice versa, has been widely studied in the literature. Specifically, there is a set of four testable hypotheses explored by researchers. These are the spend-and-tax, the tax-and-spend, the fiscal synchronization and the institutional separation hypotheses, and are briefly outlined here, as presented in Athanasenas, Katrakilidis & Trachanas (2014). As its name implies, the first one, entails that causality runs from spending to taxes, and that increases in government spending may be followed by increases in taxes. When it comes to the second, it suggests that

there is a unidirectional causal relationship running from taxes to spending, a fact that may result in increased government expenditure following an increase in revenue. As far as the third hypothesis is concerned, it indicates that there is a bidirectional causal relationship between the two fiscal variables and that, therefore, decisions on spending and taxes are made simultaneously. Finally, changes in spending are independent from changes in taxes and vice versa, according to the fourth hypothesis.

Turning again to the causal restrictions in the context of this paper, the spend-and-tax hypothesis would imply that $\lambda_{12} = 0$, whereas the tax-and-spend one would mean that $\lambda_{21} = 0$. Should the fiscal-synchronization hypothesis hold for Greece, however, one would have to either let free both λ_{12} and λ_{21} (an action that would prevent identification), or to choose on which of the two to impose an exclusion restriction. Finally, institutional separation would indicate that both λ_{12} and λ_{21} would have to be set equal to zero.

Fiscal synchronization seems to be the case for Greece, according to findings presented in some recently published papers. Athanasenas, Katrakilidis & Trachanas (2014) find evidence supporting the fiscal synchronization hypothesis for Greece and over the period 1999-2010. Kollias & Paleologou (2006) explore the same question for Greece, having a sample that covers the years 1960-2002, and support the same conclusion, as does Vamvoukas (2011), for the period 1970-2007.

Since an exclusion restriction is necessary for identification, I have followed other authors in this strand of the literature and also explored this question of direction of causality by running some Granger causality tests.[20] The notion of Granger causality is of particular usefulness in a VAR context: one can test whether current and past values of a given variable help to forecast future values of another variable. In mathematical terms and under the framework of the baseline model used in this paper, government expenditure does not Granger cause government revenue, if and only if $\gamma_{11} = 0$, and government revenue does not Granger cause government expenditure if and only if $\gamma_{12} = 0$.

Both directions of Granger-causality have been examined, and the results are presented in ***Table 8*** that follows:

[20] For example, Kollias & Paleologou (2006) use Granger causality as a main tools in their analysis, whereas Vamvoukas (2011) employs it as a robustness check.

Specification	**H₀:** ⊿*NCR does not Granger cause* ⊿*GE*	**H₀:** ⊿*GE does not Granger cause* ⊿*NCR*
VAR1	Not rejected	Not rejected
VAR2	Not rejected	Rejected at the 5% level
VAR3	Not rejected	Not rejected
VAR4	Not rejected	Not rejected
VAR5	Not rejected	Not rejected
VAR6	Not rejected	Rejected at the 5% level
VAR7	Not rejected	Not rejected
VAR8	Not rejected	Not rejected
VAR9	Not rejected	Not rejected

Table 8 – Granger-Causality Tests, Results
Source: Author's own calculations.

It is evident that no clear pattern of causality has emerged from Granger-causality analysis. One might think, that failure to reject the null hypothesis of Granger causality for both government spending and government revenue, would mean that the institutional separation hypothesis holds for Greece and in this sample. However, given that the number of observations is quite small and that the Greek crisis is also included, I cannot conclude that this is indeed the case. More importantly, detecting the direction of causality between government spending and taxes is not the focus of this paper, and, hence, not the full methodological setting indicated for this purpose is implemented. In this vein, it should be pointed out, that Granger causality is most commonly used within the framework of cointegration models.

I have, therefore, decided to follow other authors implementing the Blanchard & Perotti methodology, and set $\lambda_{12} = 0$ in all nine VAR specifications. The alternative, i.e. the restriction that $\lambda_{21} = 0$, has been employed as a way to check the robustness of the results (see **subsection 8** for more details).

After imposing this identifying restriction, one is left with:

$$e^{CA}_{\Delta GE,t} = \varepsilon_{\Delta GE,t} \tag{6.10}$$

$$e^{CA}_{\Delta NCR,t} = \lambda_{21}\varepsilon_{\Delta GE,t} + \varepsilon_{\Delta NCR,t} \tag{6.11}$$

As may be observed, one has automatically obtained $\varepsilon_{\Delta GE,t}$ and can now estimate λ_{21} and $\varepsilon_{\Delta NCR,t}$ by running a simple OLS regression of $e^{CA}_{\Delta NCR,t}$ on $\varepsilon_{\Delta GE,t}$. The series for $\varepsilon_{\Delta NCR,t}$ can be obtained as the residual values of the regression.

After having obtained estimates of the structural-form residuals of the two fiscal variables, one has now reached the third and final step of the identification process: this aims at the estimation of the third structural-form residual series, which is the one of the output variable. One should start by expressing the reduced-form residual of output, as a linear combination of the reduced-form residuals of the other two variables included in the model, and of its own structural-form residual:

$$e_{\Delta GDP,t} = \kappa_{32} e_{\Delta NCR,t} + \kappa_{31} e_{\Delta GE,t} + \varepsilon_{\Delta GDP,t} \tag{6.12}$$

Here, the parameters κ_{32} and κ_{31} account for the contemporaneous effect on output of a non-orthogonalised (or reduced-form) shock in government revenue and government spending respectively.

One would expect that, since $e_{\Delta GE,t}$, $e_{\Delta NCR,t}$ have already been found, one could obtain κ_{32}, κ_{31}, $\varepsilon_{\Delta GDP,t}$ by just running an OLS regression of $e_{\Delta GDP,t}$ on $e_{\Delta GE,t}$ and $e_{\Delta NCR,t}$. Nevertheless, this would give biased estimates, taking into account the fact that there is contemporaneous correlation among the three reduced-form residuals $e_{\Delta NCR,t}$, $e_{\Delta GE,t}$, $e_{\Delta GDP,t}$. As a result, it is necessary to instrument $e_{\Delta GE,t}$, $e_{\Delta NCR,t}$ with $e^{CA}_{\Delta GE,t}$, $e^{CA}_{\Delta NCR,t}$ respectively. The usage of instruments removes the contemporaneous correlation mentioned above and gives both consistent and unbiased estimates of the coefficients and the residuals of interest.

It should be pointed out, though, that no IV-regressions take place in the estimation; the instruments are created by the SVAR itself and used over the estimation of the unknown parameters. This becomes possible, due to the fact that the Maximum Likelihood Estimator (MLE) –i.e. the estimator used by *Stata*, when estimating the SVAR- can be perceived to be equivalent with the 2SLS and 3SLS estimators.[21] In particular, Hausman (1975) developed an instrumental-variable interpretation of the Full Information Maximum Likelihood (FIML) estimator in Simultaneous Equation Models (SEMs), extending it a few years later (Hausman, Newey & Taylor (1986)) to SEMs imposing restrictions on the variance-covariance matrix of the structural residuals.[22] According to that interpretation, the "…FIML also uses estimated residuals as instruments for the equations with which they are uncorrelated" (Hausman, Newey & Taylor,

[21] In contrast with the reduced-form VARs, which are estimated using a Seemingly Unrelated Regression (SUR) estimator, SVARs are estimated using a Maximum Likelihood estimator (MLE). That is, the estimation of the parameters of interest within the SVAR is done *simultaneously* and not *recursively*.

[22] The FIML estimator is equivalent with the MLE estimator in the case of SVARs, given that the estimation of its parameters is done *simultaneously*, using *all* information available in *all* equations.

1986, Headnote) and the "…covariance restrictions have the interpretation that they provide additional instrumental variables for use in estimation" (Hausman, Newey & Taylor, 1986, p. 1).

SVARs can make use of the instrumental-variable interpretation of the FIML estimator, since they can be thought of as special cases of the SEMs (Gottschalk (2001)). Both the former and the latter groups of models can be written, in their structural form as:

$$\Gamma Y_t = \mathrm{B} X_t + \varepsilon_t,$$

with SVARs taking the form:

$$\Gamma Y_t = \mathrm{B}(L) X_t + \varepsilon_t.$$

Y_t is the vector of the endogenous variables of the system, X_t contains the exogenous and lagged endogenous variables, ε_t is the vector of structural errors with a variance- covariance matrix Σ_ε and L is the lag operator.

The main difference between SVARs and SEMs is that the latter group usually leaves the Σ_ε unrestricted, while the former group imposes the restriction that the covariances between the structural residuals are equal to zero.

Wrapping up all the steps presented so far, the three equations connecting the reduced-form to the structural-form residuals can be rewritten and, from there, the innovation model that maps the relationship between the structural- and reduced- form residuals can be derived:

$$\begin{cases} e_{\Delta GE,t} = \eta_{GE,GDP} e_{GDP,t} + \lambda_{12} \varepsilon_{\Delta NCR,t} + \varepsilon_{\Delta GE,t} \\ e_{\Delta NCR,t} = \eta_{NCR,GDP} e_{\Delta GDP,t} + \lambda_{21} \varepsilon_{\Delta GE,t} + \varepsilon_{\Delta NCR,t} \\ e_{\Delta GDP,t} = \kappa_{32} e_{\Delta NCR,t} + \kappa_{31} e_{\Delta GE,t} + \varepsilon_{\Delta GDP,t} \end{cases} \Rightarrow \begin{cases} e_{\Delta GE,t} - \eta_{GE,GDP} e_{\Delta GDP,t} = \varepsilon_{\Delta GE,t} + \lambda_{12} \varepsilon_{\Delta NCR,t} \\ e_{\Delta NCR,t} - \eta_{NCR,GDP} e_{\Delta GDP,t} = \lambda_{21} \varepsilon_{\Delta GE,t} + \varepsilon_{\Delta NCR,t} \Rightarrow \\ -\kappa_{31} e_{\Delta GE,t} - \kappa_{32} e_{\Delta NCR,t} + e_{\Delta GDP,t} = \varepsilon_{\Delta GDP,t} \end{cases}$$

$$\Rightarrow \begin{bmatrix} 1 & 0 & -\eta_{GE,GDP} \\ 0 & 1 & -\eta_{NCR,GDP} \\ -\kappa_{31} & -\kappa_{32} & 1 \end{bmatrix} \begin{bmatrix} e_{\Delta GE,t} \\ e_{\Delta NCR,t} \\ e_{\Delta GDP,t} \end{bmatrix} = \begin{bmatrix} 1 & \lambda_{12} & 0 \\ \lambda_{21} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_{\Delta GE,t} \\ \varepsilon_{\Delta NCR,t} \\ \varepsilon_{\Delta GDP,t} \end{bmatrix} \Rightarrow$$

$$\Rightarrow \mathrm{K} e_t = \Lambda \varepsilon_t \xrightarrow[by\ K^{-1}]{premultiplication} e_t = \mathrm{K}^{-1} \Lambda \varepsilon_t \Rightarrow e_t = B^{-1} \varepsilon_t$$

Where

$$\mathrm{K}=\begin{bmatrix} 1 & 0 & -\eta_{GE,GDP} \\ 0 & 1 & -\eta_{NCR,GDP} \\ -\kappa_{31} & -\kappa_{32} & 1 \end{bmatrix},\ \Lambda=\begin{bmatrix} 1 & \lambda_{12} & 0 \\ \lambda_{21} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}=\begin{bmatrix} 1 & 0 & 0 \\ \lambda_{21} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix},\ e_t=\begin{bmatrix} e_{\Delta GE,t} \\ e_{\Delta NCR,t} \\ e_{\Delta GDP,t} \end{bmatrix},$$

$$\varepsilon_t=\begin{bmatrix} \varepsilon_{\Delta GE,t} \\ \varepsilon_{\Delta NCR,t} \\ \varepsilon_{\Delta GDP,t} \end{bmatrix} \text{and}\ \ \mathrm{B}^{-1}=\mathrm{K}^{-1}\Lambda\ .$$

As pointed out by Kilian (2012), the way matrix Λ has been defined implies that the variances of the structural-form residuals (i.e. the diagonal elements of matrix Σ_ε) are different from unity, and thus unrestricted. Hence, the variance-covariance matrix of the structural residuals is modelled as

$$\Sigma_\varepsilon=\begin{bmatrix} \sigma^2_{\Delta GE} & 0 & 0 \\ 0 & \sigma^2_{\Delta NCR} & 0 \\ 0 & 0 & \sigma^2_{\Delta GDP} \end{bmatrix},$$ as already presented in the previous subsection.

However, *Stata* implicitly assumes that the aforementioned variances are equal to unity and, hence, the structural-form residuals are not only orthogonal but also orthonormal. Therefore, the matrix in question becomes an identity matrix:

$$\Sigma_\varepsilon=\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}=I_{3\times 3}$$

Imposing both restrictions, i.e. that $\Lambda=\begin{bmatrix} 1 & \lambda_{12} & 0 \\ \lambda_{21} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$ and that $\Sigma_\varepsilon=I_{3\times 3}$, would result in three over-identifying restrictions (see further below for more details) and in an over-normalisation of the parameters of the system. Obviously, the system would fail to be solved and would reject the over-identifying restrictions as invalid. What one should instead do, is to let free the diagonal elements of matrix Λ, while assuming that $\Sigma_\varepsilon=I_{3\times 3}$. Therefore, instead of mapping the reduced-form residuals into the structural-form ones using the relationship

$$\begin{bmatrix} 1 & 0 & -\eta_{GE,GDP} \\ 0 & 1 & -\eta_{NCR,GDP} \\ -\kappa_{31} & -\kappa_{32} & 1 \end{bmatrix} e_t=\begin{bmatrix} 1 & \lambda_{12} & 0 \\ \lambda_{21} & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}\varepsilon_t,$$

I have used the following one:

$$\begin{bmatrix} 1 & 0 & -\eta_{GE,GDP} \\ 0 & 1 & -\eta_{NCR,GDP} \\ -\kappa_{31} & -\kappa_{32} & 1 \end{bmatrix} e_t = \begin{bmatrix} \lambda_{11} & \lambda_{12} & 0 \\ \lambda_{21} & \lambda_{22} & 0 \\ 0 & 0 & \lambda_{33} \end{bmatrix} \varepsilon_t$$

As Kilian (2012) argues, the two normalization assumptions are equivalent, and their only difference is in the unit of measure in which the innovations in the structural shocks are expressed. Using the former implies that a given innovation will have to be rescaled by one residual standard deviation, in order for it to represent a shock of one standard deviation, while using the latter ensures a priori that innovations are always equal to one.

Determining the number of restrictions that need to be imposed in order for the structural system to be identified is as important as is appropriately defining the matrices that offer a roadmap for this identification. Since the variance-covariance matrix of the reduced-form errors e_t, $\Sigma_e = \begin{bmatrix} \sigma_1^2 & \sigma_{12} & \sigma_{13} \\ \sigma_{21} & \sigma_2^2 & \sigma_{23} \\ \sigma_{31} & \sigma_{32} & \sigma_3^2 \end{bmatrix}$, is symmetric about the diagonal, it contains only $(3^2+3)/2=6$ distinct elements. This number represents the 3 elements on the diagonal and the other 3 on either the lower or upper triangle of the matrix. However, the structural system has $3^2=9$ unknown elements in total, since $\Sigma_\varepsilon = I_{3\times3}$ is known and matrix $\mathrm{B}^{-1} = \mathrm{K}^{-1}\Lambda$ contains 9 unknown elements. Therefore, in order for identification to be possible, one has to impose at least 9-6=3 identifying restrictions, otherwise the model is under-identified. If, eventually, the restrictions are equal to 3, the model is said to be exactly-identified, whereas a number of restrictions larger than 3 leads to an over-identified model. In the context of this paper, the model is exactly-identified, since just 3 identifying restrictions have been imposed and these include the parameters $\eta_{GE,GDP}$, $\eta_{NCR,GDP}$ and λ_{12}.

With an exactly-identified model at one's disposal, one may now proceed with studying the effects of fiscal policy on output and its components. However, before presenting the results, I first present the procedure followed, in order to obtain the aforementioned elasticities $\eta_{GE,GDP}$, $\eta_{NCR,GDP}$ and, thereafter, present the final form of the K and Λ matrices (and, therefore, the B^{-1} matrix).

6.3 Calculating Contemporaneous Elasticities

6.3.1 Theoretical Definition

Following Price et al (2014), I define the elasticities of cyclically-sensitive parts of government revenue and expenditure with respect to output (our only macroeconomic variable), as constituting of two components:

1) The elasticity of a given revenue or expenditure component with respect to its base (denoted as $\eta_{FV,B}$), where FV is the fiscal variable of interest and B is its base, and
2) The elasticity of the base with respect to output (denoted as $\eta_{B,GDP}$).

As a result, the resulting short-term elasticity of a certain fiscal variable with respect to output will be given by the following formula:

$$\eta_{FV,GDP} = \eta_{FV,B} \cdot \eta_{B,GDP} \tag{6.13}$$

The parts of government revenue and expenditure that are deemed to be cyclically-sensitive, their respective bases, as well as the formulas for their output-related elasticities, are given below.[23]

I. Personal-Income Taxes (PIT)

The main base of personal-income taxes is the wage bill, defined as the total (real) gross earnings –i.e. wages and salaries- of the (private sector of the) economy. However, other important sources of taxable income are the ones generated by self-employment, capital gains and property. Although it is a relatively common practice to only model real wages and salaries as the base of personal-income taxes, it might be that the other sources of personal income might behave differently, as regards the business cycle and –therefore- exhibit different elasticities with respect to GDP.[24] Therefore, a further disaggregation of the personal-income tax base would be needed, in order to account for these potential differences in business-cycle behaviour. Indeed, in the latest working paper calculating elasticities with respect to output gap published by the OECD - (Price et al 2014)-, the aforementioned tax base is decomposed into wages and salaries, self-employment income

[23] All OECD papers that have established models for the calculation of such elasticities have also established and followed this classification approach. These are: Giorno et al (1995), van den Noord (2000), Girouard & Andrè (2005) and Price et al (2014). Blanchard & Perotti (2002) –as well as all subsequent papers following the same methodology, with Giordano et al (2007), de Castro & Hernandez de Cos (2008) and Coutinho Pereira & Wemans (2013) among others- base many aspects of the calculation and estimation of the elasticities included in their model on Giorno et al (1995).

[24] For example, Blanchard and Perotti (2002), Perotti (2004), Giordano et al (2007) and de Castro and Hernández de Cos (2008) apply this approach.

and capital income, while property income is left out as a relatively insignificant source of government tax revenue.[25]

In this paper, I have decided to disaggregate the base for personal-income taxes into wages and salaries –as represented by Real Private Gross Wages and salaries (RPRW) - and self-employment income –as represented by Gross Mixed Income (GMI)-, while ignoring the income generated by capital gains and property. This choice has been based on the following grounds:

- While I have been able to find data on gross wages and salaries and on self-employment income, data for property- and capital- income could not be found on a quarterly basis for Greece and over the period 2000-2013.
- While the share of property income to the personal-income tax base is equal to approximately 10% on average over the period 2006-2011 in Greece, its contribution to total income-tax revenue is probably small, since it accounts for 15,41% on average and over the same period, but together with all other sources of income excluding wages and salaries and corporate income. ***Figures 9 and 10*** show these facts, and have been compiled using data from the General Secretariat of Informational Systems (GSIS) of the Greek Ministry of Finance:[26]

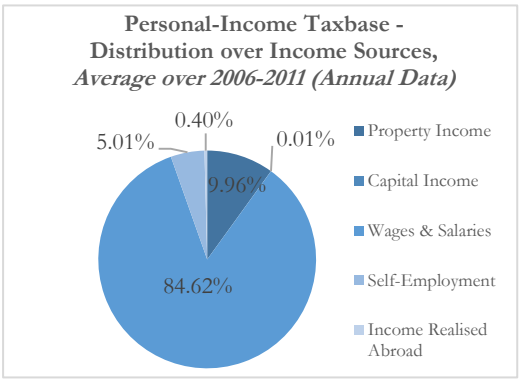

Figure 9 – Personal-Income Taxbase

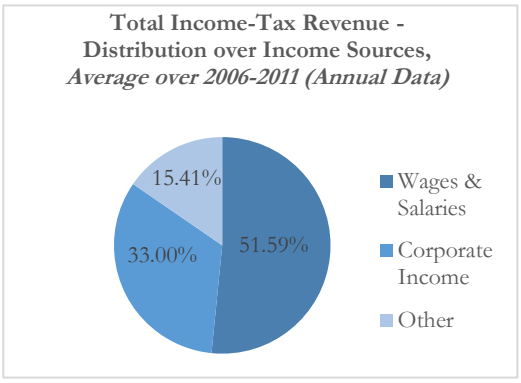

Figure 10 – Total Income-Tax Revenue

Note: Expressed as distributions over income sources and averages over the years 2006-2011.
Source: Created by the author. Based on annual data provided by the GSIS service of the Greek Ministry of Finance.

Consequently, the elasticity of personal-income taxes with respect to output can be written as:

$$\eta_{PIT,GDP} = w_{RPRW} \cdot \eta_{PIT,RPRW} \cdot \eta_{RPRW,GDP} + w_{GMI} \cdot \eta_{PIT,GMI} \cdot \eta_{GMI,GDP} \qquad (6.14)$$

[25] Accounting for only 2,3% on average over the period 1990-2013 and across the whole sample (with Greece included).
[26] GSIS, Greek Ministry of Finance (2006; 2007; 2008; 2009; 2010; and 2011).

where w_{RPRW} and w_{GMI} are the weights of RPRW and salaries and GMI respectively, adjusted to account for 100% of personal-income tax-revenue.[27]

It should be noted, though, that using the total real gross wages and salaries of the private sector, as well as the self-employment income, as the base for personal-income taxes implies the following:

a) The wages and salaries of the public sector are assumed to have a zero elasticity with respect to personal-income taxes
b) It is also assumed that other components of the personal-income tax base, mainly income from capital gains and property, are characterized by a similar behaviour to the one of the weighted sum of wages and salaries and self-employment income.

It is worth mentioning at this point, that several authors further decompose the wage bill into two subcomponents -by using its definition as the product of the average real wage and total employment-, when calculating the elasticity of the personal-income tax base relative to output.[28] Specifically, they first regress the (change in the) average real wage on employment and employment on output and, subsequently, take the product of the two coefficients estimated. The aforementioned breakdown was also used by older OECD papers and results into a three-stage formula for this elasticity.[29] However, the two more recent OECD papers use the two-stage formula, as has already been presented in the beginning of this subsection.[30]

II. Social Contributions (SC)

Since social contributions are levied on the gross earnings of each employee, total Real Private gross Wages and Salaries (RPRW) are considered to be the base of this tax component, as well. Thus, the elasticity of social contributions with respect to output will be given by:

$$\eta_{SC,GDP} = \eta_{SC,RPRW} \cdot \eta_{RPRW,GDP} \tag{6.15}$$

[27] As seen in the graph on the right above, wages and salaries account for 33% of total income tax-revenue, whereas self-employment income –which represents the "other" sources of personal income- accounts for 15,41%. When adjusted to account for 100% of personal-income tax-revenue, these weights turn into 68,17% and 31,83% respectively (by taking a simple rule of three).
[28] Blanchard & Perotti (2002), Perotti (2004), Coutinho Pereira & Wemans (2013) and de Castro & Hernandez de Cos (2008) are some of those.
[29] Giorno et al (1995) and van den Noord (2000).
[30] Girouard & Andrè (2005) and Price et al (2014).

As one may observe, the second component of this elasticity is identical to the one used for personal-income taxes.

III. Corporate-Income Taxes (CIT)

Gross Operating Surplus (GOS) is considered to be the variable that best approximates the base of corporate-income taxes, since these are levied on the gross profits of firms. This leads to the output elasticity of this type of tax being calculated as:

$$\eta_{CIT,GDP} = \eta_{CIT,GOS} \cdot \eta_{GOS,GDP} \tag{6.16}$$

IV. Indirect Taxes (INDT)

Consumption is used as the main base of indirect taxes, since Value-Added Tax (VAT) – the main tax of this category- is levied on the majority of goods and services used in production and bought by consumers. Therefore, the elasticity of indirect taxes with respect to output will be given by:

$$\eta_{INDT,GDP} = \eta_{INDT,CONS} \cdot \eta_{CONS,GDP} \tag{6.17}$$

V. Government Transfers (GTRANS)

Unemployment-related benefits (UNEMB) –which include subsidised employment, unemployment compensation and early retirement-, as well as income-related benefits (INCB) –which include family benefits, housing benefits and in-work benefits-, are the only types of government expenditure that are considered to be cyclically-sensitive. Thus, this elasticity can be expressed as:

$$\eta_{GTRANS,GDP} = \eta_{UNEMB,U} \cdot \eta_{U,GDP} + \eta_{INCB,RPRW} \cdot \eta_{RPRW,GDP} \tag{6.18}$$

The other categories of government revenue and expenditure, including, among others, market output, intermediate consumption and interest payments and receipts, are considered to be exogenous to the cyclical movements of output.

6.3.2 Elasticities in the Making

The estimation of the elasticities connecting personal-income taxes and social contributions to their base (gross real wages and salaries) can be a quite complicated process.[31] Therefore, and in

[31] These elasticities "…are derived from average earnings data, which relate per capita income tax paid to incomes along a distribution scale measured in multiples of average earnings. For individuals/households with identical characteristics as to marriage status and children, the average and marginal taxes can be calculated from the relevant tax codes at each point along the earnings schedule. The aggregate average and marginal tax rates are then calculated by an income-weighting process, to provide the aggregate elasticity of tax relative to earnings" (Price et al 2014, p. 9).

accordance with other papers using those in their analysis, I take the elasticities of personal-income taxes (PIT) and social contributions (SC) relative to their bases as given and actually borrow the values calculated by Price et al (2014).[32] As mentioned previously in this section, Price et al (2014) improve the estimate of the elasticity of personal-income taxes with respect to their base –and that with respect to output, on the next stage- by including non-earnings components of income in their calculations. As already discussed, it has been decided to partly take this improvement into account in this paper, by also including self-employment income in the analysis. Fortunately, Price et al (2014) provide separate values for the elasticity of personal-income tax relative to each one of the subcomponents of its base, before aggregating them to obtain the total personal-income tax-to-tax-base elasticity.

As for the elasticity of social contributions with respect to their base, the methodology underlying its calculation has also been improved in Price et al (2014).[33] Since this improvement only affects this first stage of calculation and not the subsequent estimation of the elasticity of real (private) gross wages and salaries (the base of social contributions) with respect to output, I can use the updated value of Price et al (2014), without any further concerns.

Once the first component of the personal-income-tax and social-contribution elasticities relative to their common base –i.e. private wages and salaries (PRW) - was available, the next step was to calculate the one of PRW with respect to output. This has been done by econometric estimation. The initial series of PRW and GDP were first transformed into logarithms –and, the logarithm of PRW was also expressed in real terms (RPRW) by subtracting the logarithm of the GDP deflator- and then tested for stationarity, by using the Elliott-Rothenberg-Stock (ERS) test. Since they were found to be non-stationary, they were both first-differenced, a transformation that yielded the desired stationarity property.[34,35]

An important aspect has been to determine the correct number of lags that should be included in the regression, by using one of the lag-order selection criteria. A maximum number of four lags of the first-differenced logarithm of GDP has been added in the different regressions, and the latter have been run again, after also adding one lead of the same variable.[36] Since both series were random walks with drift in levels, a constant term has been included in all regressions. Last

[32] With Blanchard & Perotti (2002), Perotti (2004), Giordano et al (2007) and Coutinho Pereira & Wemans (2013) among others.

[33] In particular, they also take employers' contributions into account, apart from employees' contributions, when calculating the aforementioned elasticity.

[34] As mentioned also in **Section 5**, the reader should refer to **Appendix B. The Data, Seasonal Adjustment and Pretesting** for more details on the unit-root pretesting process followed in this paper.

[35] The transformation in differences between period t and period t-4 could not be used here, since the definition of the *within-quarter* elasticity takes into account the changes *within a quarter* of a pair of given variables.

[36] I also tested whether a lead of the logarithm of GDP should be included in the elasticity regressions, since Perotti (2004) does include it in the relative regressions.

but not least, to account for arbitrary forms of heteroscedasticity, I have used Huber-White standard errors.[37] The GC dummy already described in **subsection 6.1**, along with two lags was initially also included in the regressions, in order to control for the Greek Crisis. One would think that the behaviour of the elasticity of wages with respect to GDP might change after the introduction of the first labour reforms deemed necessary by the EAP, and this might bias the coefficient of interest. The optimum number of lags has been selected based on Schwarz's Bayesian Information Criterion (SBIC).As presented in ***Table 9*** below, the smallest value for SBIC was obtained after running the 1-lag-0-lead model, and therefore the latter was deemed to be the most suitable one to model the elasticity of interest:

Number of lags/leads	SBIC
0 lags - 0 leads	-238.3437
0 lags - 1 lead	-232.8569
1 lag - 0 leads	-238.6922
1 lag - 1 lead	-231.9095
2 lags - 0 leads	-231.0059
2 lags - 1 lead	-224.5357
3 lags - 0 leads	-221.6448
3 lags - 1 lead	-214.9081
4 lags - 0 leads	-213.7723
4 lags - 1 lead	-206.7949

Table 9 - RPRW on GDP, Lag Selection, SBIC Results
Source: Author's own calculations.

Girouard & Andrè (2005) and Price et al (2014) also add an AR(1) term to the residual series of the regression in first differences, in order to correct for the presence of serial correlation in the residuals. If present, this type of correlation should be accounted for and the appropriate number of AR-terms should be included in a given regression. Otherwise, the model would be misspecified, since some explanatory variables –and in particular correlated with the included ones- would have been omitted.[38] I have formally tested whether an (or more) AR-term(s) was (were) to be preferred, by, once again, calculating the SBIC after each regression. This time, though, the regressions run have been of the type ARIMA (p,0,0), with first-differenced log-real wages as the dependent variable and current and lagged first-differenced log-GDP as the dependent variables (again, in first-differences), and with the AR(p)-term being added to the

[37] In fact, the Newey-West (or, heteroscedasticity and autocorrelation consistent – HAC) standard errors would be preferred in a time-series context and when combined with non-strictly exogenous regressors, as are the lags of GDP in this case. However, the option ***newey*** in *Stata* does not store the maximum-likelihood information necessary for the calculation of the information criteria. Therefore, Huber-White (or, heteroscedasticity-consistent) standard errors were used instead. As a final point, it should be noted that the selection of standard errors was not very crucial at this stage, since the values of the information criteria do not get affected by it.
[38] Wooldridge (2009) presents the importance of a correctly dynamically-specified model in a time-series context in Chapter 12.

residuals. As in the previous regressions, a constant term has been added and robust standard errors have been used. The maximum number of lags tested for the AR-term has been two, and the results can be seen below:

AR-term	SBIC
p=0	-236.8082
p=1	-234.8975
p=2	-231.1477

Table 10 – RPRW on GDP, AR-term Determination, SBIC Results
Source: Author's own calculations.

It is evident that the model giving the smallest value for SBIC has been the ARIMA(0,0,0) one, so no AR-terms have been added. Following the results obtained above, I have run an OLS regression, including a constant term and using heteroscedasticity- and autocorrelation-consistent (HAC), or Newey-West, standard errors (controlling for autocorrelation present in up to 4 lags) to obtain the following value for the real-wages-with-respect-to-GDP elasticity:

Dependent Variables	Coefficients
dGDP	0.0287
	(0.118)
L1.dGDP	0.426**
	(2.319)
GC	-0.0153
	(-1.584)
L1.GC	-0.0309***
	(-3.268)
L2.GC	0.0231***
	(3.913)
Constant	0.00110
	(0.213)
Observations	53

Table 11 - RPRW on GDP, Main Results
*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

As ***Table 11*** above reveals, the value of the elasticity is of the correct sign (i.e. an increase in GDP results in a slight increase of real private gross wages and salaries) but not statistically significant at any level, while the coefficients on lagged GDP and the two lags of the GC dummy are significant at the 5% and 1% level respectively. Due to statistical insignificance of the coefficient of interest, the elasticity of RPRW with respect to GDP has been set to zero. It is reminded that

the coefficient on the lagged GDP could not be used instead, since the elasticity in question is the *within-quarter* one, i.e. the reaction of RPRW to changes in GDP *within the same quarter*.
It is worth mentioning at this point that the introduction of the GC dummy and its two lags is the one that has caused the estimate of the elasticity to be statistically insignificant, and that the latter would have been approximately 0,31 in magnitude, if the Greek crisis had not been controlled for. However, the estimate might be biased in that case, since it would try to fit both the usual behaviour observed over the pre-crisis period and the outlier-values observed over the crisis. There has been, therefore, a trade-off between statistical significance of and potential bias in the coefficient, and I have decided to try to eradicate the latter, in expense of the former. Tagkalakis (2013), although estimating the effects of fiscal policy in Greece and for the years 2000Q1-2012Q4, has chosen not to estimate the elasticities from the data available, but to use the ones from Girouard & Andrè (2005), who estimate those elasticities over the period 1980-2003. He does not mention the reason behind this choice, but I suspect that the unusual behaviour of the coefficient when controlling for the crisis might be the one. Whatever the reason, I do not consider the elasticities estimated by Girouard & Andrè (2005) to be suitable here; given that the analysis is conducted for the sample 2001Q1-2013Q3, it is very unlikely that such elasticities would be representative of the behaviour of the sample. Price et al (2014), on the other hand, despite the fact that they estimate all elasticities over the period 1990-2013, do not seem to control for the crisis in some way either, or at least do not mention explicitly to have done so.

The value of the elasticity of self-employment income relative to output should have been set to zero, if the collection of taxes related to self-employment income were to be realised with a lag larger than a quarter. However, since this type of income is being taxed at the source in Greece, there has been no need of such an adjustment (the reader should refer to **Appendix C. The Greek Income-Tax Code**, providing a summary of the Greek tax code). Therefore, a similar procedure with the one just described above has been followed, in order to calculate this elasticity.
After ensuring that the first-differenced series for self-employment income -as proxied by GMI- exhibits the desired stationarity property, I have –as before- run OLS regressions including maximum four lags of the first difference of log-GDP and rerun them after also adding its first lead. Once again, a constant term has been added in all regressions, along with the GC dummy and its two lags, and Huber-White standard errors have been used.
The resulting values for the SBIC are presented in ***Table 12*** below:

Number of lags/leads	SBIC
0 lags - 0 leads	-219.8111
0 lags - 1 lead	-212.4226
1 lag - 0 leads	-216.0470
1 lag - 1 lead	-208.5049
2 lags - 0 leads	-206.9436
2 lags - 1 lead	-199.3851
3 lags - 0 leads	-198.6112
3 lags - 1 lead	-190.7794
4 lags - 0 leads	-189.4765
4 lags - 1 lead	-182.2430

Table 12 – GMI on GDP, Lag Selection, SBIC Results
Source: Author's own calculations.

As one may observe, the smallest value for the SBIC has been achieved under the 0-lag-0-lead model. After also testing whether one or two AR-terms should be added in the regression, I get the following results:

AR-term	SBIC
p=0	-223.7814
p=1	-225.1581
p=2	-221.7827

Table 13 – GMI on GDP, AR-term Determination, SBIC Results
Source: Author's own calculations.

It can be seen that the model chosen by SBIC is the one that includes one AR-term in the residuals. Consequently, after running the ARIMA(1,0,0) model with robust standard errors, I have obtained the results presented in ***Table 14***.

Dependent Variables	Coefficients
dGDP	0.832***
	(3.501)
GC	-0.0144
	(-1.208)
L1.GC	-0.0277
	(-1.096)
L2.GC	0.0412**
	(2.011)
ARMA (L1)	-0.480***
	(-3.467)
Constant	-0.00183
	(-0.422)
Observations	53

Table 14 – GMI on GDP, Main Results

*Note: z-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

The elasticity of self-employment income relative to output, in contrast to the one of gross wages and salaries, is robust to the inclusion of the GC dummy, of the correct sign and statistically significant at the 5% level. An 1% increase in GDP will result in an 0,83% increase in GMI. The statistically significant (at the 5% level) coefficient on the second lag of the GC dummy translates into a higher elasticity by 4,1% (100*0,041) over the period from 2010Q3 onwards when compared to the one over the period 2000Q1-2010Q2. This seems to be true when looking at basic properties of the data; the mean of first-differenced GMI before the Greek crisis is half as large in absolute value as the one after the crisis began (0,01% compared to -0,02%), whereas the mean of first-differenced GDP since 2010Q1 is relatively close in absolute value to the one over the period 2000Q1-2009Q4 (-0,018%, as opposed to 0,015%).

Since I now have the values of the elasticities of PIT and SC relative to their respective bases, as well as the ones of RPRW and GMI relative to GDP, I can calculate the "composite" values of the elasticities of PIT and SC with respect to GDP, as follows:[39]

$$\begin{aligned}\eta_{PIT,GDP} &= w_{RPRW}\cdot\eta_{PIT,RPRW}\cdot\eta_{RPRW,GDP} + w_{GMI}\cdot\eta_{PIT,GMI}\cdot\eta_{GMI,GDP} = \\ &= 0,6817\cdot 2,3\cdot 0 + 0,3183\cdot 2,14\cdot 0,832 \\ &= 0,5668\end{aligned}$$

[39] As a reminder, an explanation for the calculation of the relative weights of RPRW and GMI has been given in the previous subsection.

$$\eta_{SC,GDP} = \eta_{SC,RPRW} \cdot \eta_{RPRW,GDP} = 0,84 \cdot 0 = 0$$

The next elasticities that had to be calculated were the ones of corporate taxes with respect to gross operating surplus and of the latter with respect to GDP. However, since corporate income taxes in Greece are levied on the profits of the previous tax year and are also collected with a lag longer than a quarter (please refer to **Appendix C. The Greek Income-Tax Code** for a brief overview of the Greek Income-Tax Code), it has been decided to set this elasticity to 0.[40]
Therefore, the elasticity of corporate-income tax with respect to output is:

$$\eta_{CIT,GDP} = \eta_{CIT,GOS} \cdot \eta_{GOS,GDP} = 0$$

Turning to indirect taxes, one can only think of them as being progressive in kind and proportional to consumption –i.e. their base- and, in turn, consumption can only be thought of as being proportional to GDP. This results to both components of the indirect-tax-to-output elasticity being set equal to one, an assumption that has been widely used in the literature.[41] In fact, Price et al (2014) have investigated the existence of evidence that might be contradictory to this assumption, but have eventually concluded that the unitary-elasticity assumption should not be dropped. In particular, their estimate for Greece is equal to 0.81, but they apply an elasticity equal to 1 instead. I, therefore, decided to keep this assumption and not estimate either of the two elasticity components econometrically.
Therefore, I obtain:

$$\eta_{INDT,GDP} = \eta_{INDT,CONS} \cdot \eta_{CONS,GDP} = 1$$

The last elasticities that would normally have to be calculated were the ones of UNEMB and INCB with respect to GDP, since these are the only components of government expenditure showing cyclical behaviour. However, taking into account the fact that the definition used for government revenue includes no transfers other than other current transfers (which are considered to be acyclical), there has been no need of such an estimation.

The assumed and estimated elasticities used in this paper can, therefore, be summarised in the following table (***Table 15***):

[40] In this, I follow Perotti (2004). He also set the corporate-income tax elasticities with respect to output equal to zero, for all countries collecting this tax with a lag longer than a quarter.
[41] Blanchard & Perotti (2002), Coutinho Pereira & Wemans 2013) and Girouard & Andrè (2005) are among those.

Output Elasticity Label		Elasticity Value
$\eta_{PIT,RPRW}$	**(1)**	2,30
$\eta_{PIT,GMI}$	**(2)**	2,14
$\eta_{SC,RPRW}$	**(3)**	0,84
$\eta_{RPRW,GDP}$	**(4)**	0,0
$\eta_{GMI,GDP}$	**(5)**	0,832
$\eta_{PIT,GDP}$ *Derived as: 0.6817 × **(1)** × **(4)** + 0.3183 × **(2)** × **(5)***	**(6)**	0,5668
$\eta_{SC,GDP}$ *Derived as: **(3)** × **(4)***	**(7)**	0
$\eta_{CIT,GDP}$	**(8)**	Set to 0
$\eta_{INDT,CONS}$	**(9)**	Set to 1
$\eta_{CONS,GDP}$	**(10)**	Set to 1
$\eta_{INDT,GDP}$ *Derived as: **(9)** × **(10)***	**(11)**	1

Table 15 – Assumed and Estimated Elasticities
Source: Author's own calculations.

Since all necessary elasticities have been obtained, I can now calculate the overall within-quarter elasticity of tax revenue with respect to output. Blanchard & Perotti (2002) define this as the weighted sum of the elasticities of all tax components with respect to output. This means that the elasticity of each tax component relative to output is multiplied/weighed by each tax component's share to total tax revenue. Therefore, if we have j tax components -defined as $T_1, T_2, ..., T_j$- constituting total tax revenue -defined as T-, and each one of them being characterised by a certain elasticity relative to output -defined as $\eta_{T_1,GDP}, \eta_{T_2,GDP}, ..., \eta_{T_j,GDP}$-, then the output elasticity of total tax revenue will be given by:

$$\eta_T = \sum_{i=1}^{j} \eta_{T_i,GDP} \frac{T_i}{T} \tag{6.19}$$

This elasticity is time-varying, since the weights of the different tax components with respect to tax revenue also vary across quarters.

In the context of our paper, and in accordance with the definition of net current (government) revenue (NCR) used here, it is given by:

$$\eta_{NCR,GDP} = w_{PIT,NCR} \cdot \eta_{PIT,GDP} + w_{SC,NCR} \cdot \eta_{SC,GDP} + w_{CIT,NCR} \cdot \eta_{CIT,GDP} + w_{INDT,NCR} \cdot \eta_{INDT,GDP} + w_{NONCYCL,NCR} \cdot \eta_{NONCYCL,GDP} \quad (6.20)$$

where NCR stands for net current (government revenue) net of current transfers, PIT is personal income tax, SC are social contributions, CIT is corporate income tax, INDT are indirect taxes, and NONCYCL is the non-cyclical component of NCR. The scalars $w_{PIT,GR}$, $w_{SC,GR}$, $w_{CIT,GR}$, $w_{INDT,GR}$, and $w_{NONCYCL,GR}$ are the weights of the different NCR-components just mentioned above and vary over time, since both the series for NCR, as well as for all its subcomponents take a different value and, thus, result in a different composition of NCR in each quarter.

Of course, the elasticity of the non-cyclical component –as its own name implies- relative to GDP is zero. However, I intentionally included it in the equation above, because I was of the opinion that it would illustrate better the next step in the calculations, which has been the definition of the different tax-component weights. As the equation under consideration suggests, each weight has been defined as the ratio of each tax-component to net current revenue and varies over time, since the relative importance of each component changes from quarter to quarter.

For illustrative purposes, I have decided to report the averages of the relative weights in ***Table 16***, so that I may point out some useful remarks:

Name of weight	Sample-average value
$w_{PIT,GR}$	0.1401
$w_{SC,GR}$	0.3544
$w_{CIT,GR}$	0.0886
$w_{INDT,GR}$	0.3352
$w_{NONCYCL,GR}$	0.0816

Table 16 – Weights of Tax Elasticity, Sample Averages
Source: Author's own calculations.

Firstly, if one sums the weights reported above, one gets 0,9998, i.e. approximately 1. This is, and should be, the case in every quarter; as the sum of the different components gives NCR, so the sum of their weights should give 100% of NCR. Furthermore, the condition just described above may not be fulfilled, when the seasonal adjustment is conducted at the aggregate level of the series (direct seasonal adjustment), as is the case here. The reason for that, is that the sum of the individually seasonally-adjusted series is not equal with the seasonally-adjusted series of the sum.

Indeed, there has been need to correct the weights of the NCR subcomponents, by using a loop that allocates the difference between the sum of the weights and unity to the different weights, according to their relative importance.

Despite its time-variation, the elasticity of total current government revenue with respect to GDP incorporated in the model is the value captured by the sample-average. This makes sense, if one takes into account the fact that only one value of the elasticity of interest is used in the matrix connecting the reduced-form to the structural-form residuals in the form of an identification restriction –as mentioned already in **Subsection 6.2** -.
Having in my disposal all the values necessary, I can now calculate the sample-average value of the elasticity of GR with respect to GDP, as:

$$\eta_{NCR,GDP} = mean(w_{PIT,NCR} \cdot \eta_{PIT,GDP} + w_{SC,NCR} \cdot \eta_{SC,GDP} + w_{CIT,NCR} \cdot \eta_{CIT,GDP} + w_{INDT,NCR} \cdot \eta_{INDT,GDP} + w_{NONCYCL,NCR} \cdot \eta_{NONCYCL,GDP}) \quad (6.21)$$
$$=0,4146$$

However, the elasticity of NCR relative to output is not the only one needed for the model's fiscal-shock identification purposes; I also incorporate other fiscal variables in the model, and in particular government expenditure (GE), government spending on goods and services (GSGS) and public wages (PW). Therefore, I also need to estimate or define the elasticity of each of these variables with respect to GDP. This procedure is quite standard in the literature: despite the differences in the values of the elasticity of GR relative to GDP across papers, all authors adopt the assumption that GE, GSGS and PW have zero elasticities with respect to output and are, thus, acyclical. This is the case because, in the way these three variables are defined, they do not contain any transfers. As Giordano et al (2007, p. 732) argue, "[t]he length of the procedures governing most payments simply exclude the possibility that a change in real GDP affects direct expenditure in the same quarter, either via automatic rules or via discretionary actions". Transfers, as already mentioned earlier in this section, are considered to be the only component of government expenditure exhibiting cyclical behaviour. This assumption is not only accepted by researchers implementing the Blanchard & Perotti (2002) approach, but also by researchers calculating elasticities for other purposes, as for instance do the Working Papers produced by OECD.[42, 43]

[42] An application where government expenditure and revenue elasticities with respect to GDP are used is, for instance, the budget surveillance pursued by the European Commission under the Stability and Growth Pact.

As a final contribution of this subsection to the description of the analytical framework used in this paper, ***Table 17*** summarises the elasticities of all fiscal variables with respect to output:

Elasticity	Value
$\eta_{NCR,GDP}$	Sample average value of 0,4146
$\eta_{GE,GDP}$	Set to 0
$\eta_{GSGS,GDP}$	Set to 0
$\eta_{PW,GDP}$	Set to 0

Table 17 – Output Elasticities of Fiscal Variables
Source: Author's own calculations.

Having outlined the process behind the determination of the parameters $\eta_{GE,GDP}$ and $\eta_{NCR,GDP}$, I can now present the final form of the structural system, before this is solved by *Stata*. It should be pointed out that matrices with the same identifying restrictions map the reduced-form residuals into the structural-form ones in all specifications:

$$\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & -0,4146 \\ -\kappa_{31} & -\kappa_{32} & 1 \end{bmatrix} e_t = \begin{bmatrix} \lambda_{11} & 0 & 0 \\ \lambda_{21} & \lambda_{22} & 0 \\ 0 & 0 & \lambda_{33} \end{bmatrix} \varepsilon_t$$

I now proceed by comparing the different identification restrictions imposed in the model implemented in this paper, to the ones imposed by other authors using the Blanchard & Perotti approach as the means to identify fiscal shocks.

7. Results

The coefficients obtained, after running the first specification of the reduced-form VAR, are presented and commented in the following pages. As for the rest, they are only briefly commented in the text, and may be found in **Appendix D. Reduced-Form-VAR Coefficients – VAR2-VAR9**. It should be reminded, though, that within the reduced-form-VAR context, these coefficients cannot have an economic interpretation and can, thus, only be described as **correlations** between the different variables.

[43] These have already been mentioned earlier, but are once again summarised here: Giorno et al (2009), van den Noord (2000), Girouard & Andrè (2005) and Price et al (2014) all calculate elasticities of government expenditure and revenue with respect to GDP.

Coefficients	Equation dRGE	dRNCR	dRGDP
L1.dRGE	0.157	0.132	0.0341
	(1.201)	(1.232)	(0.788)
L1.dRNCR	-0.108	0.241	-0.108*
	(-0.588)	(1.588)	(-1.776)
L1.dRGDP	0.132	0.577*	0.830***
	(0.368)	(1.953)	(6.974)
dU	-0.0727	-0.0182	-0.0448
	(-0.793)	(-0.241)	(-1.473)
GC	-0.171***	0.0393	-0.0118
	(-4.564)	(1.275)	(-0.950)
L4.GC	0.0649*	0.00128	0.0123
	(2.000)	(0.0480)	(1.145)
Constant	0.0447***	-0.0112	0.00353
	(3.211)	(-0.976)	(0.765)
Observations	50	50	50

Table 18 – VAR1 Specification, Reduced-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

In general, although a few of them are statistically significant at conventional levels of significance, the sign and magnitude of the coefficients seem to conform to common wisdom. Real government spending seems to be negatively correlated with real government revenue (with would mean that a decrease in spending might be correlated with an increase in taxes) and positively correlated with real GDP (which would mean that an increase in spending might be correlated with an increase in GDP). What is quite striking is that the coefficient that is the largest in magnitude and statistically significant at the 1% level is the one on the current value of the Greek-crisis dummy; the unfoldment of the Greek-crisis is strongly correlated with a decrease in expenditure. This is not the case for the coefficient on the fourth lag of the crisis dummy, which implies a positive correlation between the period after 2011Q1 and government expenditure. Government revenue seems to be positively related to GDP (a coefficient that is significant at the 10% level) and government spending. As for real GDP, a negative correlation seems to be in place between this variable and taxes (significant at the 10% level), while its relationship with spending appears to be positive. GDP is also significantly correlated with its first lag.

Looking at the coefficients of the other reduced-form VAR specifications –to be found in **Appendix D. Reduced-Form-VAR Coefficients – VAR2-VAR9**, all macroeconomic variables (i.e.

RGDP, RPRC and RPRI) are strongly and positively correlated with their first lag at the 1% level. Real GDP seems to be positively correlated with real public wages, and this is also the case for real private consumption (coefficient significant at the 5% level) and real private investment (not statistically significant coefficient). A positive relationship also seems to be in place between real private consumption and real government expenditure (at the 10% level), as well as between real private investment and expenditure (insignificant coefficient). Real private investment appears to be negatively correlated with real taxes.

I proceed with reporting the coefficients of interest obtained from the structural-VARs for the different specifications. ***Table 19*** refers to the first VAR-specification and is presented below, whereas **Appendix E. Reduced-Form-VAR Postestimation Tests** contains the rest.

	$\mathbf{e}_1$	$\mathbf{e}_2$	$\mathbf{e}_3$
ε_1		$\lambda_{21} = 0.0139 **$	
		(2.517)	
ε_2	$\lambda_{12} = 0$		
$\mathbf{e}_1$			$\kappa_{31} = 0.0641$
			(-1.324)
$\mathbf{e}_2$			$\kappa_{32} = 0.0334$
			(-0.560)
$\mathbf{e}_3$	$\eta_{GE,GDP} = 0$	$\eta_{NCR,GDP} = 0.4146$	

Table 19 – VAR1 Specification, Structural-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

All elements included in this table, form the B^{-1} matrix – as defined in **subsection 6.2**- that later, together with the coefficients from the reduced-form VAR, provides the base for the Structural Impulse Response Functions (SIRFs) that depict the causal relationships present among the variables. However, caution is needed when interpreting each of these coefficients individually. The element λ_{21} of the table above, is the coefficient showing the correlation between the structural disturbance term of government expenditure and the reduced-form disturbance term of tax revenue. Since it is statistically significant, it depicts a positive correlation between the two, but, given that this relationship exists between a structural- and a reduced-form disturbance term, one can only say that a structural-shock in taxes may positively affect government expenditure. No inference can be conducted on the opposite direction of the relationship (i.e. on the way that a shock in spending may affect taxes). The two elements equal to zero, i.e. $\lambda_{12} = 0$ and $\eta_{GE,GDP} = 0$ are two of the imposed identifying restrictions and account for the assumptions that

government spending comes causally first and that the output elasticity of government expenditure is zero respectively. The third imposed identifying restriction is that $\eta_{NCR,GDP} = 0.4146$ and this value represents the sample-average elasticity of taxes with respect to output, as already explained before. Finally, the items κ_{31} and κ_{32} are the coefficients showing the correlation between the reduced-form residual (or, forecast error) of GDP and the forecast errors of government spending and government revenue respectively. A positive correlation seems to be in place between a shock in the forecast errors of spending and GDP, while the same is probably true also for taxes and GDP. However, neither of the coefficients is statistically significant.

When it comes to the coefficients estimated by the other structural VAR-specifications, most of them are statistically significant and, therefore, I have only focused on the most interesting and statistically significant ones. In all three specifications containing real private investment, the same relationship becomes evident between the reduced-form residual of this variable and the one of real government revenue: a positive shock in the forecast error of taxes affects the forecast error of investment negatively and significantly (at the 1% level). As for real private consumption, its forecast error is positively affected by a shock in the reduced-form residual of real public wages and negatively affected by a shock in the residual of real government spending on goods and services (parameters significant at the 5% level).

Since the coefficients presented so far do not (and should not) have a causal interpretation, and as a further step towards the attempt to identify and further understand possible macroeconomic effects of fiscal policy shocks in Greece, the Structural Impulse Response Functions (SIRFs) are presented (see **Appendix G. The Logic behind IRFs and SIRFs** for a brief overview of this tool). I use either RGE -or one of its components- or RNCR as an impulse variable, and RGDP, RPRC, RPRI, RNCR (where applicable) and RGE -or one of its components- (where applicable) as response variables. The SIRFs showing the response of RNCR, RGE, RGSGS and RPW to their own shocks have been included in **Appendix H. Responses of Fiscal Variables to Own Shocks**. It is worth reminding the reader that all impulse shocks in SIRFs are unitary, in the sense that they correspond to innovations of one standard deviation.

In what follows, the SIRFs are given, grouped by each impulse variable. Therefore, four groups of such graphs have been created (i.e. Groups A, B, C, D), corresponding to the number of the fiscal variables used in this paper (i.e. RNCR, RGE, RGSGS, RPW respectively).

7.1 Dynamic Effects of a Shock in Tax Revenue

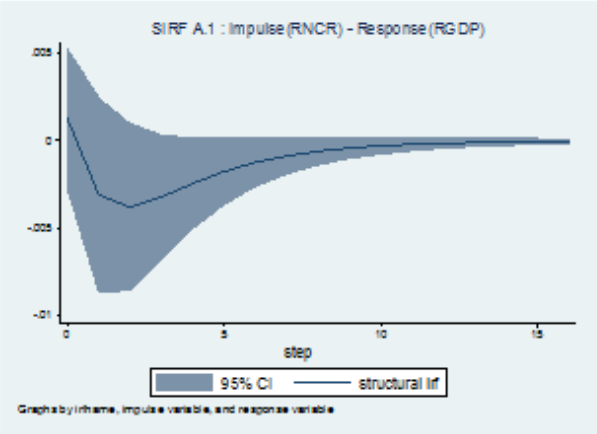

Figure 11 – Impulse: RNCR, Response: RGDP

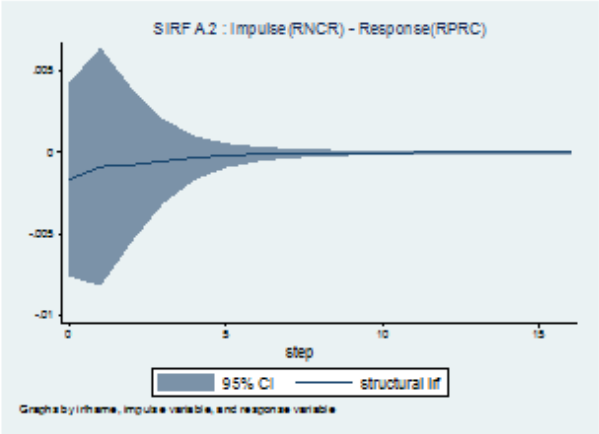

Figure 12 – Impulse: RNCR, Response: RPRC

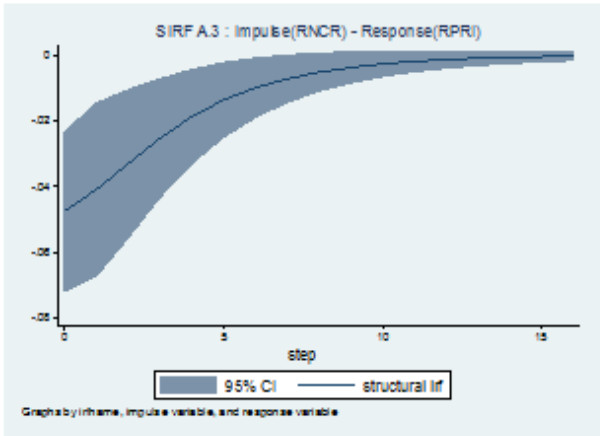

Figure 13 – Impulse: RNCR, Response: RPRI

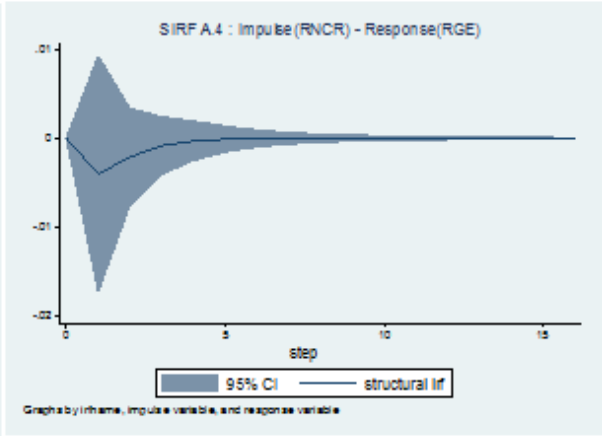

Figure 14 – Impulse: RNCR, Response: RGE

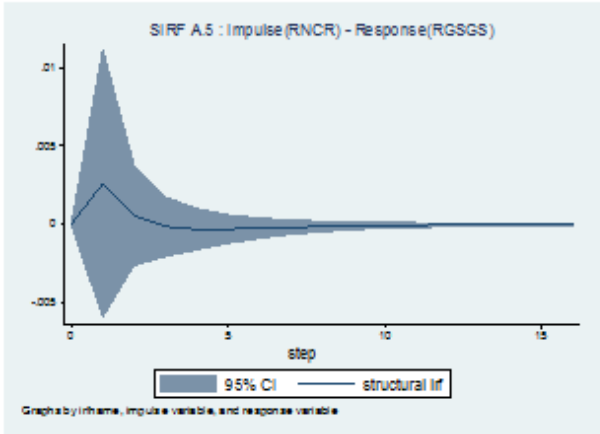

Figure 15 – Impulse: RNCR, Response: RGSGS

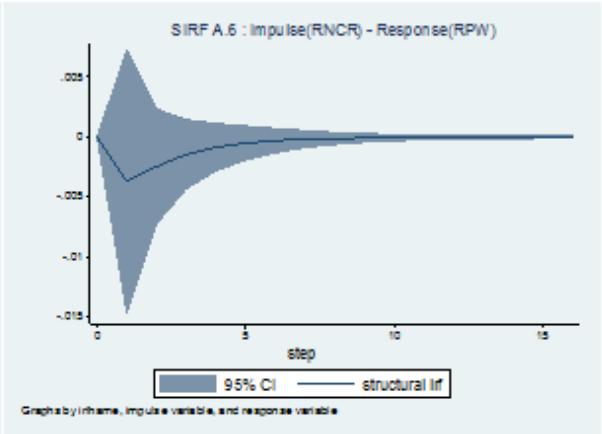

Figure 16 – Impulse: RNCR, Response: RPW

Figures 11 – 16: Group A - SIRFs, with RNCR Acting as the Impulse Variable

Note: The upper left panel shows the reaction of RGDP, while the upper right one depicts the reaction of RPRC. The two panels in the middle row illustrate the response of RPRI and RGE respectively, while the two lower ones present the response of RGSGS and RPW respectively. The response in the middle-right panel has been taken from the specification coded as VAR1, whereas the one at the middle-left has been obtained from VAR2, and the one at the middle-right from VAR3. The confidence bands have been constructed by bootstrapping the residuals using 1000 replications.

Source: Author's own calculations.

When it comes to a positive shock in tax revenue, a one-standard-deviation increase in taxes is absorbed by 100% by taxes themselves in period 0 and results in a statistically significant movement on the upper side of the SIRF (see **Appendix H. Responses of Fiscal Variables to Own Shocks**) until quarter 2. GDP absorbs approximately 3% of the shock on impact –i.e. the 0,1% increase in GDP on impact divided by the 3,8% in taxes- with a positive response, while government spending remains unchanged, following the identifying restriction already imposed, that shocks in taxes have no contemporaneous impact on revenue. In the first quarter following the shock, government expenditure decreases by 0,4%, thus reaching its trough, then demonstrates minimal further decreases until period 3, when its magnitude practically approaches zero. However, one cannot say that a positive shock in tax revenue is made more pronounced by a decrease in government expenditure in later periods, since the latter is not statistically significant at the 5% level in any period. Then again, given that neither a significant increase in spending is visible following a tax increase, one might expect to see an improved primary balance of the government, at least in the immediate short term.

Following an initial positive response, GDP decreases for the next 6 quarters after impact, reaching its trough in period 2 when it drops by approximately 0,4%. Nevertheless, this reaction is never statistically significant at the 5% level. Private consumption and investment are also negatively affected by a positive shock in taxes and, interestingly, the effect on private investment is much larger in relative magnitude and statistically significant. A one standard-deviation increase in taxes, is absorbed by 4% by consumption, which decreases by 0,17% in period 0. The effect on consumption is quite short-lived, since it almost vanishes form the third quarter onwards. The relevant share of absorption of the same shock for investment is 163% (!), which is translated in a 4,75% decrease on impact, a value that can also be seen as the trough for investment. Not only is the negative pattern observed statistically significant until the third quarter after the shock, but it is also evident until period 13 (!), when further reactions to the tax shock stop being observed.

7.2 Dynamic Effects of a Shock in Government Expenditure



Figure 17 – Impulse: RGE, Response: RGDP

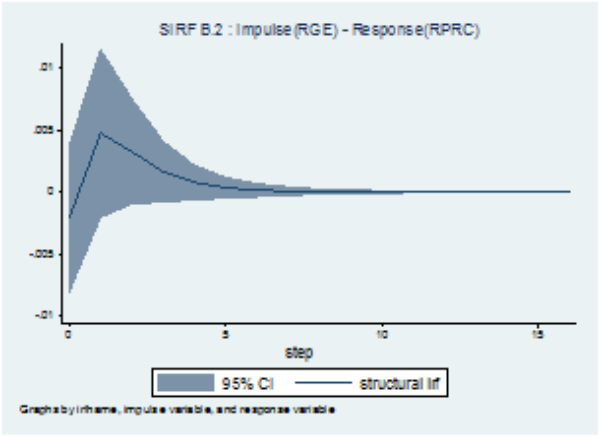

Figure 18 – Impulse: RGE, Response: RPRC

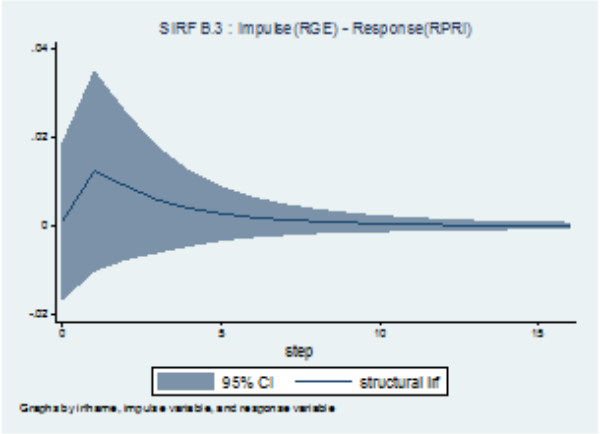

Figure 19 – Impulse: RGE, Response: RPRI

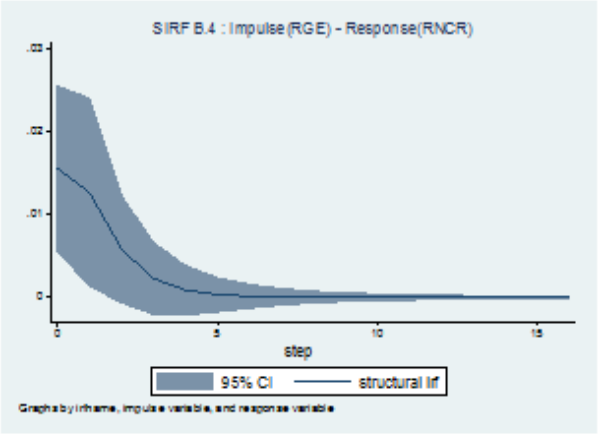

Figure 20 – Impulse: RGE, Response: RNCR

Figures 17 – 20: Group B - SIRFs, with RGE Acting as the Impulse Variable

Note: The upper left panel shows the reaction of RGDP, while the upper right one depicts the reaction of RPRC. The two panels in the middle illustrate the response of RPRI and RNCR respectively. The latter has been taken from the specification coded as VAR1. The lower panel, shows the response of RGE to its own shock. The confidence bands have been constructed by bootstrapping the residuals using 1000 replications.
Source: Author's own calculations.

As one may observe, a one-standard-deviation increase in government expenditure as a share of GDP, is absorbed by 100% by this variable's contemporaneous value in period 0, while it is absorbed by 31% -i.e. the 1,5% increase in tax revenue in period 0 divided by the 5% increase in government expenditure- by tax revenue and by 8% by GDP. All effects have a relatively short duration, since they are only evident in the first five periods after the shock (i.e. on impact and on the following four quarters). The initial increase in taxes as a result of the shock in discussion is followed by subsequent gradual decreases, however, the level of taxes remains higher than what it was before the spending shock until the fifth quarter, when it returns back to zero. Therefore, taxes move in the same direction with government expenditure in the short run when the latter increases. Given this co-movement, it is possible that the increase in spending may be partly or

fully offset by the increase in revenue, thus preventing the government's primary balance from deteriorating in the short run. It is worth mentioning, that, while the positive movement of spending (see **Appendix H. Responses of Fiscal Variables to Own Shocks**) is statistically significant at the 5% level only on impact, the response of revenue is significant both on impact and in the subsequent quarter.

Turning to GDP and its components, the effects are also relatively short-lived, since they are evident only for a maximum of 5 periods after the shock. In particular, GDP's pattern of reactions to the shock in expenditure is shorter than its own pattern after a shock in taxes. A positive shock in government expenditure has a positive effect on GDP, which remains in place until the fourth quarter following the shock, when it practically becomes equal to zero. GDP peaks on impact, with an increase of almost 0,4%, and remains virtually unchanged from quarter 4 and afterwards. However, as was also the case with a shock in taxes, none of these movements is statistically significant at the 5% level. A similar behaviour also characterizes private consumption, apart from the fact that the latter reacts to the shock in expenditure with a negative change on impact. Specifically, one standard-deviation increase in government expenditure, is absorbed by approximately 4% by private consumption on impact, which is almost half of the absorption of the shock by GDP. Turning to private investment, while its initial response to the shock is relatively small on impact, since it absorbs only 2% of the shock, investment peaks on the subsequent quarter with a positive response of 1%. Nonetheless, as has already been the case with GDP and consumption, none of the responses is statistically significant, and no movement of particularly large magnitude occurs after the fourth quarter following the initial shock.

7.3 Dynamic Effects of a Shock in Government Spending on Goods and Services

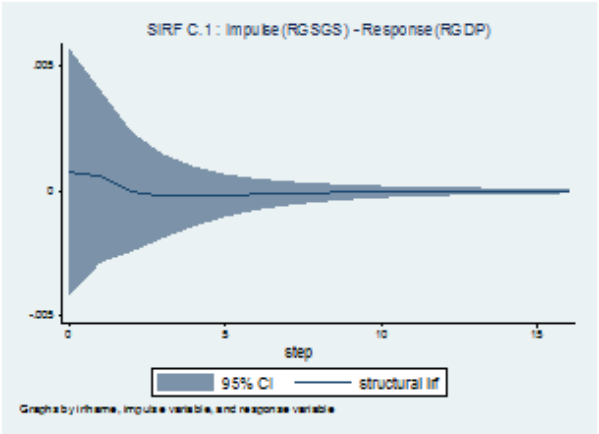

Figure 21 – Impulse: RGSGS, Response: RGDP

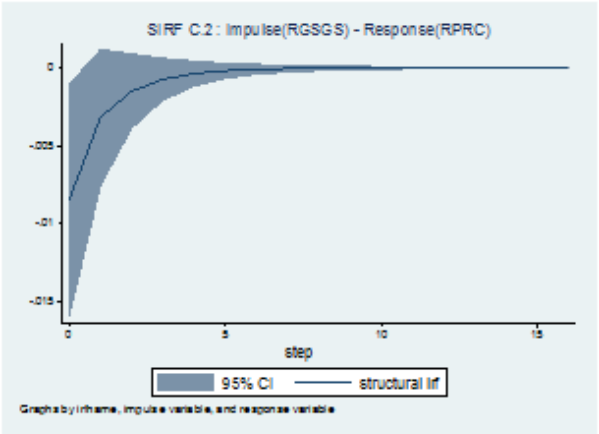

Figure 22 – Impulse: RGSGS, Response: RPRC

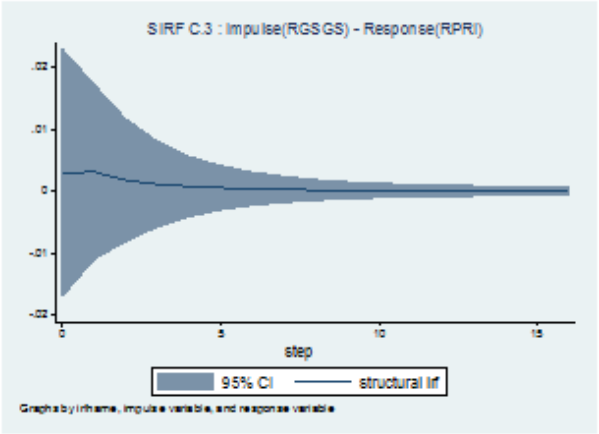

Figure 23 – Impulse: RGSGS, Response: RPRI

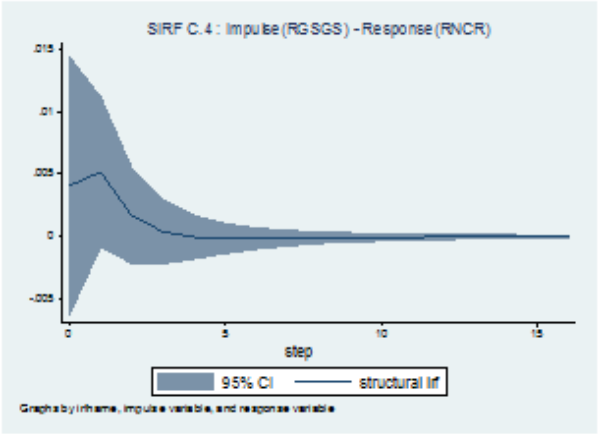

Figure 24 – Impulse: RGSGS, Response: RNCR

Figures 21 – 24: Group C - SIRFs, with RGSGS Acting as the Impulse Variable

Note: The upper left panel shows the reaction of RGDP, while the upper right one depicts the reaction of RPRC. The two panels in the middle illustrate the response of RPRI and RNCR respectively. The latter has been taken from the specification coded as VAR2. The lower panel shows the response of RGSGS to its own shock. The confidence bands have been constructed by bootstrapping the residuals using 1000 replications.
Source: Author's own calculations.

A one-standard-deviation increase in government spending on goods and services seems to have a minimal effect on GDP: it is absorbed by 1,8% by GDP in period 0, which translates into a decrease of this macroeconomic variable by 0,07%. This initial negative reaction quickly vanishes completely, since the variable practically returns to zero in the second quarter following the shock. As was the case with a shock in government spending, the reaction of GDP is not statistically significant. Surprisingly, private consumption is significantly and negatively affected by a one-standard-deviation shock in government purchases of goods and services. On impact, it absorbs 22% of the shock, a fact that results in a decrease of 0,85%. Consumption continues to decrease until the fifth quarter, but those movements cease to be statistically significant.

The reaction of investment resembles to a great extend the one of GDP: it is not statistically significant in any quarter, and the magnitude of the effect seems to be minimal. However, since investment seems to have a higher standard deviation than the other variables, it still absorbs the shock by 7,8% on impact. Finally, taxes seem to offset the increase in purchases of goods and services in period 0 and absorb 13% of the shock, although their reaction is not statistically significant.

7.4 Dynamic Effects of a Shock in Public Wages

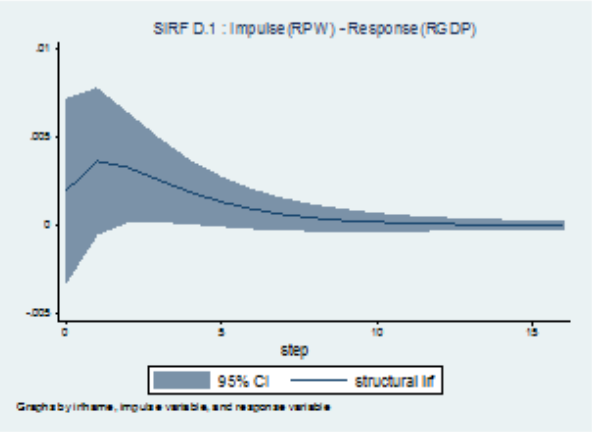

Figure 25 – Impulse: RPW, Response: RGDP

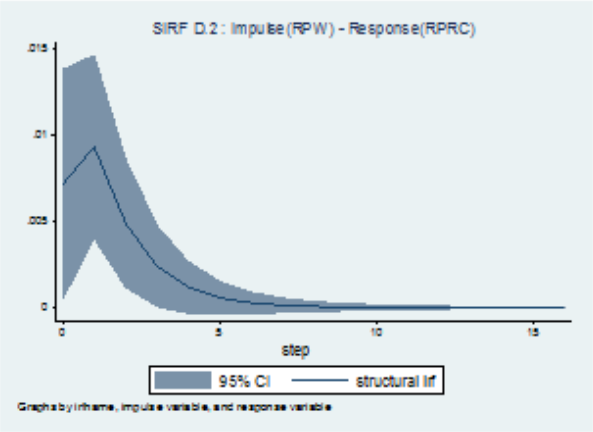

Figure 26 – Impulse: RPW, Response: RGDP

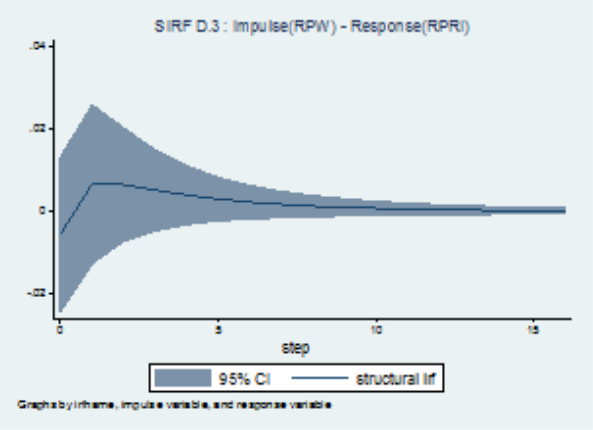

Figure 27 – Impulse: RPW, Response: RPRI

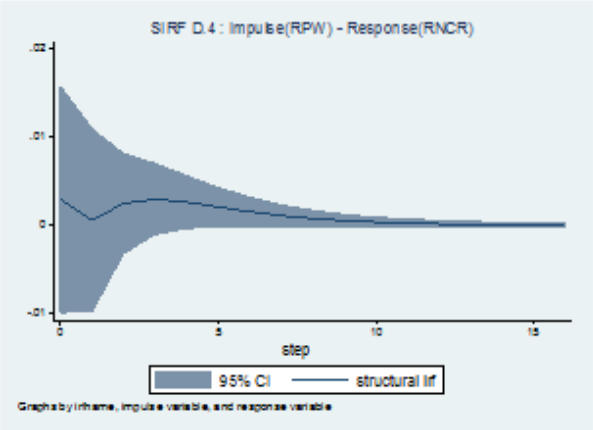

Figure 28 – Impulse: RPW, Response: RNCR

Figures 25 – 28: Group D - SIRFs, with RPW Acting as the Impulse Variable

Note: The upper left panel shows the reaction of RGDP, while the upper right one depicts the reaction of RPRC. The two panels in the middle illustrate the response of RPRI and RNCR respectively. The latter has been taken from the specification coded as VAR3. The lower panel shows the response of RPW to its own shock. The confidence bands have been constructed by bootstrapping the residuals using 1000 replications.
Source: Author's own calculations.

A positive shock in public wages positively affects all other variables in the system. Taxes initially absorb 6,6% of the shock in period 0, when they increase by 0,3%, falling back to zero in the

following quarter, but increasing again until quarter 5. Nonetheless, this reaction is not statistically significant at any stage.

Turning to GDP, 4% of the initial shock in public wages is reflected in the 0,2% increase in this variable in period 0, while the reaction just described is followed by further increases over the next 8 periods. GDP peaks in the first period following the shock, increasing by 0,36%. Once again, though, its reaction is not statistically significant.

Private consumption, on the other hand, is positively and significantly affected by a positive shock in public wages. In particular, it absorbs 15,9% of the shock in period 0, a fact that translates in a 0,7% increase in that period. It should be mentioned at this point that, at least in terms of the share of the shock being absorbed, public wages have the largest initial effect on private consumption, as would be expected. This initial increase, is followed by further increases in the following 7 quarters, but the latter are statistically significant only in the first 3 quarters after the shock.

Finally, private investment seems to initially be negatively affected by a positive shock in public wages, while it absorbs 12,7% of the shock, a fact that results in it falling by 0,56% in that period. This initial decrease in followed by increases in the next 8 periods, after which investment practically falls back to its trend. However, its reaction is not statistically significant at the 5% level.

7.5 Cumulative Multipliers

Since the SIRFs are not enough in their own right, in order to assess the extent to which positive shocks in government spending (or its components) or revenue are able to stimulate or hinge economic activity, cumulative multipliers have also been calculated and are presented below, for RGDP, RPRC and RPRI.[44] It should be pointed out that the cumulative multipliers in quarter 0 (i.e. on impact) equal impact multipliers.[45]

Before calculating the multipliers mentioned above, I rescaled all the values, so that both impulses and responses could be interpreted as changes in euros. For this purpose, and following Auerbach & Gorodnichenko (2012), I have multiplied each impulse and response variable by one-hundred (100) times its sample-average share with respect to real GDP. For instance, in

[44] Those are defined as: $\frac{Total\ change\ in\ output\ (or\ its\ components)}{Total\ change\ in\ fiscal\ variable}$.

[45] The difference between impact and cumulative multipliers is that the former take into account only changes within the reference period, while the latter take into account the sum of changes that have taken place until the reference period, including that as well.

order to rescale the response of output (denoted as $\Delta GDP_{t=0}$) in period 0 to a shock in government expenditure (denoted as $\Delta GE_{t=0}$), I have done the following calculation:[46]

$$rescaled\ \Delta GDP_{t=0} = \Delta GDP_{t=0} \cdot 100 \cdot mean\left(\frac{RGDP}{RGDP}\right)$$

The sample-average shares that have been used throughout the rescaling process are as follows:

Variable	Sample-Average Share w.r.t. RGDP (%)
RGE	75,51
RGSGS	64,86
RPW	58,01
RNCR	83,84
RGDP	100,00
RPRC	94,23
RPRI	71,03

Table 20 – Shares of Variables with Respect to GDP, Sample Averages
Source: Author's own calculations.

While cumulative multipliers usually cover quite long periods of time (to the best of my knowledge, up until 5 years after the initial shock), I only report cumulative responses for quarters 0, 1, and 4, since most of the reactions of the macroeconomic variables studied cease to be significantly different from zero in magnitude after 5 quarters:

Cumulative Multipliers of RGDP				**Cumulative Multipliers of RPRC**			**Cumulative Multipliers of RPRI**		
Impulse Variable	*On impact*	*1st Quarter*	*4th Quarter*	*On impact*	*1st Quarter*	*4th Quarter*	*On impact*	*1st Quarter*	*4th Quarter*
RGE	0,098	0,160	0,217	-0,053	0,055	0,184	0,028	0,22	0,531
RGSGS	0,030	0,051	0,033	**-0,325****	-0,421	-0,513	0,082	0,166	0,260
RPW	0,076	0,189	0,424	**0,262****	**0,517****	0,732	-0,156	0,024	0,385
RNCR	0,040	-0,045	-0,310	-0,048	-0,056	-0,085	**-1,379****	**-2,317****	-7,694

Table 21 – Cumulative Fiscal Multipliers of RGDP, RPRC, RPRI
*Note: ** denotes statistical significance at the 5% level.*
Source: Author's own calculations.

From what can be seen above, and with the exception of the tax multiplier of investment, all other multipliers seem to be significantly smaller (in absolute value) than one. However, this can only be safely concluded for the statistically significant multipliers. Turning to the latter ones, government wages have the greatest cumulative effect on private consumption: a one-euro increase in wages in period 0 results in a 0,26-euros increase in consumption, while the total increase rises to 0,51 euros in the first quarter (which means that consumption increased further

[46] It should be pointed out, however, (in order to avoid confusion with previously used notation) that the Δ operator does not stand for changes between periods t and t-4 here, but for impulses and responses.

by 0,51-0,26=0,25 euros in that period). On the other hand, a one-euro increase in government spending on goods and services decreases consumption by 0,33 euros on impact. As far as private investment is concerned, this is greatly affected by increases in taxes: a one-euro increase in taxes results in a 1,38-euros decrease in investment on impact and this decrease accumulates to 2,32 euros in the first quarter. The effect just described is by far the largest one observed in the model.

8. Robustness Analysis

8.1 Testing for Cointegration

Stemming from the fact that all series included in the analysis are integrated of order one, another important aspect one should test is the possibility of the presence of one or more cointegrating relationships. This is of special importance, in the cases where economic theory can justify their presence. When it comes to government revenue and expenditure, and their long-run relationship to macroeconomic variables –in particular, GDP-, there are two main strands of the literature that are particularly interested in cointegration-testing. The first one focuses on examining the sustainability of fiscal finances and has the Intertemporal Budget Constraint (IBC) of the government as its main relationship of interest, while the second examines whether Wagner's Law (still) holds in modern developed and developing countries.

As far as the former is concerned, it implies that there is a long-run equilibrium between government expenditure and revenue, since the government has to satisfy the IBC, which –in turn- states that the expected present value of the future differences between revenue and expenditure (primary balances) must equal each period's public debt. However, there is also evidence pointing towards the possibility that the IBC may be satisfied even in the absence of cointegration, at least under certain conditions, as argued, for instance, by Bohn (2007). When it comes to Greece in particular, there is no consensus on whether there is a cointegrating relationship between these two variables. Papadopoulos & Sidiropoulos (1999) find evidence for the presence of cointegration over the period 1961-1995, while Hondroyiannis & Papapetrou (1996) get similar results when exploring the same issue from 1957 to 1993. Nonetheless, Afonso (2005) studies the same relationship over the period 1970-2003 and presents evidence to the opposite direction, as do Leachman et al (2005), who explore this question for the years 1960-1998.

As for the latter, Wagner's Law dictates that the share of government expenditure relative to GDP increases over time, as the economy grows in terms of GDP. In other words, it implies that

economic development also causes the magnitude of government expenditure to grow. This comes as a result of the fact that the elasticity of consumption as regards public goods is greater than one, which, in turn, means that government-provided goods are considered by agents to be similar with luxury goods. Studies focusing on Wagner's Law in the context of the Greek economy over different time periods –here, we refer to Chletsos & Kollias (1997), who use data over the period 1958-1993 and Dritsakis & Adamopoulos (2004), who do their analysis for the period 1960-2001- have concluded that it either holds for specific subcomponents of government expenditure, and in particular for military expenditure (Chletsos & Kollias (1997)) or that is holds for both government expenditure in total and miscellaneous expenditure categories (Dritsakis & Adamopoulos (2004)).

In my quest to determine whether there are any cointegrating relationships connecting government revenue and expenditure, or government expenditure (including subcategories) and GDP, I have conducted several tests of cointegration. These tests have been based both on the Johansen and on the Engle-Granger methodologies for the detection of cointegrating relationships.

Starting from first to last, I have conducted Johansen tests for integration for all nine VAR specifications, and with both one and two lags of the endogenous variables included. This has been done, since the trace test has been found by Stock & Watson (1993) to be very sensitive to the number of lags included in the model. Indeed, when including only one lag, the number of detected cointegrated vectors has usually been either one or two, whereas this number has become zero for almost all cases when increasing the number of lags to two. Moreover, the test has lower power in finite samples and tends to indicate cointegration, when there is not. Johansen (2002) proposes a small-sample correction, in order to overcome this deficiency of the estimator. However, the implementation of this correction factor is very complicated. Given the fact that the number of observations at hand has been equal to 50, I have considered the trace test alone to be insufficient and have also applied the Engle-Granger testing procedure. For all nine VAR specifications, the test has pointed towards the absence of cointegration (non-stationary residuals).

Since I have found mixed and weak evidence on the presence of cointegration, I have decided not to specify the model including cointegrating vectors.

8.2 Ordering Taxes First

As already mentioned in **subsection 6.2**, Granger-causality tests have not provided a clear pattern concerning the direction of causality between government spending and government

revenue. Moreover, most of the studies exploring the issue and focusing on the Greek economy have found that there is a bi-directional causal relationship between the two variables, implying that expenditure and tax decisions are taken simultaneously. Still, an exclusion restriction has been necessary, in order for the system to be identified and I have consequently decided to put spending causally first, following many authors in the field that have already done so. However, if the SVAR specification is sensitive to the identifying restrictions imposed, a change in the causal ordering of the variables might also significantly change the results. Therefore, such a robustness check has been deemed to be necessary.

The baseline model (VAR1) has been rerun using the alternative causal ordering that taxes come first (followed by spending and output), and the resulting SIRFs can be found in **Appendix I. SIRFs from Robustness Checks**). As one may observe, their shape and magnitude has essentially remained the same.

8.3 Using the Choleski Decomposition as Identification Scheme

Using the Choleski decomposition as the identification scheme for the baseline model (VAR1), with government expenditure coming -once again- first, has been decided to serve as a third robustness check in this study. This selection has been made, given the fact that the Choleski decomposition mainly relies on the causal ordering of the variables involved and can, therefore, be thought of as a partly-automated process that sometimes hardly represents complete arguments related to economic theory.

Looking at the corresponding SIRFs (see **Appendix I. SIRFs from Robustness Checks**) one can observe that the reaction of GDP to a positive shock in government expenditure is essentially unchanged. However, a positive shock in taxes seems to have a slightly stronger effect on GDP on impact: this is marginally statistically insignificant and of larger magnitude that the one obtained from the baseline model. In addition, the negative effect evident in later periods (although statistically insignificant) seems to be underestimated, compared to the one given by the benchmark specification.

How could these differences possibly be explained? I believe that specifying the model according to the Choleski decomposition results in that an informational set of crucial importance is being missed by the system. In contrast to the Blanchard & Perotti (2002) methodology, the Choleski specification does not take into account any institutional and country-specific information on the contemporaneous elasticity of taxes with respect to GDP, a fact that is equivalent to assuming that this elasticity is equal to zero. This, in turn, would mean that the effects of fiscal policy on

the real sector of a given economy would be independent of the way the tax system has been designed; this cannot be considered to be a very realistic assumption.

9. Discussion

9.1 What Do the Results Tell Us about the Real Effects of Fiscal Policy and What Do They Not?

Taking into consideration the results that have already been presented in **section 7**, one may conclude that:

1) ***An increase in government spending on goods and services decreases consumption in the short run.*** From a theoretical perspective, this result seems to be compatible with standard neoclassical models, like the one presented in Finn (1998). In that model, an increase in government purchases (defined in a similar way with GSGS) is procyclical in general, since it results in an increase in total output. However, government consumption is not perfectly substitutable for private consumption in individuals' utility function. Therefore, individuals would consider themselves relatively poorer after observing an expanded use of private resources by the government and would increase hours worked, while decreasing their level of consumption.
2) ***In contrast, an increase in public wages leads to an increase in consumption.*** In contrast to the dynamics described before, the fact that an increase in public wages results in increased private consumption does not provide evidence in favour of the model developed by Finn (1998). In the model, an increase in government employment is countercyclical, since it reduces output, consumption and investment.[47] The mechanism is the same with the one just presented above: Increased public wages would create a negative wealth effect that would cause private consumption to fall, given that individuals would not consider the increased spending component as perfectly substitutable for private consumption in their utility.

   From a Neo-Keynesian point of view, such an increase could be possible, if the marginal utility is not independent from hours worked and, instead, increases with a rise in employment. Last but not least, the reaction of private consumption to an increase in public wages seems to also be in accordance with the Keynesian framework: the increased disposable income of the workers within the public sector means that increased consumption of these workers will be observed. This increased demand effect will

[47] The reader should take into account the fact that an increase in government wages can be either due to an increase in the wage rates themselves, or due to an increase in government employment.

eventually spill over to the rest of the economy, creating an even larger increase in private consumption. However, one cannot conclude that there is evidence supporting these two models, since the output multiplier (which would be expected to be greater than one in both models) is statistically insignificant.

3) ***Investment is negatively and significantly affected by tax increases.*** This negative impact of taxes on investment may be justified by either a model in the spirit of Alesina et al (2002), or a model in the classical Keynesian tradition. According to the first one, a decrease in investment might be a result of an increase in income taxes, or social security contributions, within both a competitive and a unionized labour market. In an economy with a competitive labour market, an increase in income taxes would mean an increase of the cost of labour relative to leisure, labour supply would decrease and real wages would increase, suppressing profits and decreasing investment. In an economy with a unionized labour market, the fall in investment would be due to the fact that employers would have to pay higher pre-tax wages, while workers would receive lower after-tax wages. However, this model also predicts that government spending affects investment to a larger extend than government revenue. This is not the case in this paper, since I have found that the tax multiplier of investment is significantly larger than the spending one. Then, a traditional Keynesian model such as the IS-LM framework could serve as an alternative interpretation of this result. Under this model, a fiscal expansion results in higher interest rates and may result in a crowding-out effect on investment.[48] In particular, the more sensitive to the interest rate investment is, the larger the crowding-out effect will be. However, this effect tends to be minimised, when an accommodative monetary policy is in place. Given the fact that the model used in this thesis does not control for an interaction between fiscal and monetary policy, I cannot conclude whether Keynesian theory is indeed the answer to the observed effect on investment.

4) ***The cumulative effect of public wages on output is larger than that of government expenditure as a whole, as well as the one of government spending on goods and services. Still, it is not statistically significant.*** While government wages positively and significantly affect consumption, no such effect is evident on output. Finn (1998) has suggested that the ability of government spending and its components to explain fluctuations in output may be constrained by the fact that their shares are too small in the economy. She finds that increasing these shares in the model, increases the effects those variables can have on output. Interestingly, government employment accounts for 8,8%

[48] One should not forget that an increase in taxes is also considered to be a fiscal expansion (since the final result is that the size of the government is bigger).

of private employment on average over the period 2000-2008, a value that is even less than the one Finn (1998) finds in her sample (18%).[49]

5) ***The model has produced inconclusive evidence on the effect of government spending on GDP and its components.***

   An increase in government expenditure seems to result in increased GDP, private consumption and private investment. Nonetheless, all relative results produced by the model are not statistically significant at any conventional level and, therefore, one cannot and should not make any conclusions on the best-suited theoretical explanation.

6) ***A crowding-out effect on private investment, as a result of increased government spending, has not been rejected or confirmed by the model.*** The effect of government spending as a whole, as well as the ones of public wages and government spending on goods and services have been statistically insignificant at all conventional levels of significance, thus, not allowing the observer to make conclusions about the theories that could best explain their interplay with private investment.

7) ***The results do not point towards a clear direction, concerning the impact of positive tax shocks on output and private consumption.*** Once again, the coefficients of the SIRFs, as well as the tax multipliers are statistically insignificant. Even if that were not the case, it would be very hard to tell which model better describes the negative effect of taxes on output and consumption, since there are versions of both Keynesian and neoclassical models supporting this course of events. Although an increase of lump-sum taxes has no effect on consumption in a neoclassical model with infinitely-living households, such an increase decreases private consumption if the agents live for a finite horizon. Furthermore, even if Ricardian equivalence holds (and, therefore, agents do not die), distortionary taxation always affects consumption negatively. Finally, within a Keynesian context, an increase in taxes may crowd-out private consumption, since it results in lower disposable incomes.

8) ***While there is no evidence supporting the existence of non-Keynesian effects, there is also no evidence against it.*** Expectations about the future conduct of fiscal policy and its impact on the public finances of a given country can alter the reaction of the macroeconomy and lead to non-Keynesian effects of spending and tax increases. As Bertola & Drazen (1993) very interestingly point out, "[…] The key characteristic of the expectations view of fiscal policy is that nonstandard effects of fiscal policy are explained by the role of current policy in shaping expectations of future policy changes. A policy

[49] Data following the NACER1 methodology was not available after that point of time, while data following the NACER2 methodology had 2008 as its starting point.

innovation that would be contractionary in a static model may be expansionary if it induces sufficiently strong expectations of future policy directions in the opposite direction". Although there is no evidence from the model supporting this standpoint, there is reason to believe that expectations about future fiscal policy might be quite important under adverse economic conditions similar to the ones experienced by Greece in the years following 2008.

9) ***There is no clear conclusion about whether the spending multiplier is greater or less than one.*** The fact that all spending multipliers calculated in this thesis are smaller than unity would normally mean that they are incompatible with Keynesian theory, and compatible with neoclassical or Neo-Keynesian (under certain specifications) theory. In specific, while in neoclassical models multipliers of small magnitude –even a negative one- are acceptable, it is hard to reconcile such values with traditional Keynesian theory: the definition of the multiplier as such, implies that the latter should have a value greater than one. However, taking into consideration the fact that almost all spending multipliers (with two exceptions) are statistically insignificant, it is impossible to draw any conclusions on this issue.

10) ***Neither can one conclude on whether the tax multiplier is smaller in magnitude than the spending multiplier.*** Although there is some evidence that spending affects output to a greater degree than taxes, at least on impact, once again those values have not been statistically significant at any conventional level and, hence, only provide some indications about the possible magnitude of the effects.

9.2 The Results Relative to the Ones of Other Studies: A Brief Comparison

When trying to compare the results to the ones of other papers studying the effects of fiscal policy on macroeconomic variables, it is possible to make the following observations:

1) ***The effects of the different fiscal variables on the macroeconomy are relatively short-lived and of low magnitude, compared to other studies.***[50] In fact, I have only observed effects that seem to be in place for only five quarters after each shock on average, and that are quite low in terms of magnitude and statistically insignificant. As far as the spending-related effects are concerned, this may be explained by the fact that all impulses of government spending and its components are not particularly persistent and wear off after the first period following the shock. On the other hand, they seem to cause

[50] It should be reminded that the results of this thesis and the ones of other papers are not directly comparable: in most of the studies, effects are reported directly in euros or in percentage points relative to GDP. In contrast, the SIRFs in this thesis report them in percentage changes, since rescaling the SIRFs has not been achieved in *Stata*. Therefore, one has to look instead at the multipliers reported.

a bit longer responses on taxes, which may partly offset the possible beneficial effect on output. Looking at the duration of results of other studies, de Castro & Hernandez de Cos (2008) observe effects that are apparent even 40 quarters (10 years) after the shock, while Blanchard & Perotti (2002) also obtain relatively long-lasting results, that do not fade away until the 12th period. Turning to magnitude, the value of the impact spending multiplier of output is about half the one found by Giordano et al (2007), while the value of the impact wages multiplier is four times less than the one reported by Coutinho Pereira & Wemans (2013). Finally, one can say that the results of this thesis are not unique, when it comes to absence of statistical significance, at least to a certain degree. Giordano et al. (2007) also report statistically insignificant effects of government spending on goods and services and of public wages on output, while Coutinho Pereira & Wemans (2013) obtain statistically insignificant impacts of taxes and of government spending on goods and services on output.

2) ***Public wages have the largest cumulative effect on output, although this is not statistically significant.*** This is in accordance with other studies. For example, this is also the case for Coutinho Pereira & Wemans (2013), who estimate a cumulative wage multiplier 20 times larger than the one of government spending on goods and services and 10 times larger than the one of government consumption as a whole. However, in contrast to the ones of this thesis, these results are statistically significant.
3) ***An increase in government expenditure and its components increases investment in the short run. This is in accordance with what some other studies have found in other EU countries.*** Among the studies that have found an increase in investment as a result of a government-spending shock in the short run are de Castro & Hernandez de Cos (2008) and Giordano et al (2007).
4) ***There has been evidence in other studies that the effects of fiscal policy on private investment can be large in magnitude.*** Investment has been recognized as an important factor that can significantly affect GDP growth. As argued by Alesina et al (2002, p. 571), "… descriptive evidence suggests that changes in private investment may explain a greater share of the response of GDP growth to large fiscal consolidations than changes in private consumption". Still, they find that the effects of government spending on investment are larger than the ones of taxes. However, I tend to think that their results are not comparable to mine, since they also detect a negative effect of government spending increase on private investment.

5) ***As for the output multipliers, the ones presented in this paper are of smaller magnitude than the ones in other studies.*** To the best of my knowledge, the majority of other studies (except for some values of Tagkalakis (2013) and Coutinho Pereira & Wemans (2013)) find output multipliers of a magnitude greater than one, which comes in contrast with what I have found here. A possible explanation for this, as already outlined before, could be that both the shocks and responses of the variables do not seem to be particularly persistent and are rather short-lived.

6) ***Although the results of this thesis and the ones of Tagkalakis (2013) are very close in terms of sign, there is a discrepancy between them in terms of magnitude and statistical significance.***

   Similarly to this thesis, Tagkalakis (2013) finds positive effects of government spending and wages on output. However, those are quite persistent in that paper, with both of them remaining in place for 12 periods after the shock. The results between the two papers seem to agree in terms of sign and persistence when it comes to the effects of positive tax shocks; output is negatively affected in both cases, and the impact is apparent for approximately 8 quarters after the shock. However, differences become evident when it comes to magnitude and statistical significance. The majority of the results presented by Tagkalakis (2013) is statistically significant, and all of them are larger in magnitude. A discussion on the possible causes of these differences takes place in **subsection 9.3**.

9.3 Why Are They Different? : Internal & External Validity of the Results

But why are the results of this thesis different to the ones of other studies? Many different factors may explain these differences, especially in the case when other countries are in focus. Nonetheless, I will abstract from a discussion concerning discrepancies with those studies and concentrate on differences with Tagkalakis (2013).

Both this thesis and the aforementioned study have tried to pin down possible effects of fiscal policy on the macroeconomy of the same country and approximately over the same time period. Moreover, the same methodology has been used (i.e. a SVAR following the methodology developed by Blanchard & Perotti (2002)), variables are almost identical in terms of their definitions and transformation before entering the model, the same number of lags has been included and the same causal-ordering restrictions have been imposed in the identification scheme (i.e. spending comes first, taxes come second and output comes last). The only differences between the two models, in terms of specification, have to do with the value of the

output elasticity of taxes, the definition of the GC dummy and the endogenous and exogenous variables included in the system. Looking at the value of the elasticity mentioned above, one can see that the value used here (0,4146) is almost half as large as the one used by Tagkalakis (0,90). However, the use of the latter was not considered to be appropriate here for a number of reasons, which have been outlined in **subsection 6.3.2**. Furthermore, as already explained in **subsection 6.1**, the GC dummy in this thesis takes the value of 1 for the first time one quarter earlier than the one defined by Tagkalakis (2013), and this has been done in order to control for the possible existence of anticipated shocks in fiscal policy. As for the endogenous and exogenous variables, unemployment is the fourth endogenous variable in the system used by Tagkalakis (2013), while it serves as an exogenous variable here. Moreover, the lagged value of the debt-to-GDP ratio is included in his analysis as exogenous, while this is not the case in this thesis. Could these differences play such a big role? Maybe, at least in other cases, but not in this one. Specifying the model exactly as the one of Tagkalakis (2013) did not provide significantly different results. In addition, the lagged value of the debt-to-GDP ratio was not statistically significant in any of the regressions and, hence, had to be dropped whatsoever, in order not to waste valuable degrees of freedom.

But then again, if the way the model has been specified is not an issue, there should be another explanation for these differences in the results. Should one try to search for alternatives, one would, most probably, think of one remaining possible explanation: discrepancies in the sources of data. This seems, indeed, to account for the variation in question. The data used in this thesis has been almost exclusively collected from the database of Eurostat, and in specific its datasets on Sectoral and Governmental Accounts (please see **section 5** and **Appendix B. The Data, Seasonal Adjustment and Pretesting** for more details), while the data in Tagkalakis (2013) comes from the International Financial Statistics database of the IMF, the OECD Economic Outlook No. 91 and the OECD Quarterly National Accounts. Normally, one would not expect to find significant discrepancies, especially among datasets that follow the same methodology (i.e. ESA1995), but this possibility cannot be excluded either. Moreover, what is special with Greek data is that most of their values are flagged as provisional.[51] In other words, their values might be subject to change, until the statistical authorities complete the reviewing process. Therefore, I suspect that the data may have been modified before the final data collection for this thesis took place and that, given the short length of the time-series, these changes have probably affected the results. I now turn to examine a bit closer the internal and external validity of the model.

[51] That was the case at the time of the final data collection for this thesis.

The quality of the data used is one of the most common problems among empirical studies, since the existence of measurement error might bias the results. Although the possibility of the existence of measurement error in the initially collected data cannot be excluded, I have conducted several reliability tests, in order to ensure that the dataset formed does not suffer from inconsistencies among the different series, either between sectors or between the transactions paid and the transactions received. Therefore, the possibility of limited reliability has been eliminated. Of course, it would have been desirable for the analysis to have been conducted using a dataset following the new ESA2010 methodology, since the quality of the data is expected to increase as new methodologies of collection and measurement are developed. Given, though, that all new series start only in 2006, it has been impossible to use them instead and, therefore, this task is left to future studies exploring the same topic.

Omitted variable bias and endogeneity have also been considered as potential issues. Although some additional variables (i.e. the long-term interest rate and the debt-to-GDP ratio) have been initially included in the model as exogenous factors, they have not affected the results significantly and have in all cases been statistically insignificant. As for endogeneity, possible prior anticipation of the fiscal policy shocks by the private sector has been controlled for by appropriately defining the GC dummy (already mentioned earlier in this section). Still, I do not think that the analysis conducted in this thesis can be considered to be completely free from these problems. The reason is that the special conditions prevalent in the monetary part of the economy (i.e. the binding Zero Lower Bound (ZLB)), as well as the extremely adverse economic conditions resulting from the severe economic and fiscal crisis that Greece has been suffering from since 2011, along with the corresponding changing expectations of the private sector, have not been taken into account explicitly and might, hence, bias the results. As far as the ZLB is concerned, it has been found to lead to increased spending multipliers (see Christiano, Eichenbaum & Rebelo (2011) for an example), since this phenomenon can be compared to an accommodative monetary policy that does not increase interest rates rapidly after a positive spending shock. However, it has been pointed out that it is almost impossible to identify exogenous fiscal policy shocks in the presence of the ZLB. In particular, as Christiano, Eichenbaum & Rebelo (2011, p. 81) argue: "To know the government spending multiplier we need to know what output would have been had government spending not risen". Turning to the recent crisis and expectations, those could be explicitly controlled for within a context resembling either the one of Perotti (1999) (i.e. threshold analysis that also allows for non-Keynesian effects) or the one of Auerbach & Gorodnichenko (2012) (i.e. regime-switching models allowing for

state-dependent multipliers). Nonetheless, I am of the opinion that this analysis might not be possible, given the small number of observations at a researcher's disposal.

Having investigated in more detail the internal validity of the results, their external validity comes next to mind. Could the conclusions drawn by the analysis conducted in this thesis be applied either to Greece but in a different time period or to economies other than Greece? Not in the least. This is because there are special characteristics that are related both to the time period and the economy in focus. As far as the time covered is concerned, one should remember that approximately one fifth of the observations in the sample (15 out of 55) have been realized after the outburst of the Greek Debt Crisis. Of course, trying to extrapolate results affected (or even biased) by the crisis, in order to interpret the effects of fiscal policy in good times cannot be considered to be appropriate. Similarly, when it comes to applying these results to a different country, one should keep in mind that a set of institutional and country-specific information has been explicitly controlled for in the model. Evidently, the design of the tax system differs from country to country and, thus, the output elasticity of wages or of taxes may also differ significantly.

9.4 Policy Implications

Identifying the theoretical background that best describes the effects of fiscal policy on output and its components is also important from a policymaking perspective: knowing the determinants of a fall or rise in output, private consumption and investment, determines the set of tools at policymakers' disposal that can be used accordingly to prevent undesirable macroeconomic fluctuations. Given that the evidence collected in this paper has been mixed and inconclusive, it is very hard to determine the trade-offs encountered in the conduct of fiscal policy. Even if that was not the case, choosing appropriate policy mixtures can be quite complicated in the case of Greece; these would have to conform both to the rules of the Maastricht Treaty and the Stability Growth Pact within the framework of the EMU, but also to the goals set by the EAP for Greece. Therefore, I will only provide some considerations about investment, since this has lately been at the centre of attention of policymakers.

But, what is special with investment? Investment, relative to its peak in 2007, had dropped by approximately 15% by the second quarter of 2014 (European Commission (2014b)). However, the drop has been more severe in some Member States than in others. It is worth mentioning that only five out of the 28 countries have accounted for 75% of this change, with the fall of

investment in Greece accounting for 9% (European Commission (2014b)). Undoubtedly, suitable macroeconomic and fiscal policies are needed, in order to help it return to its long-run trend.

This seems to be asserted by policymakers in Europe, judging from the fact that a large-scale project called "Investment Plan for Europe" was launched by the European Commission and the European Investment Bank in 2015, aiming at boosting strategic investment in small and medium sized enterprises, as well as in mid-cap firms throughout the EU. In addition, in its latest European Economic Forecast (Autumn 2015), the European Commission (2015, p. ix, 1) has stressed that "[…] Investment activity, in particular, is still lagging despite favourable financing conditions due to economic and policy uncertainty" and that "…macroeconomic policies need to continue supporting the recovery by underpinning the rotation from external to domestic demand, notably investment. This requires supportive fiscal policies in full respect of fiscal rules, combined with a more growth-friendly composition of public finances". Therefore, designing and implementing investment-friendly fiscal policy measures in Greece could undoubtedly play a unique role in stabilising the economy of the country.

10. Conclusions

In this paper, the effects of different types of fiscal policy shocks on GDP and its components in Greece, and over the period 2000-2013 have been investigated, while using the methodology developed by Blanchard & Perotti (2002) as the analytical tool. I have been particularly interested in attempting to trace the potential existence or absence of consistency between the empirical findings and certain, widely used theoretical models covering the main strands of economic thinking.

Looking at the results as a whole, one may find that these are smaller in magnitude, less persistent and of smaller statistical significance than those typically observed in papers exploring the same questions. Most notably, the reactions of output to shocks of government spending and revenue are less pronounced and smaller in magnitude than the ones previously estimated for Greece (i.e. Tagkalakis (2013)). Those discrepancies can be attributed to differences in the sources of the data, and to the possibility that the data is still being reviewed and updated accordingly by the statistical authorities.

The fact that some of the different effects of fiscal policy studied - among which are the effects of government spending and taxes on output, as well as the effects of government spending on private consumption and investment- have been found to be statistically insignificant, has prevented this paper from providing any firm conclusions concerning their properties.

Specifically, only some indications of the potential reaction of the variables involved have been observed, which do not allow one to either reject or confirm any theoretical considerations and frameworks.

As for the statistically significant results, no uniform evidence has been found on whether the reactions of the macroeconomic variables studied follow a traditional Keynesian, neoclassical or Neo-Keynesian pattern. In particular, the model has provided mixed results with respect to the different reactions of private consumption. A positive shock in government spending on goods and services negatively and significantly affects consumption in the short-run, whereas a positive shock in government wages affects it significantly and positively. While the former is consistent with neoclassical theory and certain specifications of models within the Neo-Keynesian tradition, the latter is consistent with Classical Keynesian theory and specifications of Neo-Keynesian models that are mutually exclusive with the ones just mentioned above.

When it comes to private investment, this has been found to be particularly sensitive to positive shocks in taxes (tax increases). Interestingly, a 1-euro increase in taxes results in a 1,38-euros decrease in investment on impact, which immediately translates into the presence of a significant crowding-out effect. However, it is not clear whether neoclassical or classical Keynesian theory, which are both compatible with such an effect, can better explain its existence. Still, this result is of no little importance: investment can be crucial for economic recovery and, thus, fiscal policies should not become an impediment towards its growth by involving non-investment-friendly measures.

One can, then, conclude that further in-depth research is needed, in order to illuminate important factors linking the fiscal and the real sectors of the Greek economy. The usage of data of higher quality and of availability over longer time periods would enable researchers to use more sophisticated methods requiring a large number of observations and to draw safer conclusions based on larger samples. In addition, the development of even more advanced techniques that could allow for an interaction between fiscal and monetary policies would be expected to shed even more light on this important topic.

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Appendix A. List of Main Variables

A large number of sectoral accounts was used, in order to eventually be able to define the main variables included in our analysis. A very brief description of each of them has already been given in the List of Abbreviations and Names. Therefore, I only define here –both in words and in mathematical terms- the variables included in the nine VAR specifications analysed in the main text, as well as the variables used for the derivation of the miscellaneous tax elasticities. All variables that have been included in the different VARs have been expressed in logarithms and in real terms before being used in the analysis. As for the other variables, i.e. mainly the ones used in the calculations of elasticities, all of them have been expressed in logarithms and some of them in real terms, depending on whether it is usual to do so in the literature.

Government Expenditure: It is defined as the sum of government spending on goods and services, public wages and public investment.

$$GE = GSGS + PW + PI \tag{11.1}$$

Government Spending on Goods and Services: It is the sum of intermediate consumption and social transfers in kind.

$$GSGS = P2_S13 + D6311_D63121_D63131PAY_S13 \tag{11.2}$$

Public Wages: Solely consists of the sectoral account representing the compensation of employees within the public sector.

$$PW = D1PAY_S13 \tag{11.3}$$

Public Investment: It only includes the gross fixed capital formation of general government.

$$PI = P51_S13 \tag{11.4}$$

Net Current (Government) Revenue: It is defined as the sum of net receivable taxes on production and imports, net receivable current taxes on income and wealth, receivable social contributions, market output, output for own final use and payments for other non-market output, receivable property income (net of interest payments), and net receivable current transfers. In other words, the definition used in this paper for government revenue corresponds to the one of total current revenue minus current transfers.

$$NCR = D2REC_S13 + D5REC_S13 + D61REC_S13 + P11_P12_P131_S13 + D4REC_S13 + D7REC_S13 - D29PAY_S13 - D5PAY_S13 - D7PAY_S13 \quad (11.5)$$

Private Consumption: It solely consists of the sectoral-account indicator representing the final consumption expenditure of households and of Non-Profitable Institutions Serving Households (NPISH).

$$PRC = P3_S14_S15 \quad (1.1)$$

Private Investment: It is defined as the sum of gross capital formation of financial and non-financial corporations, households and NPISH.

$$PRI = P5_S11 + P5_S12 + P5_S14_S15 \quad (11.6)$$

Greek-Crisis dummy: It is equal to unity from quarter 2010q1 onwards and captures the rising expectations in the financial markets perceiving Greece as relatively risky, as well as the effort of the Greek government to put its public finances back in order.

$$GC = \begin{cases} 1, \text{ if } t >= 2010q1 \\ 0, \text{ otherwise} \end{cases} \quad (11.7)$$

Unemployment rate: It has been defined as the ratio of the number of unemployed persons (in thousands) aged 15-64 over the number of active persons (in thousands) aged 15-64.

$$U = \frac{Unemployed(15-64)}{Active(15-64)} \quad (11.8)$$

Private Wages: It is the difference between total gross wages and salaries and gross wages and salaries within the branches of economic activity that include public administration, compulsory social security, education, human health, and social work activities.

$$PRW = D11PAY_NACER2 - D11PAY_OQ_NACER2 \quad (11.9)$$

Gross Mixed Income: It is "…the remuneration for the work carried out by the owner (or by members of his family) of an unincorporated enterprise" (Eurostat, Statistics Explained). In other

words, it can be considered to represent self-employment income. It includes the gross mixed income of households and NPISH.

$$GMI = B3G_S14_S15 \tag{11.10}$$

Gross Operating Surplus: It is the sum of gross operating surplus and mixed income of non-financial and financial corporations.[52]

$$GOS = B2_B3G_S11 + B2_B3G_S12 \tag{11.11}$$

Personal-Income Tax: It is defined as the taxes on current income, wealth etc. paid by households to the general government (net of tax returns).

$$PIT = D5PAY_S14_S15 \tag{11.12}$$

Corporate-Income Tax: It is defined as the taxes on current income, wealth etc. paid by the non-financial and financial corporations to the general government (net of tax returns).

$$CIT = D5PAY_S11 + D5PAY_S12 \tag{11.13}$$

Social Contributions: They represent the total social contributions (both by employers and employees) received by the general government.

$$SC = D61REC_S13 \tag{11.14}$$

Indirect Taxes: They are defined as the taxes on production and imports received by the general government.

$$INDT = D2REC_S13 - D29PAY_S13 \tag{11.15}$$

Non-Cyclical Component (of Government Revenue, net of transfers): It represents all the components included in our definition of GR, which have not been found to show any cyclical

[52] No data was available for only gross operating surplus or mixed income of non-financial and financial corporations. But this is absolutely natural since, according to the definition provided by the OECD, "Mixed income is the surplus or deficit accruing from production by unincorporated enterprises owned by households; it implicitly contains an element of remuneration for work done by the owner, or other members of the household, that cannot be separately identified from the return to the owner as entrepreneur but it excludes the operating surplus coming from owner-occupied dwellings." It, therefore, follows that the indicator Gross Operating Surplus and Mixed Income corresponds to Gross Operating Surplus of non-financial and financial corporations.

behaviour. These include market output, output for own final use and payments for other non-market output, receivable property income and net receivable current transfers.[53]

$$NONCYCL = P11_P12_P131_S13 + D4REC_S13 + D7REC_S13 - D7PAY_S13 \quad (11.16)$$

Appendix B. The Data, Seasonal Adjustment and Pretesting

As presented in **Section 5**, several sub-categories of Eurostat's database, as well as the ECB's Statistical Data Warehouse have been used, in order to collect the indicators necessary for the analysis. Normally, a table would be provided at this point, presenting several characteristics of every individual indicator, such as the unit in which each indicator is expressed, its timespan, as well as the specific database it has been collected from. However, given that the number of indicators retrieved is quite large, it has been decided to present the aforementioned characteristics very briefly, by grouping the indicators into categories. In the cases where only one or two indicators have been collected from a given dataset, these have been presented separately. The reader interested in understanding exactly which indicators have been collected from each dataset is urged to refer to the **List of Abbreviations**, where all indicators from each category are presented in alphabetical order and are briefly described.

[53] The reader interested in more details about the cyclical and non-cyclical components of government revenue could refer both to **section 6.3** of this paper and to Price et al (2014).

Category of Indicators (or individual indicator)	Unit	Timespan	Source	Code-name of the dataset
Sector Account Components	Millions of national currency	2000Q1-2013Q3	Eurostat, quarterly Sectoral Accounts	nasq_nf_tr
Governmental Account Components	Millions of national currency	1999Q1-2014Q1	Eurostat, quarterly Accounts of General Government	gov_q_ggnfa
GDP_DEFL	2005=100, national currency	2000Q1-2014Q2	Eurostat, quarterly National Accounts, Price Indices	namq_gdp_p
D11_NACER2	Millions of national currency	2000Q1-2014Q1	Eurostat, quarterly National Accounts by 10 branches	namq_nace10_c
D11PAY_OQ_NACER2	Millions of national currency	2000Q1-2014Q1	Eurostat, quarterly National Accounts by 10 branches	namq_nace10_c
Labour Force Survey Components	Thousands	1998Q1-2014Q2	Eurostat, Population by sex, age, nationality and labour status, LFS series	lfsq_pganws

Table 22 – Basic Data Characteristics
Source: Created by the author.

Given that none of the time series collected was seasonally adjusted at the source, I had to seasonally adjust them myself, by applying the X-13-ARIMA-SEATS method for seasonal adjustment, as implemented by the *Eviews* software package. Over the seasonal-adjustment process, I have tried to follow the criteria presented below as closely as possible. But since seasonal adjustment can be a quite complicated process, exceptions to these rules have also been occasionally made:

- First, the method is run in a default mode and potential problems are detected.
- If there is no evidence in support of the existence of seasonality, the original, non-seasonally adjusted series is used and is considered to be ex-ante seasonally adjusted.
- If no ARIMA model is automatically selected by the program, the most parsimonious model is selected instead -as long as there are no signs of misspecification-.

- The existence of residual seasonality is also checked.[54]
- Direct seasonal adjustment is preferred to indirect seasonal adjustment. That is, if a given indicator is the aggregate of two or more sub-indicators, the non-seasonally-adjusted components are first added in order to give the non-seasonally-adjusted indicator, and seasonal adjustment is conducted on the latter.

The next step while forming the dataset has been to express all variables in logarithms and in real terms. The latter transformation has been realized by subtracting the logarithm of the GDP deflator from the logarithm of each variable. I have subsequently tested for potential existence of a unit root with the Elliott-Rothenberg-Stock test (ERS). The optimum number of lags has been determined using the Schwarz's Bayesian Information Criterion (SBIC). Since the ERS test can be run with or without a trend –with the former resulting in the series being detrended in the Generalised Least Squares (GLS) regression and the latter in the series being demeaned in the GLS regression-, I have also visually inspected all series for the presence or absence of a trend. All variables have been found to be integrated of order of unity –I (1) series-. After taking year-over-year differences, all series have been again tested for the presence of a unit root by using, once again, the appropriate version of the ERS test and by determining the optimum number of lags using the SBIC. All variables have been found to still be integrated of order one, but this fact has not caused any further concerns; given that the stability condition has been fulfilled in all VARs run, convergence of the coefficients is guaranteed and inference, as well as construction of IRS:s can be conducted as usual.

Appendix C. The Greek Income-Tax Code

Wages and salaries, as well as self-employment income are taxed at the source in Greece. Every employer has the obligation to calculate the tax to be paid on a monthly basis, and subtract it from their employee's gross wages. The tax year for wage-and-salary earners, as well as pensioners and self-employed individuals coincides with the calendar year. Usually in the second quarter after the previous tax-year has been completed, all individual taxpayers are obliged to submit their income declaration to the public authority responsible. Then, if any differences between the taxes already paid at source and the total taxes to be paid occur, the taxpayer either pays or receives the difference.

Social security contributions are also levied at the source. Both the employee and the employer have to contribute a share of this tax, with the share paid by the employer being the largest- on a

[54] No residual seasonality should be present in the seasonally-adjusted series. Indeed, this is the case for all of our indicators.

monthly basis. The social contributions paid by the employee are also subtracted from his/her monthly salary.

Finally, corporate-income taxes can be considered to be proportional to profits in Greece, since a uniform tax rate of 26% is applied on the profits realised during the previous tax year. However, in contrast to the uniformity of the tax itself, each company can choose either a tax year that coincides with the calendar year –i.e. one that starts on January 1st and ends on December 31st- or a tax year that starts on the 1st of July and ends on the 31st of June. An income declaration has to be submitted by a given company within 6 months from the end of its last tax-year and the first instalment of the tax is deposited on the day of the submission.

Appendix D. Reduced-Form-VAR Coefficients – VAR2-VAR9

		Equation	
Coefficients	**dRGSGS**	**dRNCR**	**dRGDP**
L1.dRGSGS	0.0521	0.0995**	0.0101
	(1.101)	(2.034)	(0.475)
L1.dRNCR	0.0638	0.209	-0.107*
	(0.452)	(1.428)	(-1.688)
L1.dRGDP	0.0711	0.713**	0.851***
	(0.266)	(2.573)	(7.071)
dU	-1.183***	-0.0534	-0.00724
	(-19.97)	(-0.870)	(-0.272)
dRPI	-0.161**	0.00462	-0.0438
	(-2.341)	(0.0647)	(-1.414)
GC	0.0433	0.0427	-0.0128
	(1.510)	(1.441)	(-0.993)
L4.GC	0.0207	0.0144	0.0132
	(0.832)	(0.557)	(1.172)
Constant	-0.0175	-0.0185	0.00347
	(-1.623)	(-1.652)	(0.714)
Observations	50	50	50

Table 23 – VAR2 Specification, Reduced-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

Coefficients	Equation dRGE	dRNCR	dRGDP
L1.dRPW	0.142	-0.0377	0.0520
	(1.350)	(-0.384)	(1.300)
L1.dRNCR	-0.110	0.284*	-0.0956
	(-0.695)	(1.925)	(-1.587)
L1.dRGDP	0.278	0.706**	0.825***
	(0.882)	(2.409)	(6.891)
dU	-0.151**	-0.115**	-0.0113
	(-2.505)	(-2.053)	(-0.492)
dRPI	0.135*	-0.0113	-0.0467
	(1.702)	(-0.153)	(-1.541)
GC	-0.152***	0.0478	-0.00917
	(-4.529)	(1.527)	(-0.718)
L4.GC	0.0619**	-0.000329	0.0135
	(2.191)	(-0.0125)	(1.260)
Constant	0.0269**	-0.0151	0.00170
	(2.053)	(-1.239)	(0.342)
Observations	50	50	50

Table 24 – VAR3 Specification, Reduced-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

Coefficients	Equation dRGE	dRNCR	dRPRC
L1.dRGE	0.157	0.170	0.115*
	(1.198)	(1.526)	(1.844)
L1.dRNCR	-0.0736	0.309**	6.47e-05
	(-0.413)	(2.034)	(0.000758)
L1.dRPRC	-0.109	0.208	0.521***
	(-0.364)	(0.812)	(3.623)
dU	-0.0943	-0.0608	-0.0446
	(-1.081)	(-0.818)	(-1.069)
GC	-0.178***	0.0329	-0.00616
	(-4.684)	(1.019)	(-0.340)
L4.GC	0.0561*	-0.00737	-0.00528
	(1.690)	(-0.261)	(-0.333)
Constant	0.0504***	-0.00324	0.00310
	(3.720)	(-0.280)	(0.478)
Observations	50	50	50

Table 25 – VAR4 Specification, Reduced-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

Coefficients	Equation dRGE	dRNCR	dRPRI
L1.dRGE	0.165	0.162	0.279
	(1.283)	(1.505)	(1.367)
L1.dRNCR	-0.125	0.274*	-0.173
	(-0.702)	(1.839)	(-0.613)
L1.dRPRI	0.0638	0.102*	0.753***
	(0.926)	(1.777)	(6.886)
dU	-0.0580	-0.0316	-0.131
	(-0.653)	(-0.425)	(-0.926)
GC	-0.173***	0.0262	0.0148
	(-4.801)	(0.866)	(0.258)
L4.GC	0.0655**	-0.00882	0.0128
	(2.136)	(-0.343)	(0.263)
Constant	0.0469***	0.000814	-0.0101
	(4.204)	(0.0872)	(-0.571)
Observations	50	50	50

Table 26 – VAR5 Specification, Reduced-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

Coefficients	Equation dRGSGS	dRNCR	dRPRC
L1.dRGSGS	0.0511	0.120**	0.0280
	(1.032)	(2.249)	(0.856)
L1.dRNCR	0.0772	0.274*	0.00378
	(0.561)	(1.846)	(0.0417)
L1.dRPRC	-0.00668	0.418	0.500***
	(-0.0282)	(1.631)	(3.192)
dU	-1.182***	-0.0432	0.0475
	(-19.99)	(-0.677)	(1.214)
dRPI	-0.170**	-0.0390	-0.0576
	(-2.593)	(-0.553)	(-1.334)
GC	0.0408	0.0342	-0.0249
	(1.433)	(1.112)	(-1.325)
L4.GC	0.0180	0.0113	-0.00703
	(0.691)	(0.400)	(-0.407)
Constant	-0.0154	-0.0104	0.0114
	(-1.505)	(-0.944)	(1.678)
Observations	50	50	50

Table 27 – VAR6 Specification, Reduced-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

Coefficients	Equation dRGSGS	dRNCR	dRPRI
L1.dRGSGS	0.0509	0.0985*	0.0386
	(1.077)	(1.942)	(0.376)
L1.dRNCR	0.0855	0.269*	-0.118
	(0.623)	(1.828)	(-0.396)
L1.dRPRI	-0.0147	0.101*	0.751***
	(-0.282)	(1.811)	(6.643)
dU	-1.183***	-0.0331	-0.00932
	(-19.98)	(-0.521)	(-0.0724)
dRPI	-0.175**	-0.0290	-0.155
	(-2.642)	(-0.408)	(-1.075)
GC	0.0412	0.0196	-0.00842
	(1.503)	(0.666)	(-0.141)
L4.GC	0.0172	-0.00158	0.00757
	(0.729)	(-0.0622)	(0.147)
Constant	-0.0155*	9.64e-05	0.000613
	(-1.929)	(0.0112)	(0.0350)
Observations	50	50	50

Table 28 – VAR7 Specification, Reduced-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

Coefficients	Equation dRPW	dRNCR	dRPRC
L1.dRPW	0.146	-0.0175	0.142**
	(1.379)	(-0.169)	(2.513)
L1.dRNCR	-0.0786	0.379**	0.0327
	(-0.517)	(2.546)	(0.403)
L1.dRPRC	0.162	0.253	0.402***
	(0.603)	(0.966)	(2.818)
dU	-0.152**	-0.110*	0.0387
	(-2.475)	(-1.837)	(1.185)
dRPI	0.117	-0.0686	-0.0649
	(1.565)	(-0.936)	(-1.625)
GC	-0.154***	0.0364	-0.0164
	(-4.580)	(1.102)	(-0.914)
L4.GC	0.0598**	-0.0117	-0.00780
	(2.085)	(-0.418)	(-0.510)
Constant	0.0300**	-0.00376	0.00720
	(2.433)	(-0.312)	(1.096)
Observations	50	50	50

Table 29 – VAR8 Specification, Reduced-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

Coefficients	Equation dRPW	dRNCR	dRPRI
L1.dRPW	0.161	0.00576	0.252
	(1.554)	(0.0575)	(1.321)
L1.dRNCR	-0.102	0.345**	-0.0940
	(-0.665)	(2.332)	(-0.333)
L1.dRPRI	0.0640	0.0959	0.755***
	(1.064)	(1.650)	(6.807)
dU	-0.141**	-0.0936	-0.0253
	(-2.362)	(-1.620)	(-0.230)
dRPI	0.134*	-0.0450	-0.152
	(1.747)	(-0.609)	(-1.078)
GC	-0.160***	0.0279	0.0124
	(-4.955)	(0.893)	(0.208)
L4.GC	0.0584**	-0.0142	0.0152
	(2.171)	(-0.545)	(0.307)
Constant	0.0331***	0.00109	-0.0115
	(3.109)	(0.106)	(-0.588)
Observations	50	50	50

Table 30 – VAR9 Specification, Reduced-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

Appendix E. Reduced-Form-VAR Postestimation Tests

The results from the different postestimation tests run can be found in the table that follows. Such tests consist of the test for remaining serial correlation in the residual series for the whole model (i.e. the *varlmar* command in *Stata*), the test for multivariate normality (i.e. the *varnorm* command in *Stata*), the test for model-stability (i.e. the *varstabl*e command in *Stata*) and the test for the null of no remaining serial correlation for each individual residual series (i.e. the *wntestq* command in *Stata*). Wherever there is a "Passed" label, it implies that the model has passed the test at all levels of statistical significance (i.e. 1%, 5% and 10%). To the contrary, wherever exists a "Failed" label, it means that the model has failed to pass the test at least at one of the aforementioned levels. As a final remark, it should be mentioned that the failure of the first test is due to remaining serial correlation in the fourth lag, for all models. There was no remaining correlation in the other lags.

Test (Command in *Stata*)	VAR1	VAR2	VAR3	VAR4	VAR5	VAR6	VAR7	VAR8	VAR9
varlmar (max 4 lags)	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Passed	Failed
varnorm	Passed	Passed	Failed	Passed	Failed	Passed	Failed	Failed	Failed
varstable	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed	Passed
wntestq (max 4 lags)	Failed	Failed	Failed	Failed	Failed	Failed	Failed	Passed	Failed

Table 31 – Reduced-VAR Postestimation Tests, Results
Source: Author's own calculations.

Appendix F. Tables with SVAR-Coefficients, VAR2-VAR9

In the tables that follow, the coefficients of interest that have been obtained from the structural VAR-specifications coded as VAR2-VAR9 are presented. For notational convenience, and in order to maintain consistency with the table of the baseline presented in the text, the names of the different residuals have remained the same. Therefore, e_1, e_2 and e_3 stand for the reduced-form residuals of government expenditure (or one of its subcomponents), government revenue and GDP (or one of its subcomponents) respectively. As for ε_1, ε_2 and ε_3, these denote the structural-form residuals of the respective variables.

	$\mathbf{e_1}$	$\mathbf{e_2}$	$\mathbf{e_3}$
$\boldsymbol{\varepsilon_1}$		0.00374	
		(0.702)	
$\boldsymbol{\varepsilon_2}$	$\lambda_{12}=0$		
$\mathbf{e_1}$			0.0135
			(-0.219)
$\mathbf{e_2}$			0.0567
			(-0.933)
$\mathbf{e_3}$	$\eta_{GE,GDP}=0$	$\eta_{NCR,GDP}=0.4146$	

Table 32 – VAR2 Specification, Structural-VAR Results
*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

	$\mathbf{e_1}$	$\mathbf{e_2}$	$\mathbf{e_3}$
$\boldsymbol{\varepsilon_1}$		0.00212	
		(0.381)	
$\boldsymbol{\varepsilon_2}$	$\lambda_{12}=0$		
$\mathbf{e_1}$			0.0393
			(-0.765)
$\mathbf{e_2}$			0.0681
			(-1.218)
$\mathbf{e_3}$	$\eta_{GE,GDP}=0$	$\eta_{NCR,GDP}=0.4146$	

Table 33 – VAR3 Specification, Structural-VAR Results
*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

	$\mathbf{e}_1$	$\mathbf{e}_2$	$\mathbf{e}_3$
$\boldsymbol{\varepsilon}_1$		0.0174***	
		(2.966)	
$\boldsymbol{\varepsilon}_2$	$\lambda_{12} = 0$		
$\mathbf{e}_1$			-0.0289
			(0.390)
$\mathbf{e}_2$			-0.0424
			(0.474)
$\mathbf{e}_3$	$\eta_{GE,GDP} = 0$	$\eta_{NCR,GDP} = 0.4146$	

Table 34 – VAR4 Specification, Structural-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

	$\mathbf{e}_1$	$\mathbf{e}_2$	$\mathbf{e}_3$
$\boldsymbol{\varepsilon}_1$		0.0142**	
		(2.017)	
$\boldsymbol{\varepsilon}_2$	$\lambda_{12} = 0$		
$\mathbf{e}_1$			0.496
			(-1.465)
$\mathbf{e}_2$			-1.628***
			(3.113)
$\mathbf{e}_3$	$\eta_{GE,GDP} = 0$	$\eta_{NCR,GDP} = 0.4146$	

Table 35 – VAR5 Specification, Structural-VAR Results

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

	$\mathbf{e}_1$	$\mathbf{e}_2$	$\mathbf{e}_3$
$\boldsymbol{\varepsilon}_1$		0.00825	
		(1.469)	
$\boldsymbol{\varepsilon}_2$	$\lambda_{12} = 0$		
$\mathbf{e}_1$			-0.226**
			(2.566)
$\mathbf{e}_2$			0.0143
			(-0.171)
$\mathbf{e}_3$	$\eta_{GE,GDP} = 0$	$\eta_{NCR,GDP} = 0.4146$	

Table 36 – VAR6 Specification, Structural-VAR Resutls

*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

	$\mathbf{e}_1$	$\mathbf{e}_2$	$\mathbf{e}_3$
$\boldsymbol{\varepsilon}_1$		0.00394	
		(0.561)	
$\boldsymbol{\varepsilon}_2$	$\lambda_{12} = 0$		
$\mathbf{e}_1$			0.304
			(-0.716)
$\mathbf{e}_2$			-1.650***
			(3.061)
$\mathbf{e}_3$	$\eta_{GE,GDP} = 0$	$\eta_{NCR,GDP} = 0.4146$	

Table 37 – VAR7 Specification, Structural-VAR Results
*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

	$\mathbf{e}_1$	$\mathbf{e}_2$	$\mathbf{e}_3$
$\boldsymbol{\varepsilon}_1$		0.00141	
		(0.239)	
$\boldsymbol{\varepsilon}_2$	$\lambda_{12} = 0$		
$\mathbf{e}_1$			0.159**
			(-2.225)
$\mathbf{e}_2$			0.0168
			(-0.224)
$\mathbf{e}_3$	$\eta_{GE,GDP} = 0$	$\eta_{NCR,GDP} = 0.4146$	

Table 38 – VAR8 Specification, Structural-VAR Results
*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

	$\mathbf{e}_1$	$\mathbf{e}_2$	$\mathbf{e}_3$
$\boldsymbol{\varepsilon}_1$		0.00557	
		(0.783)	
$\boldsymbol{\varepsilon}_2$	$\lambda_{12} = 0$		
$\mathbf{e}_1$			-0.0246
			(0.0713)
$\mathbf{e}_2$			-1.391***
			(2.926)
$\mathbf{e}_3$	$\eta_{GE,GDP} = 0$	$\eta_{NCR,GDP} = 0.4146$	

Table 39 – VAR9 Specification, Structural-VAR Results
*Note: t-statistics in parentheses (*** denotes statistical significance at the 1% level, while ** and * imply statistical significance at the 5% and 10% levels respectively).*
Source: Author's own calculations.

Appendix G. The Logic behind IRFs and SIRFs[55]

Provided that the Reduced-Form VAR system satisfies the stationarity condition –which means that all of its eigenvalues should lie inside the unit circle -, we can transform it and write it in its Infinite Vector Moving Average form (VMA(∞)), in order to obtain the simple Impulse Response Functions (IRFs):

$$Y_t = \mu + \sum_{i=0}^{\infty} A_1^i e_{t-i} = \mu + \sum_{i=0}^{\infty} \varphi_i e_{t-i}$$

where $\varphi_i = A_1^i$, acting as impact multipliers, A_1^1 is the matrix of coefficients obtained from the reduced-form VAR estimation and μ is a mean vector.

What the IRFs estimate are the effects of a unitary shock in the innovation of one of the endogenous variables on all variables of the system. However, since the reduced-form residuals are contemporaneously correlated with one another, no causal interpretation can be exercised on these simple Impulse Response Functions. Instead, the structural-form residuals should be used in one's IRF analysis, so that one can observe how a one-standard-deviation shock in one of the residuals, affects the others, while the latter remain constant (zero). Therefore, one needs to impose identifying restrictions that depict the causal ordering among the different variables included in the model and, through which, the structural residuals are orthogonalised.

Taking into account the matrix B^{-1} (defined in **section 6**) that includes all the identifying restrictions imposed, the Structural Impulse Response Functions (SIRFs), can now be expressed as:

$$Y_t = \mu + \sum_{i=0}^{\infty} \varphi_i B^{-1} \varepsilon_{t-i}$$

It is reminded that, since the SIRFs are estimated in *Stata*, the impulses are interpreted as one-standard-deviation shocks and do not need to be rescaled any further.

The SIRFs in this paper have been calculated by bootstrapping the residuals using 1000 replications.

[55] See Sandberg (2014).

Appendix H. Responses of Fiscal Variables to Own Shocks

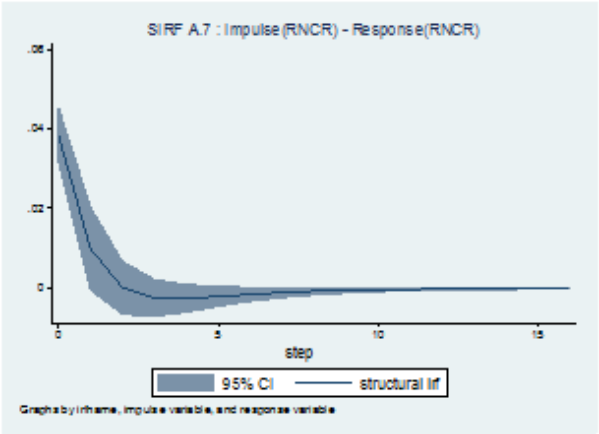

Figure 29 – Impulse: RNCR, Response: RNCR

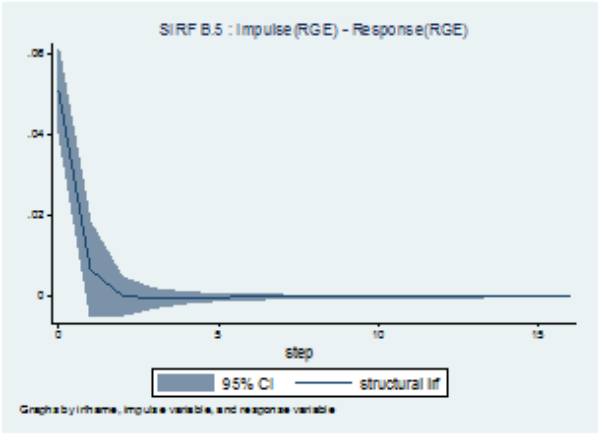

Figure 30 – Impulse: RGE, Response: RGE

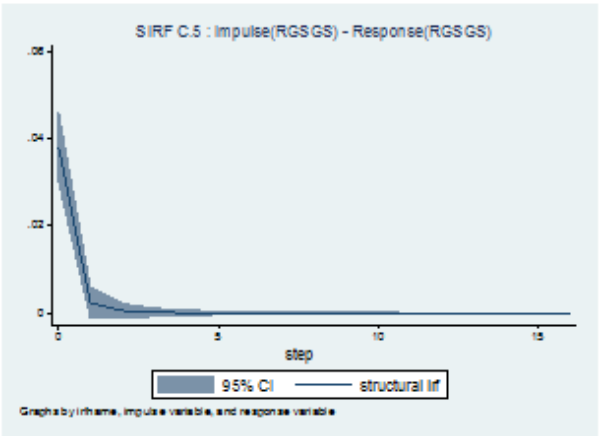

Figure 31 – Impulse: RGE, Response: RGE

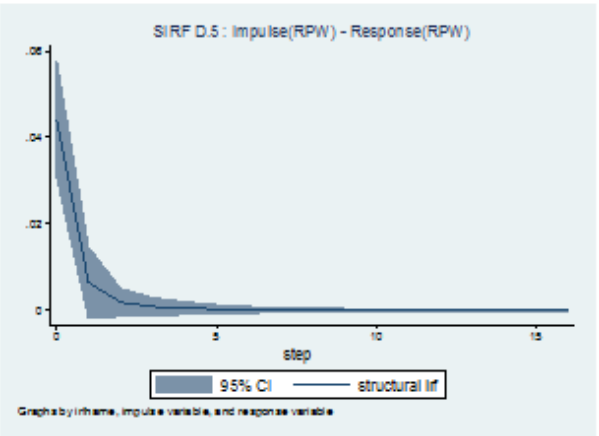

Figure 32 – Impulse: RGE, Response: RGE

Figures 29 – 32 - Responses of Fiscal Variables to Own Shocks

Note: From upper left to lower right, the panels show the reaction of RNCR, RGE, RGSGS and RPW respectively to their own shocks. The confidence bands have been constructed by bootstrapping the residuals using 1000 replications.
Source: Author's own calculations.

Appendix I. SIRFs from Robustness Checks

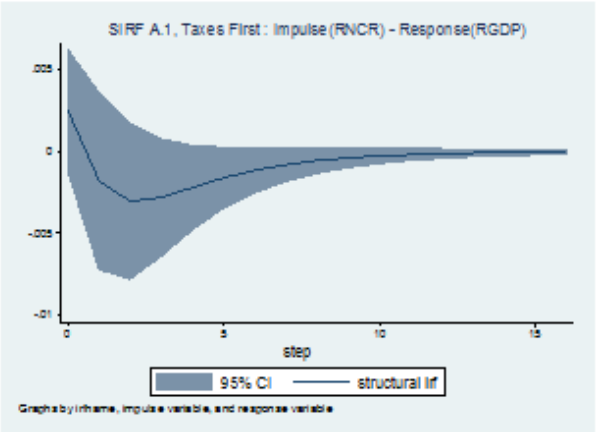

Figure 33 – Impulse: RNCR, Response: RGDP

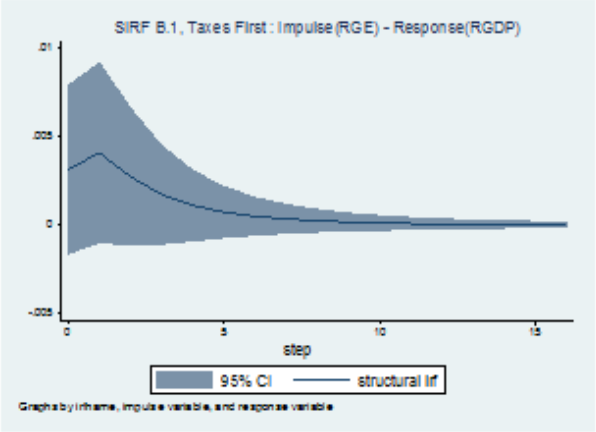

Figure 34 – Impulse: RGE, Response: RGDP

Figures 33 – 34 - Ordering Taxes First

Note: The left panel shows the reaction of RGDP to a shock in RNCR, while the right one depicts the reaction of the same variable to a shock in RGE. The confidence bands have been constructed by bootstrapping the residuals using 1000 replications.
Source: Author's own calculations.

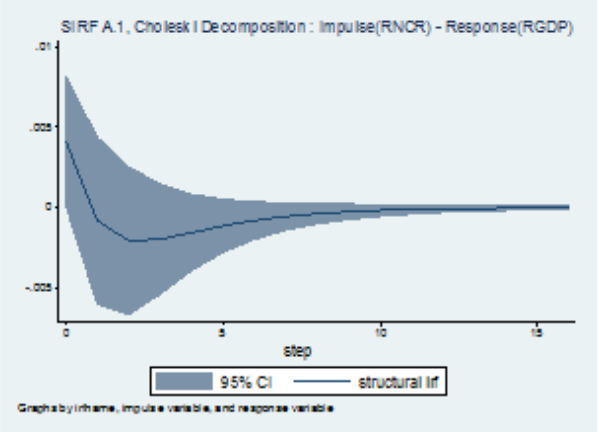

Figure 35 – Impulse: RNCR, Response: RGDP

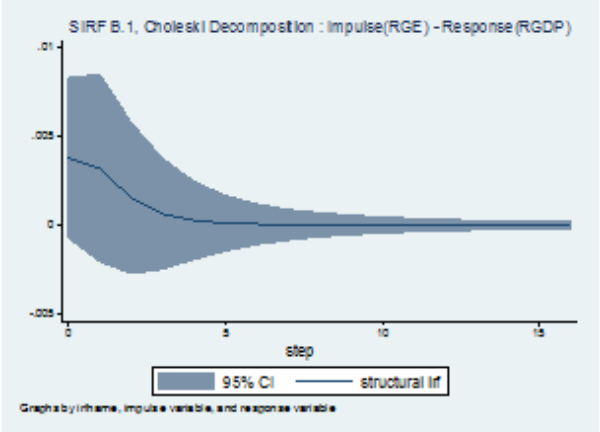

Figure 36 – Impulse: RGE, Response: RGDP

Figures 35 – 36 - Using the Choleski Decomposition as Identification Scheme

Note: The left panel shows the reaction of RGDP to a shock in RNCR, while the right one depicts the reaction of the same variable to a shock in RGE. The confidence bands have been constructed by bootstrapping the residuals using 1000 replications.
Source: Author's own calculations.