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Forecasting fiscal variables: Only a strong growth plan can sustain the Greek austerity programs- Evidence from simultaneous and structural models

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Abstract

The goal of the present paper is to investigate not only the dynamics of the Greek public debt, but also the appropriate measures required for achieving fiscal consolidation. The empirical estimation is carried out using a macroeconomic dataset spanning the period 1980-2008 and both the 3SLS methodological approach on a theoretical model and the structural VAR methodology to perform forecast tests and to calibrate the future paths of the public debt variable up to 2020. The results suggest that only an aggressive growth policy could permit the country to achieve debt sustainability. The results are expected to have important implications to policy makers for designing effective macroeconomic policy in terms of achieving sustainable levels of public debt.

Keywords

primary balance, public debt, structural modeling, Greece

JEL Classification

E62, C51, C30, E27

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ABSTRACT

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1. Introduction

Moderate levels of public debt can be good helping an economy to smooth consumption through the lifetime of individuals and across generations, and ease credit constraints faced by firms and individuals (Cecchetti et al., 2011). High levels of public debt however, can be damaging for an economy[1]. Private investment could be crowded out due to increased interest rate payments; private saving may increase in order to accommodate public dissaving leading to lower aggregate demand; and higher public debt may come at the cost of higher future taxes. High levels of public debt also increase the sensitivity of an economy to changes in global market conditions and the likelihood of defaulting (Cecchetti et al., 2011). It additionally places a strain on fiscal authorities in implementing countercyclical fiscal policy. Debt sustainability can be achieved in a number of ways including, higher future taxes (Barro, 1979) and/or curtailing government expenditure, both of which are contractionary. Another option is unanticipated high inflation which could reduce the real cost of debt servicing (Reinhart and Rogoff, 2010). These measures however, are accompanied by costs. Increasing taxes and cutting down on government spending can lead to a loss of welfare undermining growth. Similarly, reducing the cost of debt through inflation, results in higher interest rate payments (Reinhart and Rogoff, 2010).

The recent financial crisis saw an escalation in public debt levels in Greece. The increase in public debt to a height of 171% of GDP in 2011 (Eurostat 2012) led to concerns regarding Greece's fiscal sustainability. In an attempt to achieve debt sustainability, the government adopted a number of austerity measures, including public expenditure cuts and higher taxes. The country is currently caught up in a vicious cycle of austerity measures making recovery more difficult. Critics argue that

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[1] Cecchetti et al. (2011) investigating the impact of debt levels on economic growth in 18 OECD countries from 1980 to 2010, argue that debt levels beyond 85% of GDP is harmful for economic growth.

these measures are counter-productive pushing the country further into recession. Achieving fiscal sustainability within the Eurozone is a complex task due to a common monetary policy but absence of a common fiscal policy among members (Corsetti, 2012). Consequently, a common fiscal consolidation package which does not take into account country heterogeneity will not have the same outcome for all Eurozone members. The focus of policymakers hereto has been on managing systemic risk. An important implication stemming from these events is that the dynamics of public debt should be analysed on a case by case basis.

Against this backdrop, the purpose of the present paper is to examine the dynamics of the Greek public debt and investigate measures required for achieving fiscal consolidation. A macroeconomic model based on the work of Favero and Marcellino (2005), Hasko (2007), and Casadio et al. (2012) is employed for this purpose. The empirical estimation is carried out using both the three stage least squares estimation technique and a structural VAR methodology (Blanchard and Watson, 1986; Bernanke, 1986; Sims, 1986). We apply these models to perform forecast tests and to calibrate the future paths of the primary balance and public debt variables up until 2020. The results suggest that an aggressive growth policy in terms of debt and primary balance to GDP will permit the country to achieve debt sustainability. The results of this study will have important implications for designing effective macroeconomic policy for achieving sustainable levels of debt in Greece.

The rest of this paper is structured as follows. Section 2 discusses the literature. Section 3 presents the model. Section 4 describes the data, evaluates the empirical results and presents results for forecasts. Section 5 concludes.

2. The literature

Studies on fiscal adjustment include those by Favero (2002) and Marcellino (2006) for the Euro area; by Alesina and Perotti (1995), and Giannitsarou and Scott (2006) for the OECD; and by Blanchard and Perotti (2002) and Mountford and Uhlig (2002) for the U.S., among others. Favero (2002), jointly modelling the behaviour of monetary and fiscal authorities in the Euro area, concludes that fiscal stabilization was achieved independently of monetary policy. Despite interactions between the two authorities, stabilization depends to a great extent on the response of fiscal policy to interest rate payments on public debt. Similar conclusions are reached by Giannitsarou and Scott (2006) for a group of OECD economies. Examining the fiscal balance of governments using an inter-temporal budget constraint, they conclude that the primary surplus has significant explanatory power for achieving fiscal balance. Inflation plays only a very small role for the budget balance. Evidence for the fiscal balance in predicting inflation is found to be very weak. Investigating the role of monetary and fiscal policy in public debt dynamics in a group of OECD nations, Hasko (2007) on the contrary, finds that these shocks together account for approximately half the forecast error variation in the debt to GDP ratio while about 30% is explained by shocks to GDP growth. Shocks to inflation and the debt ratio itself play a very small role. However, inflation shocks play an important role in initiating a public debt problem. Examining fiscal episodes in Denmark, Ireland, Finland and Sweden, Perotti (2011) finds that in all four countries the interest rate declined, and wage reductions played an important role in fiscal adjustment.

Marcellino (2006) examines the influence of non-systematic fiscal policy in the four largest countries of the Euro area employing a structural vector autoregression (VAR) methodology. Although there is evidence of differences across countries and variation in size effects, expenditure shocks are not found in general to increase output, while tax shocks have a very small effect on output. Expenditure shocks need deficit financing, however, tax increases do not appear to require deficit financing. Increases in government consumption lead to a fall in output in all countries, while social benefits increase output. Examining fiscal changes in a group of OECD countries, Alesina and Peroti (1995) and Alesina and Ardagna (2009) argue that large fiscal increases are usually accompanied by increases in expenditure, while large fiscal adjustments are accompanied by tax increases. However, they observe a difference between fiscal adjustments that lead to permanent improvements in the fiscal balance and those that are temporary.

Blanchard and Perotti (2002) examine the dynamic effects of shocks in government expenditures and taxes on economic activity in the US during the postwar period, by using a mixed structural VAR methodology. The results indicate that positive government spending shocks have a positive effect on output, while positive tax shocks have a negative effect on output. Both, increases in taxes and government spending, are found to have a negative effect on investment spending. Similarly, Mountford and Uhlig (2002) investigate the impacts of fiscal policy shocks in the US, employing a VAR methodology. They observe that government spending shocks crowd out residential and non-residential investment, but not consumption. Deficit spending cuts lead to economic expansion and unexpected tax increases have a contractionary effect on output. According to them, the most suitable fiscal policy for stimulating the economy is a deficit-financed tax cut. Examining the role of fiscal policy in severely depressed economies, DeLong and Summers (2012) argue that government spending can be self-financing under these conditions. That is, an increase in tax revenues will finance the increase in debt service given certain assumptions hold with regard to government spending multipliers and hysteresis effects.

Using a structural VAR methodology, Giordano et al. (2007) examine the influence of fiscal policy on GDP, inflation and the rate of interest in Italy. They find that a shock to government expenditure has a positive effect on real GDP, employment, consumption and investment. There is a positive however very small effect on inflation. Also investigating the role of macroeconomic variables including US GDP growth, the price of oil, EUR/USD exchange rate, European Central Bank monetary policy stance and domestic policy instruments on the Italian debt-to-GDP ratio, Casadio et al (2012) argue that external conditions play an important role in Italian fiscal consolidation. In contrast to the VAR methodology employed by most studies, they employ the seemingly unrelated regression (SUR) estimation method.

Given the inconclusive results with regard to the influence of monetary and fiscal authorities on macroeconomic variables, a re-examination of this issue is particularly relevant in the context of Greece which was on the verge of economic collapse following the financial crisis.

3. A macroeconomic model

We follow the approach of Favero and Marcellino (2005), Hasko (2007), and Casadio *et al*. (2012) in specifying a small macroeconomic model for Greece. We start off with the evolution of public debt::

$$B_t = B_{t-1} + LR_t . B_{t-1} - PB_t \qquad (1)$$

where $B_t =$ nominal general government debt at the end of year *t*, $LR =$ the long term nominal interest rate, $PB =$ the primary balance which is equal to tax revenue less government expenditure ($T - G$), net of the interest paid on debt.[2] The budget constraint is usually expressed in terms of the growth of public debt to GDP ratio *(DEBT),* as a function of the difference between the real interest rate and output growth rate, and the ratio of the primary balance to GDP (*BAL*) (see Hasko, 2007):

$$\Delta DEBT_t = \left(LR_t - \pi_t - \Delta Y_t\right) \cdot DEBT_{t-1} - BAL_t \quad (2)$$

where $\pi =$ inflation rate, $\Delta Y =$ real GDP growth. Equation (2), which is also a debt dynamics equation, suggests that sustained GDP growth and low real interest rates are important for controlling the growth of public debt. This equation also shows that the primary balance of the government is an important determinant of government public debt.

Identity (2) can be used in empirical estimation as a single residual equation, by assuming various states for the primary balance, growth, inflation, and interest rate, in determining debt-to-GDP dynamics, or as an equation in a VAR framework taking into account the inter-dependence between these variables (Casadio et al. 2012). Here, we follow the approach of Favero (2002), Favero and Marcellino (2005), Hasko (2007), and Casadio et al. (2012) and estimate a simultaneous equations models. Our model comprises five equations:

$$\Delta Y_t = \alpha_1 + \alpha_2 \Delta Y_{t-1} + \alpha_3 (LR_{t-1} - \pi_{t-1}) + \alpha_4 BAL_{t-1} + \alpha_5 \Delta YGER_t + \alpha_6 \Delta YUS_t + \varepsilon_t^{\Delta Y} \quad (3)$$

(Output equation)

$$BAL_t = \alpha_7 + \alpha_8 BAL_{t-1} + \alpha_9 DEBT_{t-1} + \alpha_{10} \Delta Y_t + \varepsilon_t^{BAL} \quad (4)$$

(Fiscal rule)

$$DEBT_t = \alpha_{11} + \alpha_{12} DEBT_{t-1} + \alpha_{13} \Delta Y_t + \alpha_{14} BAL_{t-1} + \alpha_{15} \pi_{t-1} + \alpha_{16} LR_{t-1} + \varepsilon_t^{DEBT} \quad (5)$$

(Public debt equation)

[2] Note the same relation would hold if the variables are measured in real terms provided that the rate of inflation is measured using the GDP deflator (Casadio et al. 2012).

$$\pi_t = \alpha_{17} + \alpha_{18}\, \pi_{t-1} + \alpha_{19}\, \Delta Y_{t-1} + \alpha_{20}\, POIL_t + \varepsilon_t^{\pi} \tag{6}$$

(Inflation equation)

$$LR_t = \alpha_{21} + \alpha_{22}LR_{t-1} + \alpha_{23}\pi_{t-1} + \alpha_{24}Y_{t-1} + \alpha_{25}E_{t-1} + \varepsilon_t^{LR} \tag{7}$$

(interest rate equation)

Equation (3) is an IS curve which also incorporates the international business cycle. ΔYUS captures U.S. output growth (see Favero and Marcellino 2005), and $\Delta YGER$, German output growth. U.S. output growth is incorporated to capture the global economy, while German output growth to capture the European growth factor (as Germany is Greece's main trading partner, Dess et al., 2010). As growth in the global economy and growth in the German economy would lead to growth in Greece, we expect the coefficients, $\alpha_5 > 0$ and $\alpha_6 > 0$. (*BAL*) is the primary balance (see Hasko 2007). The coefficient on the primary balance, α_4, could be positive in the case of an expansionary fiscal policy and negative in the case of a contractionary fiscal policy. The lower the real rate of interest, the higher would be the borrowing leading to higher growth. Therefore, we would expect $\alpha_3 > 0$.

The primary balance (equation 4) is a function of the past periods primary balance to account for delayed effects of fiscal policy (Favero and Marcellino, 2005). Following Bohn (1998), growth in output and debt to GDP ratio are incorporated as right hand side variables. Bohn (1998) finds significant support for the primary surplus to be an increasing function of the debt-GDP ratio. The primary balance is a positive function of output (α_{10}>0) and the debt-to-GDP-ratio (α_9>0).

The public debt equation (5) is a function of the past value of the debt to GDP ratio, growth, inflation, the primary balance and the interest rate. Lagged levels of public debt are included to account for delayed impacts of debt on current levels (Favero and Marcellino, 2005). As cyclical variations in output influence the debt to GDP ratio we include output (Hasko, 2007; Bohn, 1998; Casadio et al., 2012). The inclusion of inflation, the primary balance and the interest rate in the debt equation is supported by Faini (2006) and Hasko (2007). We expect: α_{13}<0 and α_{14}<0. As higher inflation could lead to lower debt servicing costs (Reinhart and Rogeff, 2010) we expect α_{15}<0. Higher interest rates lead to a higher debt burden (Hnatkovska et al., 2008), therefore, α_{16}>0.

Equation (6), the Phillips curve equation, is a positive function of output, α_{19}>0, and the oil price, α_{20}>0 (see, Blanchard and Gali, 2005; Casadio et al., 2012).

Equation (7) is a backward looking Taylor rule (see Hasko, 2007) where the interest rate responds to inflation (α_{23}>0) and τo output (α_{24}>0). As changes in the exchange rate also influence the interest rate, we include the exchange rate (see Casadio et al., 2012). *E* is the Euro to US Dollar exchange rate. We expect this coefficient, α_{25}, to be positive.

4. Empirical analysis and results

4.1. Data

Quarterly data on real (at constant 2000 prices) GDP (Y), government primary balance defined as the difference between total government revenues and government spending excluding interest payments (BAL), gross public debt as a percentage of GDP (DEBT), the long-term nominal interest rate, measured as the yield on 10-year government bonds (LR), consumer prices, measured as the CPI index (P), world oil prices, measured as West Texas Intermediate-WTI crude oil spot prices in dollars (POIL), the nominal exchange rate between the euro and the dollar (E), real GDP for both the U.S. and Germany (YUS and YGER), and government expenses, measured as percentage of GDP (G). All economic data were obtained from the Eurostat database spanning the period 1980-2008. For the empirical purposes of the study, we also built the long-run real interest rate (LRR) as the difference between nominal interest rates and inflation, while inflation (π) was measured as logarithmic difference of the CPI index. Finally, the RATS software (Version 7.0) assisted the empirical analysis.

4.2. Descriptive statistics

To examine the distributional properties of the data used in the empirical part of the study, various descriptive statistics are calculated and reported in Table 1.

These descriptive statistics include mean, standard deviation, skewness, kurtosis and Jarque-Bera statistics for normality test. The null hypothesis of normality is accepted at the 1% level using the Jarque-Bera statistics. Further evidence of the nature of acceptance or rejection of normality may be gleaned from the sample skewness and kurtosis measures. The skewness measure is relatively small with a negative magnitude, while at the same time kurtosis is not large. Since kurtosis refers to excess kurtosis, a value of zero corresponds to normality. The low values of kurtosis indicate that the normality hypothesis is accepted due to the absence of excess kurtosis.

Table 1. Descriptive statistics

Variable	Mean	Max	Min	Std. Dev.	Skewness	Kurtosis	Jarque-Bera
Y	91024.4	233197.7	6106.2	73740.2	0.48	1.89	2.59(0.27)
BAL	-650.4	4131.6	-11982.0	3254.7	-0.29	1.34	4.50(0.14)
DEBT	85.9	123.6	23.6	33.7	-0.57	1.83	3.22(0.19)
LRR	5.6	9.3	1.7	2.4	0.24	1.11	2.64(0.15)
LR	9.7	17.2	3.6	4.5	0.19	1.61	2.52(0.28)
P	50.9	98.9	5.5	31.6	-0.06	1.51	2.71(0.26)
E	0.9	1.3	0.6	0.2	0.18	2.48	4.02(0.13)
G	47.0	118.0	4.1	31.5	0.20	1.39	1.69(0.43)
YUS	9252.7	13206.4	5834.0	2414.5	0.21	1.75	2.11(0.35)
YGER	3466.2	7239.2	3477.9	1283,1	0.15	1.38	2.63(0.12)
POIL	29.7	91.7	11.3	17.0	2.04	2.50	4.63(0.12)

Notes: Figures in parentheses denote probability values.

4.3. Integration analysis

We test for unit root non-stationarity by using the tests proposed by Dickey and Fuller (1981). In particular, the analysis is based on the augmented Dickey-Fuller unit root tests, the results of which are presented in Table 2. Using a 5 per cent significance level, those data clearly cannot reject the hypothesis of a unit root for all series in levels. When first differences were used, unit root non-stationarity was rejected.

However, the power of the statistical unit root test is of critical importance. Therefore, two modified Dickey-Fuller tests with good power are also applied. They are the DF-WS test, proposed by Park and Fuller (1995), which makes use of the WSLS estimator, which is more efficient then the OLS estimator in estimating autoregressive parameters and the DF-GLS test, proposed by Elliott *et al.* (1996), which analyzes the sequence of Neyman-Pearson tests of the null hypothesis of the presence of a unit root. The results are also reported in Table 1. They indicate that all the variables are integrated of order one. Finally, in order to detect any number and the dates of potential structural breaks, we recently employed a developed impulse indicator saturation technique (Hendry et al., 2008; Johansen and Nielsen, 2009; Hendry and Santos, 2010). To analyze the properties of the econometric model, this method uses zero-one impulse indicator dummies. Since there are potentially T such dummy variables, inclusion all of them in a model is not feasible. The impulse indicator dummies, however, can be included in a model as separate blocks. In the simplest case with two blocks, the sample is split in two equal parts ($T/2$), then the impulse indicator dummies are included only for the first half of the sample, and statistically significant dummies at a chosen significant level are stored. Further, chosen in the previous step, the impulse indicator dummies are dropped and another part of the dummies are included in the model. After that, the procedure is repeated for the second part of the sample. Statistically significant impulse indicator dummies from two blocks are combined and jointly significant ones are retained. A computational algorithm, utilized in the OxMetrics software, performs optimal splitting and selection of the final model for any number of blocks.

The results recommend the presence of one structural break (two different regimes) in the dynamics of the variables under study. The specific date of the structural break has been obtained by impulse indicator saturation break test and indicates the 2000Q4-2001Q1 date that occurs due to the participation of the country to the European Monetary Union (EMU) and the following changes of monetary policy.

Since the above break points has a clear-cut economic interpretation, the inclusion of the appropriate dummy, taking into account the impact of such a break in a unit root test, is not just a “fitting” of the regression; it is based on a solid economic ground. It is also important, that the break point is chosen endogenously within the impulse indicator saturation break test.

The step dummy is then included in the univariate Dickey-Fuller unit root test and it considered as an additional variable when determining the appropriate critical values and critical values are determined on the basis of Ericsson and MacKinnon (2002). The results are also reported in Table 2 and provide further support to the presence of a unit root in the levels of the variables under study and to the absence of a unit root in their first differences.

Table 2. Unit root tests

ADF Tests

	Levels		First differences	
	Without trend	With trend	Without trend	With trend
Y	-1.25(3)	-1.65(2)	-6.10(2)*	-6.43(1)*
BAL	-1.42(3)	-1.72(3)	-4.93(2)*	-5.62(2)*
DEBT	-1.39(3)	-1.83(3)	-4.91(1)*	-5.58(1)*
LRR	-1.48(3)	-1.97(3)	-5.71(2)*	-6.48(2)*
LR	-1.39(3)	-1.86(3)	-4.94(2)*	-5.62(2)*
P	-1.32(3)	-1.69(3)	-5.41(1)*	-5.81(1)*
E	-1.06(3)	-1.49(2)	-7.11(1)*	-7.38(1)*
G	-1.28(3)	-1.65(3)	-5.63(2)*	-6.11(2)*
YUS	-1.41(3)	-1.52(3)	-4.85(1)*	-5.23(2)*
YGER	-1.38(3)	-1.62(3)	-4.75(2)*	-5.16(1)*
POIL	-1.57(3)	-1.82(3)	-5.13(2)*	-5.46(2)*

DF-WS Test

	Levels-trend	First differences-trend
Y	-2.19(2)	-4.66(1)*
BAL	-0.40(3)	-4.28(2)*
DEBT	-0.92(3)	-4.24(1)*
LRR	-2.72(3)	-4.13(2)*
LR	-1.85(3)	-4.37(1)*
P	-1.69(3)	-4.62(1)*
E	-2.51(2)	-4.61(1)*
G	-2.54(3)	-4.87(2)*
YUS	-2.65(3)	-4.79(2)*
YGER	-2.11(3)	-4.88(1)*
POIL	-2.67(3)	-6.86(2)*

DF-GLS

	Levels	First differences
Y	-2.27(3)	-4.72(2)*
BAL	-0.84(2)	-4.58(2)*
DEBT	-1.13(3)	-4.38(2)*
LRR	-2.14(3)	-4.58(2)*
P	-1.52(3)	-4.77(2)*
SR	-2.06(4)	-4.72(2)*
G	-2.19(3)	-4.81(2)*
YUS	-2.53(3)	-4.61(1)*
YGER	-2.17(2)	-4.95(1)*
POIL	-2.39(3)	-5.94(1)*

ADF Test with Break

	Levels-trend	First differences-trend
Y	-2.45(3)	-4.85(2)*
BAL	-0.86(3)	-4.73(2)*
DEBT	-1.24(3)	-4.62(1)*
LRR	-2.51(3)	-4.59(1)*
LR	-1.91(3)	-4.66(1)*
P	-1.48(2)	-4.94(1)*
E	-2.14(3)	-4.84(1)*
G	-2.17(3)	-5.38(2)*
YUS	-2.44(2)	-4.95(1)*
YGER	-1.91(3)	-5.09(2)*
POIL	-2.10(2)	-7.43(1)*

Notes: Numbers in square brackets denote the optimal number of lags used in the augmentation of the test regression and were obtained through the Akaike criterion. * indicates that the unit root null hypothesis is rejected at the 5 per cent level.

4.4. Estimating the model (3)-(7)-A simultaneous system of equations

In the first step of the empirical analysis, the system of equations (3) to (7) is estimated as a system of equation using three stages least squares (3SLS), which deals with the potential endogeneity problem, while, based on our unit root tests, all variables are in first differences, while the dummy variable (DUMEMU) has been included to capture the country's participation in the EMU. Table 3 reports the results of the estimation of the system of equation (3)-(7). The empirical findings point out that all coefficients have the expected theoretical sign as it was explained above in terms of the theoretical model, while they are statistically significant. To check the statistical validity of the model we also performed a couple of diagnostic tests. In particular, LM and RESET are tests for serial correlation and model functional misspecification, respectively, while figures in brackets denote p-values.

By focusing on the two equations of interest, equations (4) and (5), the results in equation (4) show that the primary balance shows high inertia, e.g. 0.764, confirming the presence of delayed effects in terms of fiscal policy. In addition, an increase of 1% of the debt-GDP ratio, output growth and changes in the long-term interest rate leads to a 0.33%, 0.60% and 0.84%, respectively, increase in the primary balance. In terms of equation (5), a 1% increase in the primary balance, in the growth rate and in inflation leads to a 0.07%, 0.21% and 0.07%, respectively, decline in the public debt to GDP ratio. By contrast, a 1% increase in the change of the long-term interest rate leads to a 0.71% increase in the public debt to GDP ratio. Finally, the public debt to GDP ratio also displays high inertia, e.g. 0.708, confirming that higher long term interest rates tend to worsen the debt burden of the country.

Table 3. Estimations of equations (3)-(7)

Variables	Equation (3)	Equation (4)	Equation (5)	Equation (6)	Equation (7)
Constant	2.107	0.428	-1.714	2.316	0.432
	(0.38)	(0.47)	(-1.24)***	(3.68)*	(0.72)
ΔY(-1)	0.718			0.528	0.138
	(5.62)*			(5.64)*	(5.94)*
ΔLRR(-1)	0.072				
	(4.88)*				
ΔBAL(-1)	-0.614	0.781	-0.189		
	(-6.36)*	(4.83)*	(-5.38)*		
ΔYUS	0.237				
	(5.11)*				
ΔYGER	0.369				
	(6.74)*				
ΔDEBT(-1)		0.348	0.761		
		(7.24)*	(5.71)*		
ΔY		0.637	-0.265		
		(6.31)*	(-5.61)*		
π(-1)			-0.078	0.839	0.195
			(-4.84)*	(7.37)*	(6.39)*
ΔLR(-1)			0.793		0.761
			(6.35)*		(4.53)*
ΔPOIL				0.562	
				(6.39)*	
ΔE(-1)					0.0512
					(6.11)*
DUMEMU	0.218	0.085	0.258	-0.318	-0.227
	(4.57)*	(5.13)*	(4.94)*	(-5.38)*	(-5.26)*
Diagnostics					
R^2-adjusted	0.71	0.62	0.72	0.68	0.70
LM	[0.26]	[0.31]	[0.35]	[0.33]	[0.43]
RESET	[0.25]	[0.56]	[0.39]	[0.24]	[0.28]

Notes: Figures in parentheses denote t-statistics, while probability values are in brackets. LM is a serial correlation test and RESET is a functional misspecification test. The following instruments were used: for equation (3)=lagged values for ΔLLR, ΔBAL, ΔYUS, ΔYGER and lags 3 and 4 for ΔY, for equation (4) = lagged values of ΔBAL and ΔDEBT, 3 lags for ΔY, for equation (5) = 2 lags for ΔBAL, ΔDEBT and ΔLR, 3 lags for ΔY and π, for equation (6) = 2lags for ΔY and 2 lags for π and ΔPOIL, and for equation (7) = 2 lags for ΔY and π, 3 lags for ΔLR and ΔE.
*, *** indicates statistical significance at 1% and 10%, respectively.

4.5. Estimating the model (3) through (7) - a structural vector autoregressive (VAR) model

Alternatively to the methodology of a simultaneous system of equations, the model (3) through (7) is estimated using the methodological approach of the structural VAR model. This particular approach assumes that the structure of our model is described by a structural form equation, ignoring constant terms. There are several ways of specifying the restrictions to achieve identification of the structural parameters. A general method for imposing restrictions was suggested by Blanchard and Watson (1986), Bernanke (1986) and Sims (1986) that gives restrictions on only contemporaneous (long-run) structural parameters. This method permits non-recursive structures and the specification of restrictions based on prior theoretical and empirical information about public sector behavior and policy reaction functions, such as equation (7) in our model specification. These structural restrictions are summarized in Table 4. The 'exogeneity restrictions' block indicates that the variables included in this are determined exogenously and affected only by their own exogenous shocks. The restricted model is estimated with the assistance of the Bernanke (1986) restriction matrix which associates the residuals from the underlying un-restricted VAR model with the structural shocks. For the description about this matrix, see the Appendix.

Table 4. Structural restrictions

Block of exogeneity restrictions

$u^{\Delta POIL} = v^{\Delta POIL}$

$u^{\Delta E} = v^{\Delta E}$

$u^{\Delta LRR} = v^{\Delta LRR}$

$u^{\Delta YUS} = v^{\Delta YUS}$

$u^{\Delta YGER} = v^{\Delta YGER}$

Block of structural restrictions

$u^{\Delta LR} = f_1 u^{\pi} + f_2 u^{\Delta Y} + f_3 u^{\Delta E} + v^{\Delta LR}$

$u^{\pi} = d_1 u^{\Delta Y} + d_2 u^{\Delta POIL} + v^{\Delta \pi}$

$u^{\Delta DEBT} = c_1 u^{\Delta Y} + c_2 u^{\Delta BAL} + c_3 u^{\pi} + c_4 u^{\Delta LR} + v^{\Delta DEBT}$

$u^{\Delta BAL} = b_1 u^{\Delta DEBT} + b_2 u^{\Delta Y} + v^{\Delta BAL}$

$u^{\Delta Y} = a_1\, u^{\Delta LRR} + a_2\, u^{\Delta BAL} + a_3\, u^{\Delta YUS} + a_4\, u^{\Delta YGER} + v^{\Delta Y}$

Notes: u denotes residuals from the unrestricted VAR model, while v denotes structural shocks.

The estimated coefficients of the structural identification, i.e. the structural equation that belong in the block of structural restrictions of Table, 4 are summarized as follows:

$u^{\Delta LR} = 0.249\, u^{\pi} + 0.121\, u^{\Delta Y} + 0.0465\, u^{\Delta E}$

$u^{\pi} = 0.484\, u^{\Delta Y} + 0.543\, u^{\Delta POIL}$

$u^{\Delta DEBT} = -0.272\, u^{\Delta Y} - 0.224\, u^{\Delta BAL} - 0.057\, u^{\pi} + 0.712\, u^{\Delta LR}$

$u^{\Delta BAL} = 0.329\, u^{\Delta DEBT} + 0.648\, u^{\Delta Y}$

$u^{\Delta Y} = 0.079\, u^{\Delta LRR} - 0.662\, u^{\Delta BAL} + 0.248\, u^{\Delta YUS} + 0.402\, u^{\Delta YGER}$

Once again, the coefficients carry the expected theoretical sign as before in the case of the simultaneous system of equations.

4.6. Forecasting comparisons of the fiscal equations across the two models

In this part of the study we perform forecasting tests to check the forecasting capacity of the two alternative models. In particular, we perform an out-of-sample forecasting exercise, using a rolling regression methodology. That is, the model is first estimated using data up until the first forecasting period. The forecasts are generated at one, two, three and four quarters. In the next step, the estimation period is rolled forward by one quarter, keeping the total length of the estimation period fixed. New forecasts are then generated at one, two, three and four quarters. In the end, the squares of the forecast errors at the different horizons are averaged using the root mean square error (RMSE), the mean absolute error (MAE) and the Theil Inequality Coefficient (THEIL).

More specifically, the estimation period goes from 1980:1 to 2000:4, while the forecast period goes from 2001:1 to 2008:4. The reason we selected this particular break point is because on January 1st, 2001 the country joined the eurozone as a full member. We, thus, compare the out-of-sample forecasted values with the actual values. In order to assess the forecasting performance we have to analyze the forecast accuracy through a set of statistical measures, while the forecasting exercise will take place in terms of equations (4) and (5), i.e. primary balance and public debt. The empirical findings, reported in Table 4, show that the forecasting performance in both equations deteriorates, as we extend the forecasting horizon from 1 to 4 quarters ahead. The evidence using all three alternative metrics is reported in Table 4 and suggests that the structural VAR (SVAR) model performs better than the estimations through the 3SLS model at forecasting both fiscal variables and at all horizons.

Table 5. Forecasting metrics

	RMSE		MAE		THEIL	
	3SLS	SVAR	3SLS	SVAR	3SLS	SVAR
Equation (4)						
1	12.762	8.914	9.784	7.963	0.616	0.438
2	12.984	10.438	9.918	8.784	0.683	0.426
3	13.549	10.953	10.569	8.928	0.748	0.492
4	13.806	11.327	11.173	9.458	0.791	0.540
Equation (5)						
1	7.994	5.144	6.325	4.648	0.219	0.188
2	8.528	5.638	6.874	4.872	0.263	0.206
3	8.894	5.917	7.329	5.429	0.297	0.251
4	9.246	6.213	7.772	5.842	0.327	0.287

4.7. A calibration exercise with the SVAR model

Based on the forecasting superiority of the SVAR model, in this sub-section we are making use of it calibrate the future path (e.g. up to 2020) of the relevant public debt fiscal variable, under the implementation of an austerity program imposed by the 'Troika' [the International Monetary Fund-IMF, the European Central Bank-ECB, and the European Commission-EC] which the country strictly follows. To this end, we have to make the following assumptions:

- The oil price on December 1st, 2012 is $88.94 and it is assumed to remain constant across the calibration exercise.

- The euro-US dollar exchange rate on December 1st, 2012 is 1.29862 and it is also assumed to remain constant across the calibration exercise.
- For the future course of output growth we are following three alternative scenarios: a downside (poor) scenario with output growth=-4% across the calibration exercise, a mediocre scenario with output growth=1% across the calibration exercise, and, finally, an upside (good) scenario with output growth=4% across the calibration exercise.

The results for these fiscal projections are shown in Figure 1. The findings indicate that the debt-to-GDP ratio in the downside scenario reaches its maximum value of 249,6% in 2020. In the moderate scenario its value turns out to be 201.3% in 2020 and, finally, in the upside scenario its value turns out to be 166.6% in 2020. Therefore, if the country follows an aggressive growth policy, its debt (as % of GDP) is expected to significantly decline and reach reasonable levels that will allow the country to experience sustainable fiscal measures.

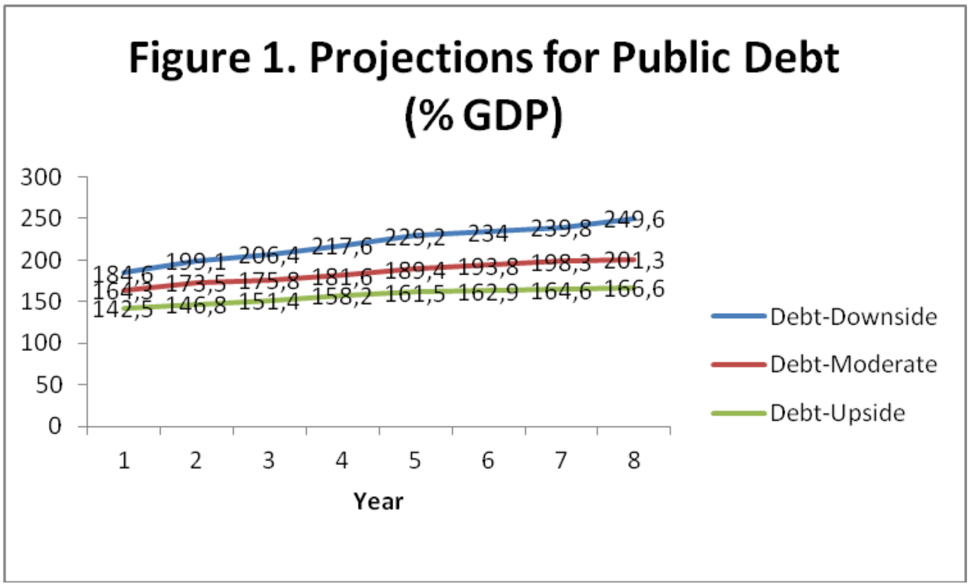

Figure 1. Projections for Public Debt (% GDP)

5. Conclusions

This paper investigated the dynamics of the Greek public debt, while it also indicated what are the appropriate measures required for achieving fiscal consolidation. The empirical estimation was carried out using a macroeconomic dataset spanning the period 1980-2008 as well as two econometric methodological approaches, i.e. the three stage least squares technique on a theoretical model and the structural VAR methodology, to perform forecast tests. The estimations were used to calibrate-simulate the evolution of the primary fiscal variables, i.e. the primary balance and public debt, until 2020. The empirical findings pointed to the fact that only an aggressive growth policy could permit the country to achieve debt sustainability.

The research implications are highly substantial for designing effective macroeconomic policy in terms of achieving sustainable levels of public debt in Greece, given the country's position in the centre of the recent European sovereign debt crisis as well as the three austerity-rescue plans imposed by the International Monetary Fund, the European Central Bank and the European Commission (the 'Troika').

Appendix

In terms of the Bernanke (1986) restrictions pattern and given the order: ΔPOIL, ΔE, ΔLRR, ΔYUS, ΔYGER, π, ΔDEBT, ΔBAL, ΔY, and ΔLR, the restriction matrix looks like:

1	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	1	0	0	0	1	0	0	1	1
1	0	0	0	0	1	0	0	1	0
0	0	0	0	0	1	1	1	1	0
0	0	0	0	0	0	1	1	1	1
0	0	1	1	1	0	0	1	1	0

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