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A dynamic macroeconomic analysis of the Greek crisis

Analysis of the current problems of the Greek economy using an open-economy dynamic macroeconomic model that incorporates public debt

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ABSTRACT

The main goal of this paper is to explain the reasons behind the weak economic situation of Greece. Through the analysis of the evolution of several macroeconomic variables, it is possible to offer the reader a clear understanding about the magnitude of the Greek economic contraction in comparison with the partners of the Euro Area. In addition, I estimate the evolution of the Greek economy under certain different scenarios. In order to do it, a dynamic macroeconomic model is going to be developed and solved through the Minimal State Variable (MSV) solution and using econometric techniques to calibrate the model and adjust it to the specific characteristics of Greece. I run four different simulations to analyze how the economy would react to either a fiscal shock or a risk premium shock.

KEY WORDS

Greece, Greek crisis, Optimum Currency Area (OCA), Greek's bailouts, Minimal State Variable (MSV) solution, dynamic macroeconomic model, public debt, fiscal shock, risk premium shock.

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1. INTRODUCTION

The European Union was created with the main objective of increasing the economic and political integration by developing a single market with free mobility of goods, services, workers and capital. The adoption of a common currency was always in the mind of the founders as a tool to enhance this process of integration. Finally, it was in 1999 when the Euro was introduced and the Eurozone emerged as a single currency area.

The theory of Optimum Currency Areas (OCA), Mundell 1961, argues that highly integrated areas (goods, assets and labor markets) are more adequate to adopt a fixed exchange rate between them. A country will decide to join a common currency area if and only if the benefits from entering exceed the costs. This means that the efficiency gains of reducing uncertainty and transaction costs must offset the economic stability losses of getting rid of monetary policy instruments and exchange rate adjustments.

After more than fifteen years since the birth of the Euro, it is time to analyze whether the Eurozone is actually and optimum currency area or not. The severe economic crisis, which started in 2007, generates serious doubts about the continuation of some countries in the Eurozone, questioning the net benefits from being part of it.

The economic crisis has shown that countries in the Eurozone are in different stages of the business cycle, therefore, are negatively affected by asymmetric shocks, which in turn, has led to deep government solvency problems. The lack of labor mobility makes the Eurozone highly dependent on fiscal transfers to solve economic crisis. However, these programs are difficult to apply due to the lack of fiscal integration within the Eurozone.

Under this scenario, it looks clear that the depth of the crisis has been different among the Eurozone's members. While the central European countries have been able to successfully get around the economic tightness, the peripheral ones have suffered deeper its effects.

The case of Greece is an example of the negative impact of the economic recession, and how the Eurozone has tried to deal with it. However, there are still voices that say that the Grexit from the Eurozone would be a better alternative than the conditional aid given to bounce back the economy. An analysis of the Greek economy's evolution and the impact of the crisis will be helpful to discuss which alternative should be more appropriate for Greece and for the rest of the Eurozone members.

2. GREEK CRISIS

2.1. The Greek economy before 2008

The origins of the Greek crisis came from the Keynesian policies applied since 1980, characterized by a strong government intervention that led to an increasing public debt. Additionally, the government started to applied macroeconomic policies that would foster the necessary convergence to enter in the Euro Area in the early 90's. These macro-convergence programs were focused on restrictive monetary policies. However, not enough attention was paid to market reforms (labor, goods and capital market integration), absolutely necessaries to incorporate the country to an OCA.

Finally, Greece became a member of the Eurozone in 2001. However, it is important to notice that, despite the macroeconomic convergence, the microeconomic convergence had not been enough, which increased the exposure of the Hellenic economy to any destabilizing shock in the Eurozone.

On the one hand, there were many benefits for Greece of adopting the Euro. First of all, the entrance in the Eurozone brought Greece, a traditional inflationary country, lower levels of inflation and inflation expectations (see Figure 1), which, in turn, gave more economic stability by reducing the uncertainty about price levels. In fact, the inflation rate in 1991 (ten years before the Euro adoption) was 19.47%, extremely high compared to the 3.37% inflation rate in 2001, when Greece entered the Euro Area. Since then, the inflation rate has remained at levels close to 2%, as the Eurozone authorities recommend.

On the other hand, Greece experienced the largest fall on interest rates and long-term government bond yields in the Eurozone (see Figure 2). Just in three years, from 1998 to 2001, the Greek long-term government bond yield for 10 years dropped 490 basis points, converging with the Euro Area average, rounded 5%, till the beginning of 2008. Therefore, the entry in the Euro Area had a strong positive impact on Greek's investment and consumption, fostering the aggregate demand and therefore, rising the Greek's income.

As a consequence, from 2001 to 2008, Greek GDP growth grew on average a 4% yearly (see Figure 3), which is 2 percentage points above the Euro Area average (2.09% average yearly growth) and more than 2.50 percentage points above Germany, (1.56% average yearly growth). Moreover, comparing this data with the average annual GDP growth during the 10 years before to the admission in the Eurozone, 3.18%, it can be said that the

entrance of Greece to the Common Currency Area allowed the country to experience an economic boom not experienced by the majority of Eurozone's countries.

Another important variable that must be analyzed is the current account balance. The Greek total current account balance (displayed in Figure 4) decreased by 130% from 1998 to 2001. This shows that the introduction of the Euro in the country fostered its international trade within the Euro Area, increasing Greek's imports in a larger proportion than its exports. Since then, its current account balance has kept constant around -10.3% of its GDP until 2008, in comparison with the Euro Area average of -0.03%. A continuous negative current account balance is problematic, since it means that the country needs to borrow money from the rest of the world to finance its purchases, increasing public debt.

Furthermore, Greece has traditionally faced a large government deficit (shown in Figure 5). Since its entrance in the Euro Area until 2008, its fiscal deficit has gradually increased from -3% to -8% of its GDP. Consequently, data show that Greece never fulfilled the Stability Growth Pact signed in the Maastricht Treaty, which considers excessive a budget deficit greater than 3% of GDP. This fiscal indiscipline had an important impact enlarging Greek's total debt, through raising the interest on previous years' public debt.

Greek total public debt (see Figure 6) has been traditionally very large, remaining close to 120% of its GDP from the adoption of the Euro to 2008. By comparing this data with the level of government debt of the Euro Area average, around 67% of its GDP, close to the limit set by the Stability Growth Pact, 60; it can be observed that the difference between them remained constant around 53 percentage points. This gap results extremely high and it shows that the likelihood of government default was much larger in Greece than in any other Euro-country. In case of an economic recession, Greece would have to raise the long-term government bond yield offered to attract investors, while a larger proportion of government income should be used to pay the interest service on sovereign debt, reducing the income available to be spent on social protection. This is what actually happened in 2008, when the financial crisis in the US expanded to Europe.

2.2. Beginning of the crisis: 2008-2010

The global financial crisis that started in 2008 has been considered the worst financial crisis since the Great Depression (Behravesh, Rogoff, & Roubini, 2009). It was triggered by an extremely easy access to credit in the US, which caused a housing bubble and it overvalued subprime mortgages. The bankruptcy of Lehman Brothers in September 2008 was the

inflection-point that diminished investors' confidence about banks' solvency, questioning their ability to rollover their short-term debt. This brought panic in the stock market. The response of the Central Banks of United States and the Euro Area was to cut down interest rates to low historical levels.

The transmission of the crisis from the US to the EU occurred through three different channels: 1) the financial market connections, 2) the shrinking of the demand due to the fall in confidence and the decrease of wealth, and 3) the collapse of global trade. The financial crisis has had a widespread impact on the EU's real economy; however, the contraction of the economy has been stronger in some concrete countries.

In particular, Greece initially dealt with the liquidity crisis relatively well, since its access to funding from international markets was not blocked. However, it was at the beginning of 2009 when Standard and Poor's downgraded Greece's grade from A+ to A justifying a loss in competitiveness as a result of the worldwide economic contraction. Therefore, investors' confidence started to diminish.

Furthermore, in October 2009 the socialist government led by George Papandreou came to power and announced that the fiscal data reported had been undervalued. As argued by the Congressional Research Service, 2010, the revision of the data showed that the actual value of Greek's government deficit for 2009 was 12.7% of GDP instead of the reported 6.7% of GDP (shown in Figure 4). Consequently, the three major agencies downgraded Greek's debt to BBB-, only one level before to be considered junk debt. This situation pushed up the Greek risk premium from 40 basis points before the crisis to 350 basis points at the beginning of 2010 (observe Figure 7), which absolutely damage investors' confidence in Greece. At this point, the liquidity problem turned into a solvency crisis for the Greek economy due to its difficulties to meet its financial obligations.

2.2.1. Why was the impact of the crisis in Greece so deep?

In order to understand why Greece has been more affected than other European countries by the global financial crisis, some domestic and international weaknesses must be analyzed.

The first domestic factor to mention, that debilitated Greece economy against the crisis, was the inefficiencies of its public administration. Greece enjoyed the most generous pension system in Europe being its public spending on pensions as percentage of GDP

(see Figure 8) extremely large. This level increased gradually and, in 2007, the weight of pensions in public spending was 12.04% of its GDP, 3.52 percentage points above the Euro Area average. Furthermore, the public administration was over-staffed and the productivity was quite low, which enlarged even more the overruns. From the revenues' side, the tax evasion contributed to increase the fiscal deficit of the Greek government.

Another important domestic weakness was the fall experienced in international competitiveness due to the increase of wages at an annual rate of 5% and the decline of productivity at the same time. Therefore, reverting both variables was recommended to improve Greece's productivity and to reduce its current account deficit.

Regarding international factors, the low interest rate that Greece enjoyed because of belonging to the Euro Area was much lower than the one it would have faced otherwise. Initially, this situation seemed to be advantageous, since it facilitated its access to credit and it fostered its aggregate demand through consumption and investment. However, as time went by, it contributed to enlarge its public debt. If the interest rate would have reflected the true Greek economic situation, it would have probably been higher, limiting its credit access and preventing the economy from this excessive borrowing.

Finally, the lack of honesty from the Hellenic government by altering the data brought Greece to a disadvantageous international position. The lack of fulfilment of the Stability Growth Pact made Greece losing the control over its public debt and government deficit, which far surpassed the 60% and 3% of its GDP respectively.

In light of this situation it looked obvious, that when the crisis extended to Europe, Greece was going to be one of the countries that would suffer the most. Its internal and external imbalances made the economy exceptionally fragile, reducing its ability of taking any immediate action.

2.2.2. Immediate effects

Since the new government published the real data about Greek's deficit, the investors' confidence diminished sharply. This was reflected in a huge jump of the risk premium, which moved from 130 points in October 2009 to more than 900 points in one year (displayed in Figure 7). Investors had serious doubts about the solvency of Greece and they asked for a higher return. That is why the long-term government bond yield (see Figure 2) increased from 5% to 11% in just one year.

On the one hand, the higher interest rate asked by investors raised the cost of borrowing of the government. Remember that Greek's public debt over its GDP accounted in 2009 120%, which was considerably high. As a consequence, Greek's indebtedness grew to 140% of its GDP in just one year.

On the other hand, the higher cost of borrowing contracted the level of investment. Furthermore, the contextual crisis forced individuals to reduce private consumption and, at the same time, the current account got worse due to the lack of competitiveness. As a consequence of the crisis, between 2009 and 2011 the accumulated GDP contraction was -5% of its GDP (shown in Figure 3), extremely high if this number is compared with the Euro Area, where the GDP growth was still positive. This economic recession was reflected on the dramatic job destruction. The unemployment rate (see Figure 9) doubled in just two years, being 21% of the population between 16 and 64 years old unemployed.

The reduction of employment had two negative implications over public deficit. Firstly, it decreased the income coming from taxes. The reduction of the employed population diminished the income generated in the economy that could be taxed. As a result, despite a rise in taxes, it resulted very difficult for the Government to increase its revenues. Secondly, the government had to dedicate a larger proportion of its budget to pensions to protect the unemployed. Due to both channels, the level of public deficit in 2009 reached 15.2% of Greek GDP.

Some correction actions were applied to prevent the economy from this self-fulfilling vicious circle that would aggravate the existing financial problems derived from the higher cost of borrowing. All of them are discussed in the next subsection.

2.3. Crisis response

In view of this risky economic environment, the Troika (European Commission, European Central Bank and International Monetary Fund-IMF) offered to Greece economic aid in exchange of applying some structural reforms. The target behind this was, firstly, to cut down Greek's public deficit through several austerity packages, as a method to decline its public debt (the objective was reducing it till 120% of GDP in 2020). Secondly, an internal devaluation was required in order to increase competitiveness and boost economic growth. Finally, it was intended to procure financial stability through the Hellenic Financial Stabilization Fund (HFSF).

2.3.1. First bailout: 2010-2011

In May 2010, due to fears of a possible default, the first bailout package was given to Greece accounting €110bn. over three years. The Prime Minister Yorgos Papandreu applied five unpopular austerity packages in exchange. Regarding the over-dimensioned public sector, the salaries of civil servants were reduced; monthly pensions were cut between 20% and 40% depending on the characteristics of the beneficiaries and the retirement age raised from 60 to 65 years old. Additionally, as a way to increase revenues, taxes on luxury goods, imported cars, high pensions and the VAT raised.

All these contractionary measures had a negative impact in the short run. The GDP growth fell from -4.3% to -9% between 2009 and 2011, which had a direct effect on unemployment raising it to 21%. This situation gave rise to the Greek indignant Citizens Movement with strong protests and strikes. However, there were improvements in the public deficit, which accounted -9.9% of GDP in 2011 (5 percentage points above 2009), thanks mainly to the reduction on government spending. These struggling austerity measures moved Papandreu to propose a referendum on the bailout, but he finally called it off due to the support of the center-right opposition towards the Troika deal.

2.3.2. Second bailout: 2012-2014

In February 2012, a new bailout amounting €130bn. was approved by the European Central Bank (ECB), in exchange of reducing the Greek public debt to 120% of GDP in 2020. This implied a tremendous challenge, since the current public debt accounted at that moment 160% of GDP. In June, new elections took place, and the center-right triumphed, forming a coalition in which the president of New Democracy was appointed the Prime Minister of the Hellenic Government.

From 2012 to 2014, four more unpopular austerity packages were approved and implemented. As a result, the industry sector acquired rights to negotiate lower wages, the minimum salary was reduced by 22% falling to €585 and there was a mass layoff of civil servants in the public sector. During this period, the GDP growth evolved from -7.3% to 0.7% and the public deficit continued decreasing. However, the unemployment rate reached, at the end of 2013, the 28%, being the highest in the Euro Area at that moment. This situation generated important strikes in the capital, Athens.

2.3.3. Third bailout: 2015

In January 2015 Syriza, a left-wing party, won the legislative elections and appointed Alexis Tsipras as Prime Minister, who promised to renegotiate with the Troika the bailout terms, the debt cancellation and the public spending budget.

At the beginning of June, the Greek government said that it would not repay the debt to the IMF, which increased the possibility of exit from the Eurozone. Tensions strengthened and the Prime Minister called for a referendum on a bailout agreement. Tsipras announced capital controls limiting to €60/day the bank withdrawal, and commercial banks closed their offices during some days. Finally, the 30th of June Greece became the first developed country to default to the IMF.

Finally, the referendum took place on the 5th of July, being 61% of the voters against the measures imposed by the Troika associated with the bailout. Nevertheless, in August the third bailout was approved and further austerity measures were applied to prevent Greece from bankruptcy and exit from the Euro Area.

3. OPEN-ECONOMY DYNAMIC MACROECONOMIC MODEL

In this section I will start presenting what a dynamic macroeconomic model is and I will stand out its most relevant characteristics. These aspects will justify its appropriateness to faithfully represent the economic reality, and consequently its use to depict the actual economic situation for Greece.

The next step will be the development of my own macroeconomic model, based on several initial static patterns that have been modified in order to turn them into a dynamic macroeconomic model. All the variables that make up this model will be clarified for a better understanding of the model and the analysis that would be implemented with it.

The main purpose of this analysis is to develop a dynamic macroeconomic model that fits the Greek economic reality and that allows representing different possible scenarios that the country could face. The derived study will provide information about the consequences of certain measures that the Hellenic government could apply in the existing context of European pressure to fulfill the required public debt and deficit levels.

3.1. Definition of a dynamic macroeconomic model

The main role of macroeconomics is to explain the economic aggregates, such as output, public deficit, public debt or the interest rates, and also their interrelations. It provides an interpretation of the economic structure, performance and decision making process, offering a better understanding of the economy as a whole.

For a better understanding of what a dynamic macroeconomic model consists on, it is convenient to compare it with a static model. According to Frisch 1933, who formalized the macrodynamics, a static model is used to analyze the existing relationships between variables that refer to the same period of time; the so-called state variables. On the contrary, a dynamic model shows the relationship, through an equation, between variables that refer to different moments in time, the so-called dynamic variables.

Consequently, the aspect that stands out in a dynamic model is its ability to measure the time it takes an adjustment process to conclude. Technically speaking, it shows how a concrete shock generates impulses in the system, that are expanded through the transmission mechanism (expressed by the variables' interrelations) and last several periods until all variables adjust and the new equilibrium is reached. Therefore, a dynamic analysis would be appropriate if the time between the shock and the final adjustment is long. On the contrary, the use of a static model would be appropriate when this adjustment occurs immediately; which is considered an important divergence point between theory and practice. This quandary about static models is what has made dynamic analysis increasingly popular nowadays.

The importance of these dynamic macroeconomic models arises because of the numerous dynamic economic evidences observed in reality. Therefore, this approach brings the opportunity to measure the evolution of these economic aggregates after the passage of time and to analyze the consequences of several hypothetical situations that can affect the economy in a certain region. Furthermore, it results extremely useful to predict the long run effects of certain government policies adopted in the present, which helps the economic and political authorities to develop strategies, which will foster economic growth in the long run.

All these mentioned characteristics make the dynamic model appropriate to present the different scenarios that Greece could face depending on the economic and political measures applied to deal with the tough European requests.

3.2. Model description

3.2.1. Introduction

The purpose of this analysis is to develop a dynamic model that contains public debt due to its importance when analyzing the evolution of an economy in the long run. In the case of Greece, its public debt has been an important determinant of its profound economic recession. Therefore, a factor of this relevance could not be missing in this study.

Consequently, the following model shows the existing interrelations between real GDP, interest rate, public debt, primary deficit and risk premium. Since this model is developed for the Greek economy, it is important to notice that any mention of foreign economy would refer to the Euro Area, the economic union to which Greece belongs to. In order to better understand the model I will proceed to explain how the model has been developed.

Firstly, before presenting the complete model, it is necessary to clarify how the different mentioned variables are related within each other. Following Krugman (2015), the general static aggregate demand equation, D, is as follows:

$$D = \underset{(+)}{C}(Y - T; \underset{(-)}{R}) + \underset{(-)}{I}(R) + G + CA\left(\underset{(+)}{FX}\frac{P^*}{P}; \underset{(-)}{Y - T}\right) \quad (1)$$

where C refers to consumption, Y means income level or real GDP, I investment, G government spending, CA current account, $Y - T$ disposable income, R Greek nominal interest rate (which equals the real interest rate since it is going to be assumed that inflation is zero) and $FX\frac{P^*}{P}$ real exchange rate. This equation contains all the important variables that must be included in the final model except for public debt, which is not contained in the aggregate demand equation presented by Krugman.

From the aggregate demand equation, (1), it can be concluded that the aggregate demand depends positively on the level of consumption. Additionally, consumption depends positively on disposable income and negatively on interest rate. The higher the level of income, the higher is consumption, and a high interest rate encourages consumers to buy less and save more. Moreover, the higher the level of investment in the country, the higher is its aggregate demand. However, a high interest rate contracts investment. Regarding exogenous public spending, aggregate demand depends positively, since a large public spending raises both the public and private consumption. Moreover, the aggregate demand depends positively on the current account balance, since as exports increase relative to

imports, the aggregate demand rises from net purchases of foreigners. More concretely, the current account depends negatively on disposable income and positively on real exchange rate. The first relation is simple to understand, the higher the level of income, the more capacity the economy has to buy from the rest of the world, raising its imports and worsening its current account. The second relation could be more difficult to understand. The reasoning behind this is that a rise in the real exchange rate (real depreciation) makes domestic goods and services relatively cheap in comparison with the foreign ones. Consequently the exports rise more than the imports improving the current account balance of the economy.

Additionally, it is important to clarify the existing negative relationship between public debt and the aggregate demand. When the level of public debt in the economy is very large, as it is the case of Greece (remember than it exceeded the 160% of its GDP in 2012), the confidence in the economy falls, making investors asking for higher interest rates to lend money to the country. A high interest rate slows down the economy through a contraction of both consumption and investment, which ends up lowering the aggregate demand.

Secondly, before starting analyzing the different equations of the model, it is important to differentiate between two important concepts: primary deficit and public debt. While primary deficit refers to the difference between government expenditures *G* and revenues through taxes *T*, the public debt has to do with the accumulation of these yearly deficits, since part of them must be financed through sovereign debt. Furthermore, it is important to make a distinction between primary deficit and government deficit, because the last one adds to primary deficit the expenditure of the government when paying the interest of the previous year public debt, RB_{t-1}. In this analysis the concept of primary deficit will be applied to understand the effects of the fiscal government policies.

After clearly understanding all these concepts, it is time now to start defining the equations that will build up the economic model. It is important to remark that, since the model is dynamic, it is necessary to add time subscripts in the variables to clearly indicate the period of time to which each variable refers.

I will start defining the concept of public debt and how it can be represented through the following equation:

$$B_t = B_{t-1} + R_t B_{t-1} + (G_t - T_t) \qquad (2)$$

This equation indicates that Public debt in period t equals the previous period's public debt that it must be paid back today, plus the interests from this old debt that must also be paid today. Moreover, it has to be added the primary deficit of this period that must be financed by the government through indebtedness. This primary deficit depends on G, which is exogenous, and T, which depends on the level of income in the economy.

By dividing all the elements of the equation by their corresponding income levels in each period, the following expression about public debt over GDP is obtained:

$$\frac{B_t}{Y_t} = \frac{B_{t-1}}{Y_{t-1}} + (r_t - g) + \frac{G_t - T_t}{Y_t} \quad (3)$$

where r_t is the nominal interest rate of debt and g refers to the rate of growth of real GDP. This equation can be simplified by assuming that $b_t = \frac{B_t}{Y_t}$:

$$b_t = b_{t-1} + (r_t - g)b_{t-1} + \frac{G_t - T_t}{Y_t} \quad (4)$$

The relationship of r_t and g with b_t indicates that when the nominal interest rate rises much more than the growth rate, the cost of debt increases a lot. On the contrary, the enlargement of the rate of GDP growth helps keeping the debt over control.

Finally, by a reformulation of equation (4), we get one of the three equations of the final model, which represent public debt in a simple manner:

$$b_t = b_{t-1} + \mathrm{d}_1(R_t - R^*) + \mathrm{d}_2 u_t \quad (5)$$

Firstly, it is important to notice that the impact that interest rate has on the current level of public debt can be also expressed by the risk premium effect, the difference between the domestic and foreign nominal interest rate. The higher the actual risk premium is, the higher the level of current public debt. This interest rate differential is multiplied by a constant, which reflects the strength by which the risk premium affects the public debt.

Secondly, for simplicity, the primary deficit effect is going to be contained in u_t, an AR(1) exogenous process, which represents the primary deficit shock, ($u_t = \rho_u u_{t-1} + k_t^u$ with $k_t^u \sim N(0, \sigma_{k^u}^2)$ as a white-noise innovation). Since the public debt is positively influenced by the primary deficit, u_t is multiplied by a positive constant, $\mathrm{d}_2 > 0$, which reflects the impact the primary deficit has to enlarge pubic debt.

To conclude, according to equation (5), the total current public debt is equal to the previous period public debt plus the positive effect from the interest rate differential, which enlarges the current level of public debt and the primary deficit shock. Additionally, it is important to stand out the different types of variables that compound the equation. Both b_{t-1} and u_t are state variables; however the difference between them is that, while the first one is predetermined, the second is an exogenous variable. Finally, b_t and R_t are considered endogenous variables; therefore a further analysis must be done to clarify how nominal interest rate is derived.

The second equation of the model is, consequently, related with R_t. As a consequence of international trade, the nominal interest rate depends on the exchange rate, which is set in the Foreign Exchange Market (FOREX). Consequently, R_t can be derived as follows:

$$R_t = R^* + \frac{FX^e_{t+1} - FX_t}{FX_t} + \rho_t(G_t - T_t) \tag{6}$$

where R_t represents the domestic nominal interest rate, R^* is the interest rate of the foreign economy, $\frac{FX^e_{t+1} - FX_t}{FX_t}$ is the expected rate of depreciation of the domestic currency against the foreign currency and ρ_t represents the risk premium, which depends on the primary deficit, $G_t - T_t$. It is important to understand that a rise in the domestic interest rate makes domestic bonds more attractive than foreigners, since they offer a higher return. This will raise the demand for domestic currency, appreciating it and, consequently, raising the rate of return of foreign bonds till restoring the equilibrium in the FOREX.

However, it must be reminded that the goal of this model is to represent the economic situation of Greece. For this reason this formula should be modified in order to capture all the required specifications. The following equation will be used in the final model to represent the nominal interest rate:

$$R_t = R^* + c_1 E_t b_{t+1} + \varepsilon_t \tag{7}$$

As a consequence, R_t represents now the Greek nominal interest rate, while R^* is now referred to the average nominal interest rate of the Euro Area. Since Greece and the remaining Eurozone countries share the same currency, the ECB is the authority in charge of controlling the monetary policy for the entire Euro Area and, therefore, of indirectly setting the exchange rate. That is why, both FX_t and FX^e_{t+1} are considered exogenous and FX_t equals 1. The reason why the expected rate of depreciation of the domestic currency

against the foreign currency has not been included in equation (7) is because the Hellenic government cannot use this mechanism to favor its economic performance.

Regarding the risk premium and with the aim of simplifying the model, the last parameter of equation (6) is substituted by ε_t, an exogenous process AR(1) that represents the risk premium shock ($\varepsilon_t = \rho_\varepsilon \varepsilon_{t-1} + k_t^\varepsilon$ with $k_t^\varepsilon \sim N(0, \sigma_{k^\varepsilon}^2)$ as a white-noise innovation). Additionally, the equation (7) includes a new factor, $c_1 E_t b_{t+1}$, which represents the expectation today of the future level of public debt, and it influences the evolution of the risk premium. The term E_t is the so-called rational expectation operator, which shows the expectation of the future level of public debt whose expectational error is unrelated with the set of available information, being consider the "best" expectation because it uses all the available information[1]. It assures the validity of the model's predictions offerings internal consistency to the model.

To summarize, the nominal interest rate in period t equals the interest rate of the Euro Area plus the expectation of future public debt and the risk premium shock. Finally, it is important to distinguish between the two endogenous variables, R_t and b_{t+1}; and the state exogenous variable, ε_t.

To finalize, the concept of income must be included to complete the entire model. The previous mentioned general aggregate demand equation (1) shows the most important variables in determining the level of income. When the value of income equals the value of aggregate demand, the goods market clearing condition, $Y_t = D_t$, is fulfilled and the equilibrium in the economy is achieved. The income equation is represented as follows:

$$Y = D(\underset{(+)}{Y - T}, \underset{(-)}{R}, \underset{(+)}{G}, \underset{(+)}{FX\frac{P*}{P}}) \tag{8}$$

Consequently, the income function that will be included in the model must depend positively on disposable income, negatively on interest rate since it reduces investment and increases savings, and positively on government spending. However, it will not depend on $FX\frac{P*}{P}$, since, as it has been previously mentioned, the Greek government cannot use the exchange rate to foster its economic performance. As a result, the third equation of the final model is derived as follows:

$$Y_t = a_0 - a_1 R_t + u_t \tag{9}$$

[1] Universidad Pública de Navarra. (2015). Rational Expectation Macroeconomics IV, International Economic

Summarizing, equation (9) shows how income depends positively on the steady state income, represented with a constant, minus a proportion of nominal interest rate, plus an exogenous process AR(1), which represents the primary deficit shock ($\mathrm{u}_t = \rho_{\mathrm{u}}\mathrm{u}_{t-1} + k_t^{\mathrm{u}}$ with $k_t^{\mathrm{u}} \sim N\ (0, \sigma_{k^{\mathrm{u}}}^2)$ as a white-noise innovation). Finally, it must be highlighted the different types of variables which configure this equation, Y_t and R_t are endogenous variables, while u_t is a state exogenous variable.

To conclude, after the presentation of all the equations, it is time now to build up the entire model, which is compound by three different equations:

$$Y_t = a_0 - a_1 R_t + u_t \tag{9}$$

$$R_t = R^* + \mathrm{c}_1 E_t b_{t+1} + \varepsilon_t \tag{7}$$

$$b_t = b_{t-1} + \mathrm{d}_1(R_t - R^*) + \mathrm{d}_2 u_t \tag{5}$$

where Y_t, R_t and b_t are endogenous variables, b_{t-1} is a predetermined variable and u_t and ε_t are exogenous variables.

Based on this model a dynamic simulation would be performed in order to analyze and interpret the behavior of the Greek economy under certain scenarios.

3.2.2. Minimal State Variable (MSV) solution

After having developed a Linear Rational Expectation Model made up with a linear system of equations, the way of proceeding is to solve the Minimal State Variable (MSV) solution under a five-steps procedure.

The first step refers to the classification of the variables that compound the model. Y_t, R_t and b_t make the set of endogenous variables, which are explained through the relationship between all existing variables in the model. The set of state variables defines the state of the dynamic system. This group can be splitted up into both predetermined and exogenous variables. The only predetermined variable in the model is b_{t-1}; it is the only variable that is determined in a period before the current time of the analysis. Lastly, the exogenous variables u_t and ε_t represent changes or shocks that come from outside the model.

Secondly, the model must be written down under the solution form. This means that each of the endogenous variables must be equalized to the sum of all the predetermined variables, multiplying each of them by an unknown factor. The solution form is as follows:

$$Y_t = S_{10} + S_{11}b_{t-1} + S_{12}u_t + S_{13}\varepsilon_t$$

$$R_t = S_{20} + S_{21}b_{t-1} + S_{22}u_t + S_{23}\varepsilon_t$$

$$b_t = S_{30} + S_{31}b_{t-1} + S_{32}u_t + S_{33}\varepsilon_t$$

$$E_t(b_{t+1}) = E(S_{30} + S_{31}b_{t-1} + S_{32}u_t + S_{33}\varepsilon_t)$$

$$= S_{30} + S_{31}b_t + S_{32}E(u_t) + S_{33}E(\varepsilon_t)$$

$$= S_{30} + S_{31}b_t + S_{32}\rho_u u_t + S_{33}\rho_\varepsilon \varepsilon_t$$

The third step consists on applying the undetermined coefficient technique. By doing so, the equations obtained in the second step are equalized to the right side of their corresponding equations in the initial model, after substituting in them the endogenous variables.

In the forth step, each unknown parameter of the left side of the equations got in the previous step must be equal to all the parameters in the right side that contain the same endogenous and state variables.

Finally, the last step requires the obtaining of the analytical solution that will give the exact value of each unknown parameter. In any case, the only correct solution is the so-called bubble free – MSV solution, this can be got if and only if the following two conditions are fulfilled for each unknown factor: feasibility and stability. Both conditions are especially relevant when a parameter is raised to the power two, as it occurs in the presented model.

On the one hand, the feasibility condition implies that the solution form of the unknown parameters cannot have an imaginary root. On the other hand, the stability condition prevents the model from the existence of bubble solutions, in which a tiny increase of a variable leads to an exponential raise of a dependent variable. Therefore, the solution of all the parameters must be feasible and bubble free.

Once the five steps are concluded, the MSV solution is obtained. Consequently each unknown parameter is defined by its analytical solution, which contains a combination of the different constant parameters of the model $R^*, a_0, a_1, c_1, d_1, d_2, \rho_u, \rho_\varepsilon$. Concretely in this model twelve analytical solutions are obtained to define the twelve different unknown parameters that make up the solution form of the model (see Appendix 2 to observe the complete numerical process to obtain the MSV solution to the model).

3.2.3. Calibration of the model

The last step necessary to finalize the model consists on giving values to the constant parameters of the model. The way of calibrating these values is through the estimation of the Ordinary Least Square (OLS) linear regressors. This econometric technique would allow estimating the constant unknown parameters in a linear regression model. For the OLS to be consistent the regressors should be exogenous. Moreover, in order for the OLS to be optimal, the errors must be homoscedastic and serially uncorrelated.[2] When all these conditions are fulfilled the estimators are unbiased and are considered the best estimators possible. Nevertheless, since an econometric analysis is not the main objective of this paper, the OLS I will introduce in the model will just show a relationship between both the regressor and the dependent variable, being at the same time significantly different from zero. To do this analysis the program Matlab is going to be used.

First of all, the parameter a_0 included in equation (9) represents the steady state income. This is the level of income in an economy when it is in equilibrium. In this case, a value equal to 100 is going to be assigned to this parameter.

Additionally, the average level of interest rate in the Eurozone during the last eight years is 0.01 (1%). Therefore this is the value that would be assigned to R^*, representing the interest rate of the foreign economy, which in this model refers to the Euro Area.

For estimating the remaining parameters, a linear regression model must be developed for each constant. To do so, it is required to obtain some actual data. In this analysis the data used contain quarterly observations extending from the first quarter of 2001 (Greek entrance in the Eurozone) to the last quarter of 2014. The data to be used in the estimation are the series of real output, public debt deflated by prices to express it on real terms, government deficit deflated by prices to express it on real terms, and the quarterly Greek government bond yield for ten years expressed in so much for one (see the attached Word "Data_OLS" to analyze the entire data set).

The first parameter that is going to be found is a_1, contained in equation (9), which captures the effect that interest rate has on the level of output. Consequently, the linear

[2] Homoscedasticity implies that all the random variables in a vector have the same variance and error term. If the errors are uncorrelated, it means that there is not a linear relationship between them. These two conditions are crucial to get the best estimator possible of the model.

regression model that would be study is: $Y_t = a_1 R_t + z$, where z is a constant parameter. When analyzing the following result:

Output 1: OLS linear regression for estimating a_1

Number of observations 56
Number of regressors 2

"	'Estimator'	'SE'	'SE_robust'	't-stat'	'p-val'
'C(1)'	[10.9799]	[0.0209]	[0.0181]	[606.4639]	[0]
'C(2)'	[-4.2026]	[0.9036]	[0.6033]	[-6.9663]	[5.1108e-09]

R2: 0.28985
Variance of s2: 0.0083462
Log likelihood: 56.0878
D-W statistics: 0.058267

it can be concluded that a_1 = -4.2026. This means that if the quarterly Greek government bond yield for ten years raises by one for one, the real output in the economy would fall by 4.2026 points. In this case, the estimator would be consider valid since it shows that 28.985% of the variation in output can be explained by the variation of the quarterly Greek government bond yield for ten years. Furthermore, it can be concluded that at 1% level of significance, the quarterly Greek government bond yield is significantly different from zero.

The second parameter is c_1, contained in equation (7). This parameter shows the relationship between the expected future public debt and the current quarterly Greek government bond yield for ten years. Therefore, the regression model that capture this relationship is: $R_t = c_1 b_{t+1} + z$, being z a constant parameter. After performing the analysis and observing the result:

Output 2: OLS linear regression for estimating c_1

Number of observations 55
Number of regressors 2

"	'Estimator'	'SE'	'SE_robust'	't-stat'	'p-val'
'C(1)'	[-0.0394]	[0.0090]	[0.0094]	[-4.1719]	[1.1502e-04]
'C(2)'	[0.0371]	[0.0057]	[0.0068]	[5.4386]	[1.4590e-06]

R2: 0.44967
Variance of s2: 0.00010818
Log likelihood: 174.6241
D-W statistics: 0.2189

it can be concluded that $c_1 = 0.0371$. Again, this estimator is valid, because it indicates that 44.967% of the variability in the quarterly Greek government bond yield for ten years is explained by the variability of the next period Greek real public debt. Moreover, the next period real public debt is significantly different from zero at a 1% level of significance.

The next two parameters, contained in equation (5) that should be calibrates are d_1 and d_2. However, after testing them, both look being not valid, since they are not significantly different from zero. Consequently, an alternative solution is required to calibrate them.

The constant d_1, relates the unconditional expectation of the rate of growth of Greek real public debt with that of the quarterly Greek government bond yield for ten years. Due to difficulties in the estimation, it has been set at the average ratio of these two variables. Consequently, the result is $d_1 = 0.619$, which represents that when the quarterly Greek government bond rises by one for one, the rate of growth of the real public debt raises by 0.619 percentage points.

Regarding the parameter d_2, which represents the relationship between the rate of growth of Greek real public debt and the real government deficit, its value must be lower than 1. This is justified because when the public deficit increases, it also raises the public debt, since part of this spending is financed through indebtedness. However, a small proportion of this spending is also financed through taxes, because higher public spending increases income and consequently the taxes collected by the government. That is why, after testing in the simulation, I have decided to assign the following value: $d_2 = 0.8$. As a result, a unitary increase in Greek real public deficit increases the rate of growth of the Greek real public debt by 0.8 percentage points.

To finalize the process ρ_u and ρ_ε must be calibrated (observe Output 3 and 4). After testing them through the residuals of the OLS regressions, the obtained result have been: $\rho_u = 0.9786$ and $\rho_\varepsilon = 0.9168$, being both of them significantly different from zero and indicating each of them a strong relationship between their respective dependent variables and regressors. However, when simulating the model the value of ρ_u appears to be extremely large, impeding the variables recovering the natural level in the long run. Consequently, after several tests in the simulation, the number that allow representing the reality in the most accurate way was 0.8, consequently the value given was: $\rho_u = 0.8$.

To summarize, the OLS estimation method has allowed obtaining the majority of the parameters of the model. Nevertheless, in those cases where the OLS estimation was not valid, an approximation has been done in order to try to represent accurately the reality of the Hellenic economy. Moreover, since the entire analysis has been performed based on real data about the Greek economy, it can be conclude that the model I present captures the details and characteristics of this economy and, consequently, it is a relatively good approximation to the reality. That is why the conclusions of the model could be extrapolated to the current situation of Greece.

4. MODEL SIMULATIONS: IMPULSE RESPONSE FUNCTIONS

Once the model is completely defined and adapted to the specific characteristics of the economic situation in Greece, it is time now to simulate the Greek economy. This simulation will provide predictions under alternative scenarios for the following five years (20 quarters).

The impulse response functions bring information about the evolution of the variables contained in the model after an idiosyncratic shock that the economy under study suffers. As a consequence, this analysis results very interesting since it allows observing how the endogenous variables react to different shocks and how much time they need to bring back the economy to equilibrium.

Two different shocks, that may hit the Greek economy, can be studied. The first one is a fiscal shock (u_t), the effect of either an enlargement or a contraction of public spending on the economy as a whole. The second one is a risk premium shock (ε_t), which shows how the rising of the risk premium, interpreted as a signal of investors' distrust in the country, affects the entire economy.

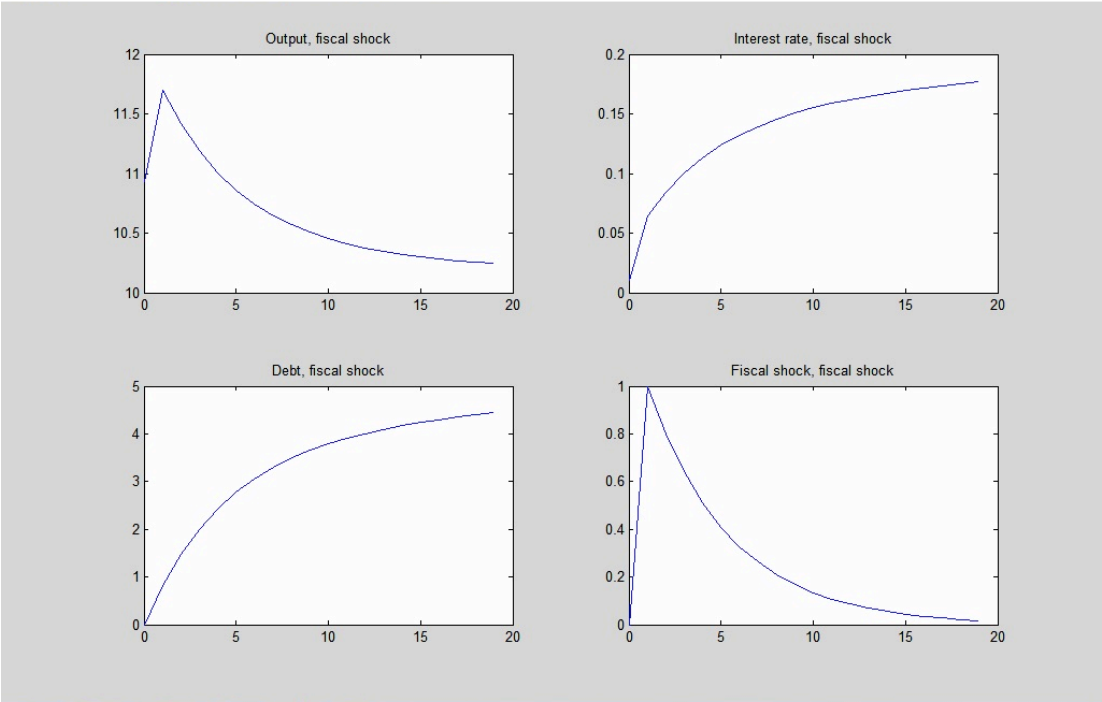
4.1. Expansionary fiscal shock: immediate versus gradual

The following two scenarios I am going to present, show how the Greek economy would be affected in the long run after implementing a fiscal expansionary policy. During the summer of 2015, Alexis Tsipras defended the possible positive outcomes derived from implementing this type of policy, highlighting its ability to reactivate the Greek economy. However, other voices showed their opposition justifying that the high level of public debt would impede a satisfactory evolution of the main macroeconomic variables in the long run. The following two scenarios explain the long run effects of such expansionary policy.

4.1.1. Immediate expansionary fiscal shock

Imagine a situation where the Greek government applies an extraordinary expansionary fiscal policy in just one quarter to stimulate the economy, and it comes back to the traditional fiscal policy the remaining periods (see Plot 1). Although the shock takes place in the first quarter, its effects extend almost fifteen quarters with diminishing returns.

Plot 1: Immediate expansionary fiscal shock



Short run effects:

The expansionary fiscal policy implies an increase in government spending. A large part of this government spending must be financed trough sovereign debt. Consequently, an increase in the public deficit requires the government to enlarge the level of public debt to finance it. That is the reason why the public debt rises during the first quarter by 1%.

This increase in public debt generates expectations for further increase in the next quarter's public debt, increasing the uncertainty of investors about the stability of the Greek economy. As a result of this mistrust, the interest rate investors ask to lend money to the country rises in the first quarter by 4 basis points.

Additionally, during this first quarter the fiscal expansion has an immediate positive effect on output, raising the income in the country by 0.7%. It is important to remark that the

raise in the interest rate affects negatively both consumption and investment, reducing the income in Greece. However, its effect over income is weaker than the positive effect the public spending has on output, consequently the level of income rises.

Medium run effects:

Once the extraordinary fiscal policy stops, the effect of the shock starts decreasing, reducing its impact over the rest of variables in a diminishing way, and allowing some macroeconomic variables returning close to its initial equilibrium in quarter four.

The level of public debt in the economy continues growing but at a lower rate. It is true that the fiscal policy has returned back to its normal level; however, an important part of the expansionary fiscal policy that took place in the first quarter was finance through indebtedness, which raised the public debt that period. The increase in the interest rate enlarges the amount the government must pay because of the interests of the accumulated debt. Consequently, the level of public debt increases by 1%.

This increase in the public debt raises even more the thoughts about a larger public debt in future periods. Consequently the investors' uncertainty about the ability of the Greek economy to pay back its debt increases, raising even more the existing interest rate. Therefore, it rises by 5 basis points from quarter one to quarter four.

The income level starts falling until reaching its initial level in quarter four. This is clarified after observing the evolution of both public spending and interest rate. The reduction of fiscal spending affects negatively the demand in the economy. Additionally, the raise of interest rate, which reduces both consumption and investment, further contracts the demand. These two channels make the income falling by 0.7% till its initial level.

Long run effects:

Although the expansionary fiscal shock takes place during the first quarter, its effects extend till quarter twenty. At this moment, its impact in the economy is close to zero.

Since quarter five, the level of public debt changes its evolution path, rising in a diminishing way. This behavior could be clarified by analyzing the rate of growth public debt, which decreases as time goes by, making the public debt increasing in a diminishing way. This occurs because the level of government deficit remains at normal levels. Therefore, the enlargement of public debt is only motivated by the raise in the interest on

the previous year's public debt. This, in turn, is derived from both the accumulation of a high ratio of public debt and the rise of interest rate. As a result, the new equilibrium is reached in quarter twenty, being the level of public debt a 4.5% above the initial level.

The raise in current public debt affects negatively investor's expectations, who predict higher levels of public debt in the future. Consequently, the interest rate rises following the diminishing path of the public debt. Finally, it is in quarter twenty when the new equilibrium is reached; at a level of interest rate 0.165 basis points above the initial level.

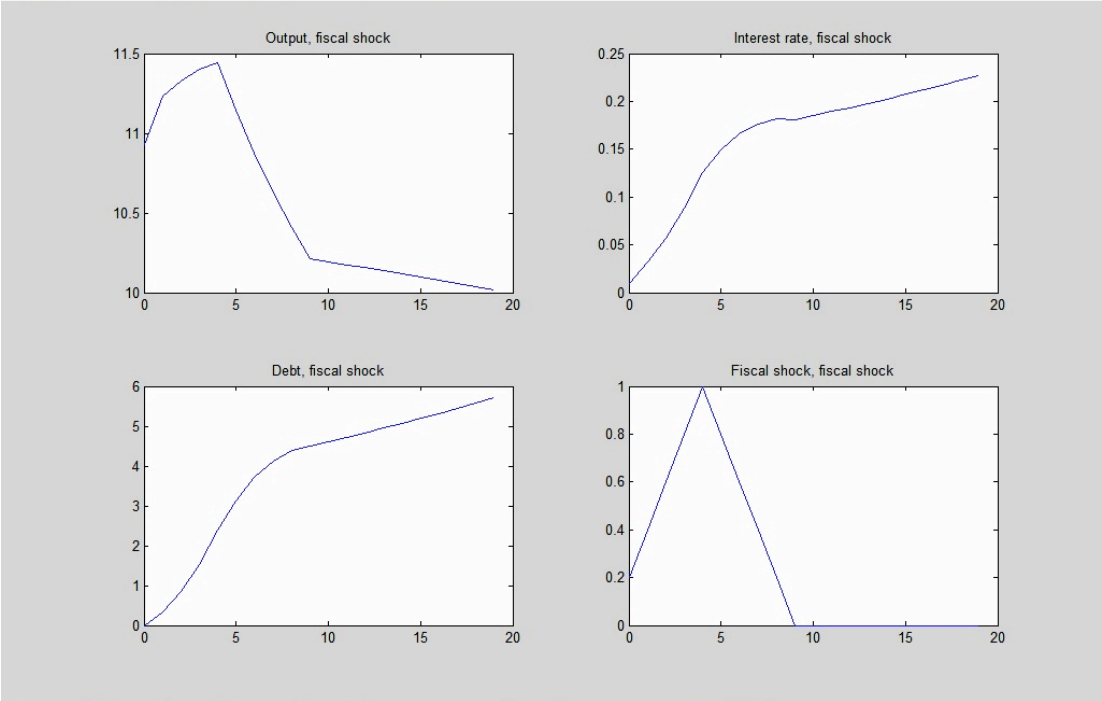
The mentioned effects on both public debt and interest rate explain why the level of output reaches the equilibrium in quarter twenty at a lower level than the initial one. A higher interest rate makes the level of income falling by contracting both consumption and investment. This situation makes the demand in the economy falling, lowering the economy's output by 0.75% below its initial equilibrium level.

To conclude, I would like to stand out that, in the long run, the level of output reaches a new equilibrium different form the initial one. This can be justified because, applying such an expansionary fiscal policy in an economy where the current level of public debt as percentage of GDP is extremely large (remember that in 2012 the level was close to 160% of its GDP) can damage even more the confidence of investors, who would ask for a higher interest rate in order to lend money to the country to finance that policy. This level of interest rate enlarges even more the public debt, and additionally, it affects negatively the level of income in the economy by contracting both consumption and investment. Therefore, according to the results of the simulation, this policy would not be recommendable for the Greek economy, since the positive effects of the short run are not large enough to overcome the negative effects in the long run.

4.1.2. Gradual expansionary fiscal shock

Another possible scenario could be the decision from the Greek government to apply a gradual expansionary policy to stimulate the economy (displayed in Plot 2). The fiscal shock would start being relatively weak in quarter one, 0.20, and it would increase from 0.20 to 0.20 until reaching the maximum strength in the fifth quarter with a shock of 1. From there, the stimulus would evolve in the opposite direction. This policy approximates more to reality, since normally the government prepares different budget packages that are implemented along several quarters.

Plot 2: Gradual expansionary fiscal shock



Short run effects:

The increase in public debt is initially weaker than in the previous scenario, since the initial fiscal shock is just 0.20% instead of 1%. Consequently, the amount of government deficit that must be financed through indebtedness is smaller than in the previous situation, where the fiscal shock was stronger in quarter one.

The increase in public debt generates expectations of larger public debt in the next period, which would make investors to ask for a higher interest rate. Under this scenario, the interest rate raises just 1.7 basis points during the first quarter, in comparison with the 5 basis points of the previous situation. This is explained because the effect on public debt is weaker now, consequently, this situation raises the interest rate in a milder way.

The increase in the level of interest rate makes the government increasing the interest paid on previous year public debt, enlarging even more the level of public debt in quarter one. As a consequence, during this first quarter, the level of public debt increases by 0.33%.

During the first quarter, the relatively small fiscal stimulus makes the income in the economy increasing more than 0.25%. An increase in public spending affects positively the demand in the Greek economy. On the contrary, the new high interest rate contracts the

level of income in the economy by lowering both consumption and investment. However, the first effect offsets the second one, making the income in the Greek economy to rise 0.25% above the initial level.

Medium run effects:

On the contrary to what happens in the previous scenario, under these alternative situation the fiscal policy not only continues, but it also acquires more strength till quarter four, when it reaches its maximum intensity.

As a consequence, the government spending increases in a greater proportion each quarter fostering the country to issue debt in a larger proportion each year. This obviously enlarges the level of public debt in an increasing path, raising the rate of growth of public debt gradually from quarter two to quarter four.

This enlargement of public debt fosters expectations of higher levels of public debt in the future, generating doubts about the ability of the country to pay back this high level of debt. The risk of default increases fostering the interest rate to grow by 8.3 basis points.

This high interest rate makes more expensive the interest of the previous years pubic debt that the government must pay today. This factor makes the public debt growing even more, reaching a rate of growth greater than during the first quarter. That is why in just three quarters, the level of public debt grows by 2.83%

As a consequence of the expansionary fiscal policy, the level on income in the economy reaches its maximum level in quarter four. However, the rate of growth is weaker than in the short run, since the income increases by 0.25 points in the next three quarters, in comparison with the 0.25 points of growth during the first quarter. The fact that the interest rate experiences a higher rate of growth during the next three quarters, clarifies why the output grows at a lower rate during the same period. This larger interest rate affects negatively the level of income through lower consumption and investment, weakening the aggregate demand.

Long run effects:

The expansionary fiscal policy starts falling gradually in quarter five and ends up in quarter nine. Since this moment the shock ends and the fiscal policy implemented by the government recovers its normal path.

This change in the path of fiscal spending makes the public debt still growing but in a diminishing way, because the fall in public spending makes the government issuing debt in a lower proportion each year. Consequently, from quarter five to quarter nine the public debt rises by just 0.5%.

This path followed by public debt makes the interest rate growing in a diminishing way too through expectations of small increases in public debt. As consequence, the Greek interest rate grows only 2.5 basis points during the next five quarters.

This interest rate growth path makes the interest on debt that the government must pay increasing in a diminishing way. This also influences the growth path followed by the level of public debt, favoring this diminishing tendency.

The change in the path of fiscal spending has also a negative effect on the level of income in the economy, which falls 0.5 points reaching the initial level of output in just two quarters. However, the income continues decreasing at a constant rate till quarter nine, when the fiscal policy ends up. At this time, the level of income is 10.25, approximately 0.75 points below the initial level of output. The fall of the fiscal stimulus together with the rise of interest rate affect negatively the income in the economy.

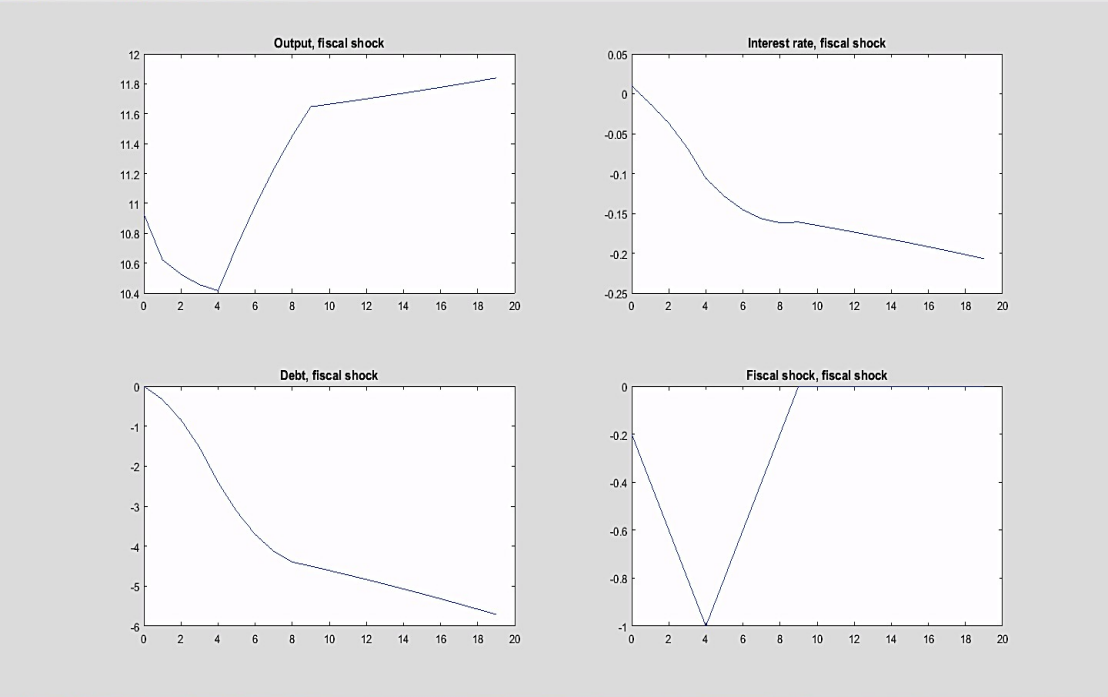
Finally, from quarter nine onwards, when the fiscal stimulus ends, the path of the three magnitudes under study changes. Output continues falling at a constant rate of 0.05% per quarter. This occurs because of the increasing behavior of both public debt and interest rate, which increase respectively at a constant rate of 0.15% and 0.005% points each quarter. This path could be justified because, despite finishing the fiscal shock, the interest over the public debt generated during the previous quarters must be paid. This enlarges the current and expected level of public debt. Furthermore, the higher interest rate affects negatively the level of output, which is not stimulated any more by the fiscal policy.

To conclude this analysis I would like to stand out that under this policy, the positive effect over the level of income in the economy lasts more than under the first scenario. However, the level of income falls constantly in the long run derived from the constant increase of both public debt and interest rate. Therefore, the most problematic issue is that it seems that there is no tendency towards a stationary equilibrium. To conclude, a gradual expansionary fiscal policy should be recommended for the Greek economy over the big push alternative, due to its ability to rise the income level not only in the short but also in the medium run.

4.2. Gradual contractionary fiscal shock

On the contrary to the previous section, it is going to be presented an additional scenario where the Greek government, following the conditions of the Troika, applies a fiscal consolidation program (displayed in Plot 4). In this case the shock is going to be gradual, since in reality this austerity packages last several periods and are applied gradually in order to prevent the economy for an immediate contraction of the economy.

Plot 3: Gradual contractionary fiscal shock



Short run effects:

The fiscal shock affects immediately the level of public debt in the economy, lowering it by 0.5% in just one quarter. This occurs because a large proportion of the fiscal deficit is financed through indebtedness. Consequently, when the public spending falls it forces the current level of public debt to decrease.

The fall in the level of public debt generates positive expectations of even lower debt in the following periods, increasing economy's confidence. Therefore, the level of Greek interest rate falls by approximately 2.5 basis points.

The reduction of the interest rate affects positively investment and consumption. However the negative effect the austerity package has on the level of income weights more, leading to a fall in the output in the economy by 0.3%.

Medium run effects:

The contractive fiscal policy applied by the government increase gradually its intensity till quarter four, where the lowest level of public spending is reached.

This dramatic reduction in the level of fiscal spending have an immediate positive effect in the level of public debt in the economy. This happens because the lower the public budget is, the lower the proportion that the government must financed through indebtedness.

The lower level of public debt generates expectations of further decrease in the following periods. This raises even more the investors' confidence, lowering the interest rate and broadening the country's access to credit. As a consequence, the interest rate in Greece falls by 9 basis points till turning to be negative. This of course would not happen in reality. Nevertheless, what it can be extracted from the simulation is that interest falls in reality until being near to 0, situation that is actually happening in the Euro Area, where the interest rate has reached its historic minimum.

This fall in the interest rate reduces the level of public debt, since it minimizes the interest the government must pay over previous periods' debt. Consequently, during the following three quarters the public debt falls by 2.25%.

The stronger fiscal contraction during this period makes the level of income continue falling but at a lower rate. The interest rate drop affects positively output through both consumption and investment. The negative effect of the fiscal contraction is still larger, however during this period the effect of the interest rate is larger than during the first quarter, smoothing the decrease in the income level in the economy, which falls 0.2%.

Long run effects:

From quarter five onwards, the government policy changes its direction, and the fiscal contractive policy starts losing intensity, minimizing the negative effect of the fiscal shock in the economy. Finally, the fiscal contraction comes to its end after eight quarters (2 years).

The reverse fiscal policy applied since quarter five reactivates the economy. The public debt continues falling till quarter nine relatively fast, since during this period this variable falls by 2.25% as a consequence to the low level of public spending.

This fall in the level of public debt makes investors expecting additional falls in the future public debt. Therefore, the risk of default is perceived lower and the interest rate falls by 5 basis points. It is important to notice that the rate of fall is lower that the one experienced in the medium run. This is explained because investors know that the austerity policy will end, diminishing the rate of fall of public debt.

The level of income in the economy starts rising by 1.3% since quarter five, thanks to the change of direction of the fiscal policy. The government spending rises in comparison with the previous period, affecting positively the economy's output. Additionally, the lower interest rate incentives both investment and consumption, rising even more Greek's aggregate demand. These two forces push income above its initial level.

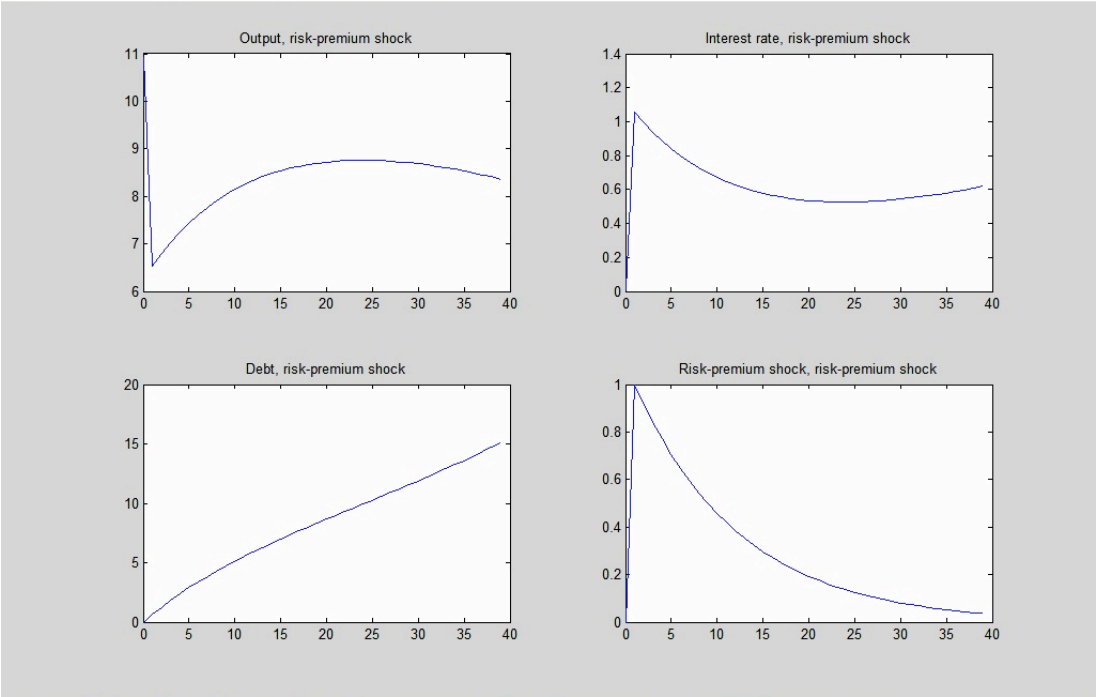
In quarter nine the fiscal policy finalizes, and both the primary deficit and the indebtedness of the country to finance it come back to their traditional levels. However, the lower interest rate makes the government reducing their spending when paying the interest derived from the previous year public debt. This fosters a continuous slow fall in public debt. This tendency keeps expectations of future lower public debt, decreasing the interest rate. Additionally, the lower level of interest rate fosters some economic growth.

To conclude, I would like to mention that in reality the interest rate would not turn negative; however, the calibration of the model has fostered this path. In reality, this fact should be interpreted as a reduction of the interest rate close to zero. Additionally, it results important to notice that the output does not reach a long turn equilibrium, but it continues increasing along time instead. This occurs because since interest rate falls continuously, output keeps growing through higher levels of aggregate demand.

4.3. Immediate risk premium shock

The last scenario that I am going to present is the possibility of Greece to face a risk premium shock, interpreted as a drop in investors' confidence in the Greek economy, derived from fears of a possible default of sovereign debt and Grexit (observe Plot 4). This shock would be immediate and it would last just one quarter; however, as it is going to be observed in the following analysis, its effects would extend several periods after the shock.

Plot 4: Risk premium shock



Short run effects:

In the first quarter the risk premium experiences an important shock that make this variable increasing by almost 0.9% in just one quarter. This of course has an immediate effect on the Greek interest rate, which rise in the same proportion.

This raise in the interest rate has an immediate dramatic effect on output, through lower consumption and investment, lowering the level of income in the economy by 4% in just one quarter.

The moderate increase in the public debt during the first quarter, it raises just 0.6%, is derived because of the raise of the interest rate. Part of the previous year government spending is financed through indebtedness; consequently in quarter one the government must pay the interest derived from the previous year public debt. The raise in interest rate increases the amount the government must pay for the interest on previous public debt.

Medium run effects:

After the first four quarters, the effect of the risk premium shock starts decreasing. However, its falling path evolves relatively slowly, since it diminish just 0.2% in the next

three quarters. Again, the interest rate evolution is the same as the risk premium, falling by 0.2%, since the expectation of future public debt remains still at a low level.

This tiny reduction in the interest rate affects positively the level of income. The lower interest rate incentives both consumption and investment, which raise the output by 0.5% in the next three quarters, 3% above the initial level of income.

During the same period, the public debt rises by almost 2%. The government incurs just in the necessary debt to finance the ordinary level of government spending. However, the continuous increase in the interest rate enlarges the cumulative amount of public debt, through higher level of interest on previous debt.

Long run effects:

The risk premium starts falling in a diminishing way since quarter five. This new path slows down the rhythm of the economic recovery, prolonging the effects of the shock in the economy. This of course affects the evolution of the interest rate, which falls just 0.3% in the next sixteen quarters, till quarter twenty, when the shock effect disappears.

The slow fall in the interest rate makes the level of income in the economy recovers very slowly too. Therefore, in quarter twenty the current level of output is still 2% below the initial level of output, increasing just 1% in sixteen periods.

The public debt rises dramatically during the same period moving from 0.5 to 7.5 points. This increase could be explained because of the slow path of recovery followed by the interest rate, which impedes the government reducing the amount of interest it must pay for the previous debt. This affects seriously the expectations of future public debt, impeding the recovery of the interest rate. Consequently in quarter twenty, the volume of debt is so high that the Greek interest rate starts increasing again, the public debt continues increasing and the income starts falling.

To conclude this final simulation, I would highlight the changing path that the economy experiences, preventing it from a recovery. The risk premium shock is so deep that affects dramatically the public debt. The growth of public debt ends up with the recovery of the economy, due to fears of investors of a possible default. This raises again the interest rates and the level of income starts falling. Consequently, the economy enters in a second recession without having being able to recover from the initial shock. This scenario shows

how weak is the economic situation in Greece, and how much important results for this economy to control its level of public debt.

5. CONCLUSIONS

The economic impact of the crisis has been extremely intense in Greece, especially when comparing the evolution of its main macroeconomic variables with other central European countries like Germany.

The most important reason behind this fact is the serious economic disequilibrium that the Greek economy presented before the beginning of the crisis. The levels of both public deficit and public debt did not fulfill the Stability and Growth Pact. In this Treaty, the EU recommends all the Eurozone countries to keep their budget deficit under control, without exceeding the 3% of each country GDP. Regarding public deficit, the EU authorities consider excessive any level, which exceeds 60% of each country GDP. A low primary deficit reduces the necessity of the government to increase its indebtedness to finance this public spending. This low public debt prevents the volume of debt from rising yearly at a high rate, which increases the confidence of investors in the economy, who agree on lower levels of interest rate to lend money to the country. The existing low interest rate drives both consumption and investment, which end up fostering the economic growth.

In the case of Greece, the government deficit accounted in 2008 for 9.8% of its GDP, while its public deficit doubles the limit set by the EU. Of course, this economic instability made Greek being highly exposed to any possible international economic shock. That is why, when the crises expanded to Europe, the Greek economy was deeply affected.

Moreover, the social and political instability experienced since 2010 to the summer of 2015 influenced negatively the capacity of Greece to appropriately confront the economic recession. The Troika offers three different bailout packages along this period to try to foster the Greek economy in the long run; however, the conditions of government deficit reduction had immediate negative effects in the short run, contracting the economy even more. As a result, the lack effectiveness in the measures imposed by the EU and the political instability in Greece postpone even more the possible recovery of this economy.

I have described a dynamic macroeconomic model, which shows the inefficiencies of this economy and can predict the evolution of main macroeconomic variables: output, interest rate and public debt.

It is important to remark that the calibration of the presented model has been difficult to set, due to the problems when obtaining data about the evolution of the main variables. In the calibration only between 54 and 56 observations have been used, which could be considered insufficient to represent accurately this economy. Furthermore, with the data available some estimations have not resulted representative, which has forced me to get some approximations applying statistical concepts.

Despite these difficulties, the model has allowed to forecast several different scenarios of possible fiscal and risk premium shocks. Thanks to this, it is possible to analyze which measures would be more appropriate to reactivate the Greek economy in the long run.

Regarding the fiscal policy, my recommendation derived from the simulations, would be to apply a gradual contractionary fiscal policy. This policy has the ability to reactivate the economy in the long run, making possible an absolute recovery of the Greek economy. The Greek government deficit would fall under this measure, reducing the level of public debt and improving the expectations of investors about the Greek economy. Consequently, they would smooth the conditions to lend money to the country, asking for a lower interest rate. A low interest rate would raise the aggregate demand through higher level of both consumption and investment, which would foster economic growth. This would improve the economic performance reducing the risk of default in the economy and minimizing the possibilities of a Grexit. However, it is important to mention that the short run effects of this policy are extremely hard, since the contraction of the economy during the first year makes the level of income falling by 4.81%. An important aspect to mention about this scenario is the fact that the interest rate turns negative. This of course would not happen in reality. In the simulation the possibility of having a negative interest rate fosters income and reduces the level public debt indefinitely. Consequently, the growth path that is observed under this scenario would not be that large in reality.

Regarding the two expansionary policies presented in this paper, it stands out the important increase in income in the short run. However, the negative effects on the level of income due to the cumulative debt and interest rate raise make these policies inadequate to reach the objective of fostering the economy in the long run.

In relation with a possible risk premium shock, the simulation shows the difficulty that the Greek economy would have if this situation would happen in reality. The high current levels of public debt and government deficit would impede the economy recovering the

initial level of income after a shock of this type. This clearly indicates that the measures imposed by the Troika in exchange for economic aid and the fiscal policy implemented by the government have not provided the Greek economy the necessary stability to be able to face this possible situation.

Finally, I would like to stand out that the findings of the presented model are restricted to several conditions. Consequently, it is difficult to extrapolate them to reality. Nevertheless, it is fair to say that they offer an approximation to what it would occur if these shocks would take place in Greece. Therefore, although the results are not absolutely accurate, the offer a general idea about what could happen in such a weak economy as Greece.

APPENDIX 1: Figures

(All figures attached in this paper have been own made).

Figure 1: Inflation, consumer prices (annual %)

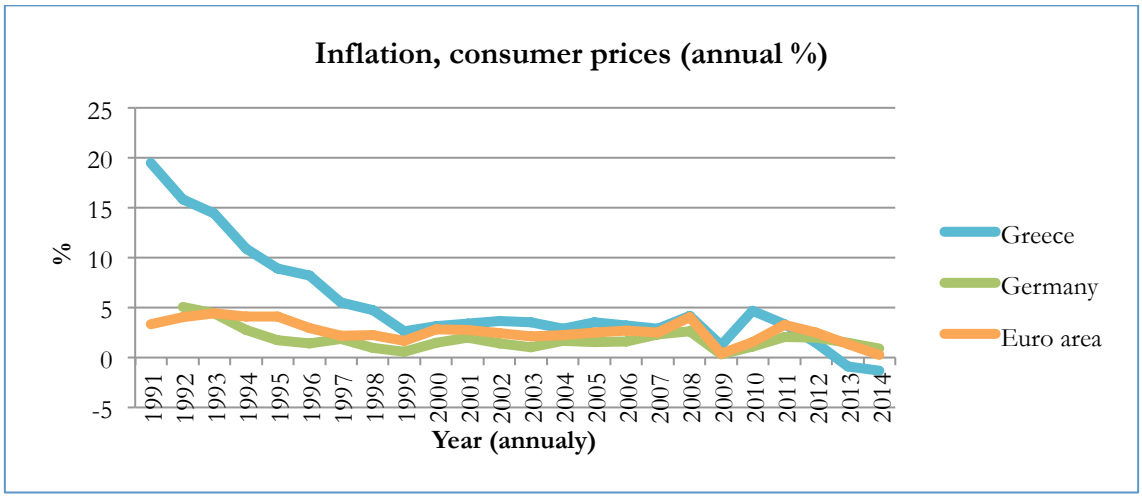


Figure 2: Long-term government bond yields: 10 years

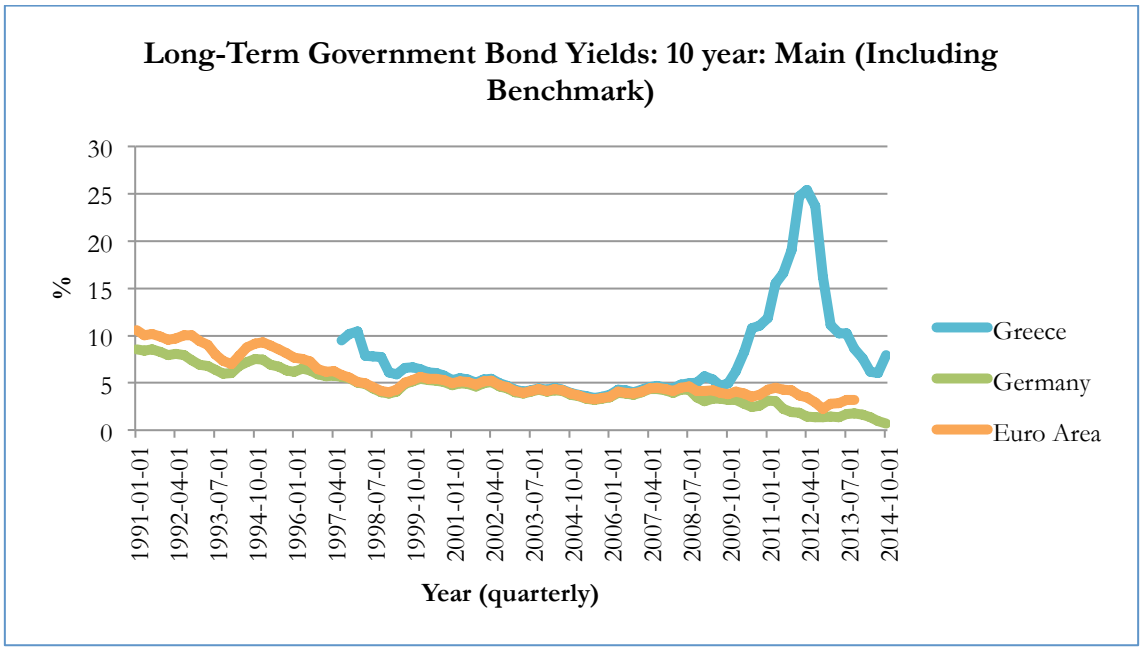


Figure 3: GDP growth (annual %)

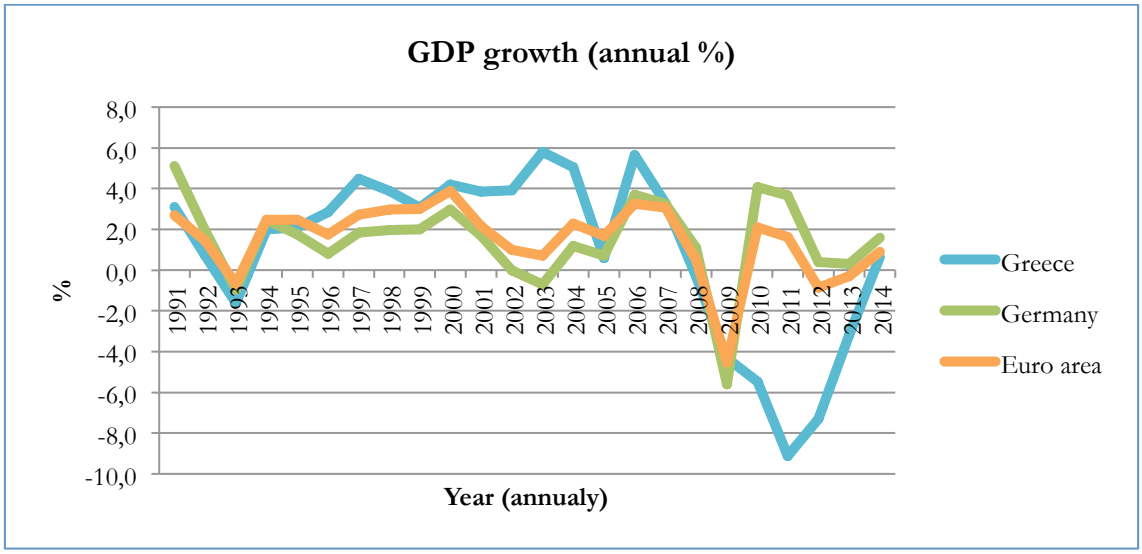


Figure 4: Total Current Account Balance (% of GDP)

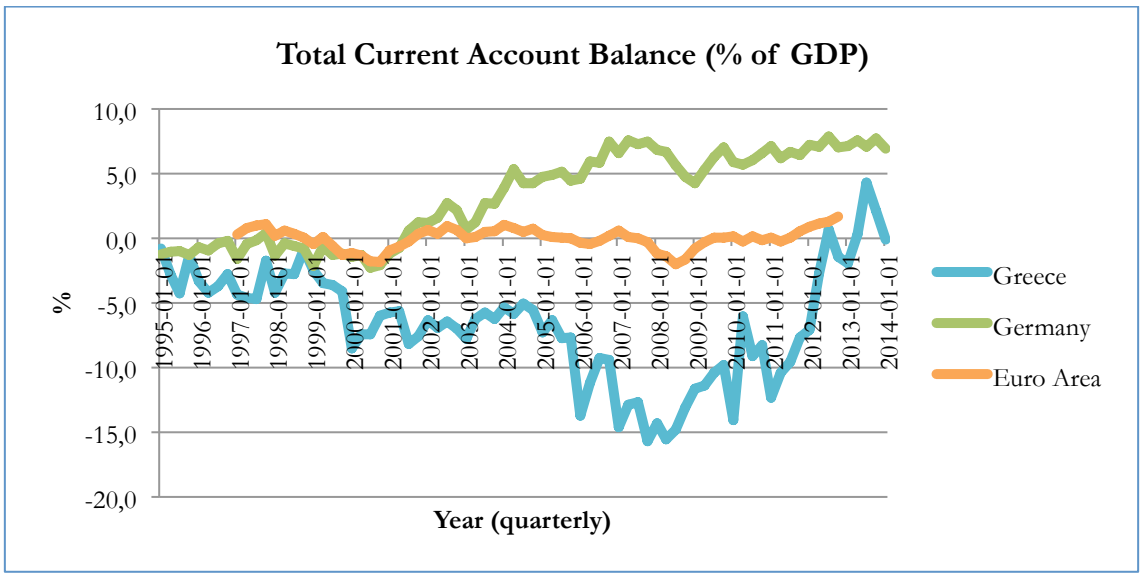


Figure 5: Cash surplus/deficit (% of GDP)

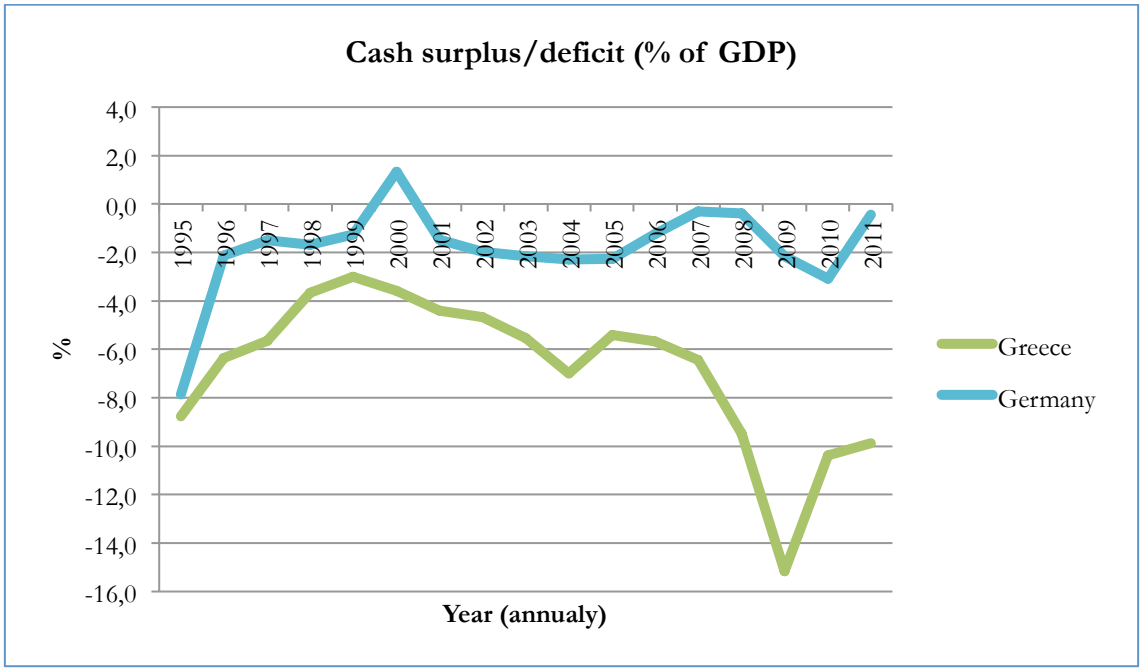


Figure 6: Central government debt, total (% of GDP)

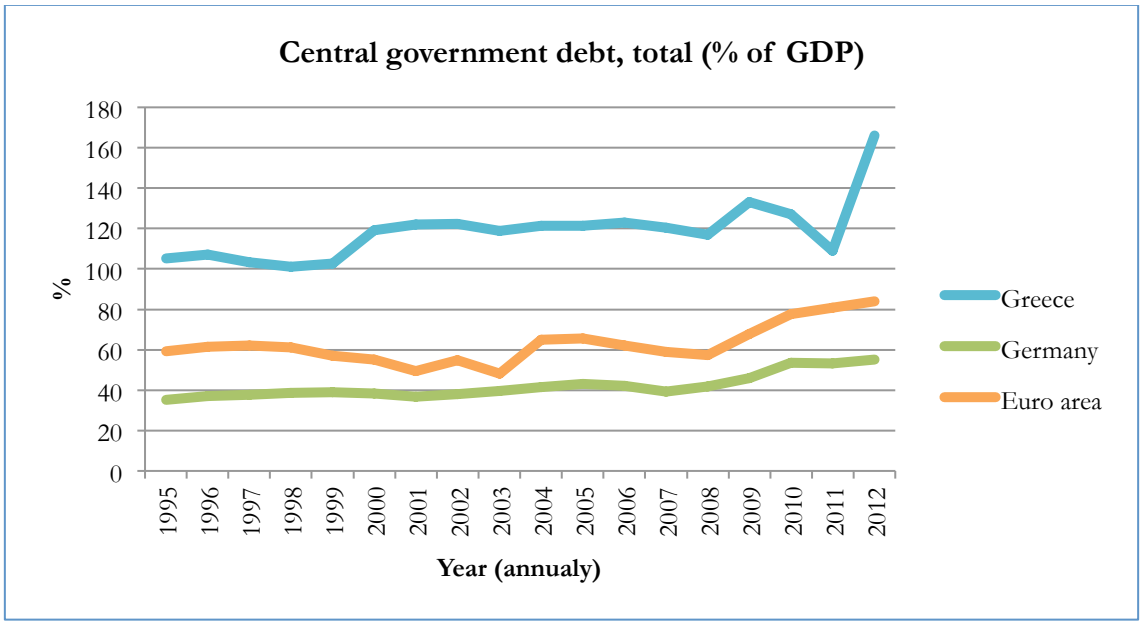


Figure 7: Greek risk premium

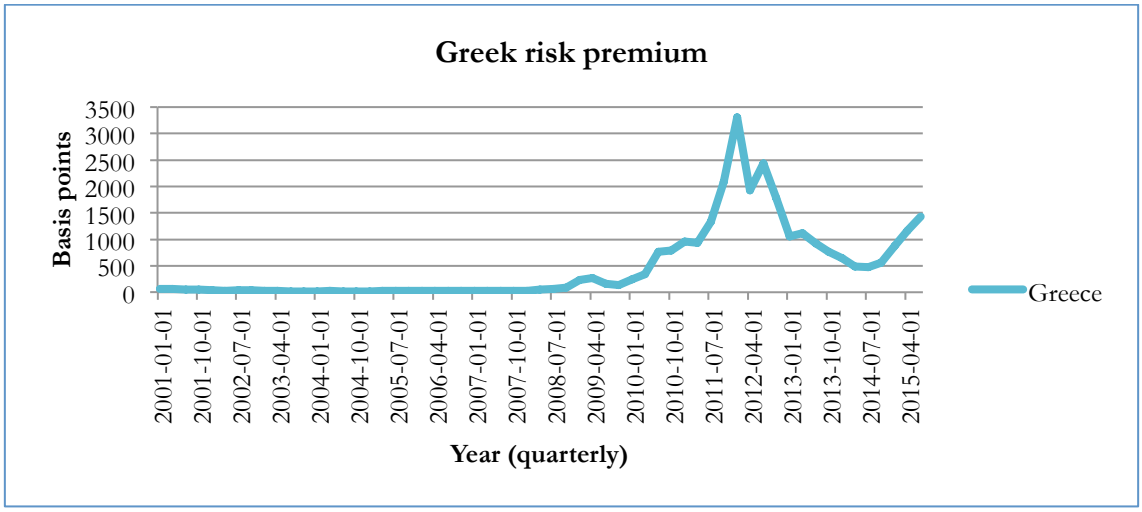


Figure 8: Public pension spending (% of GDP)

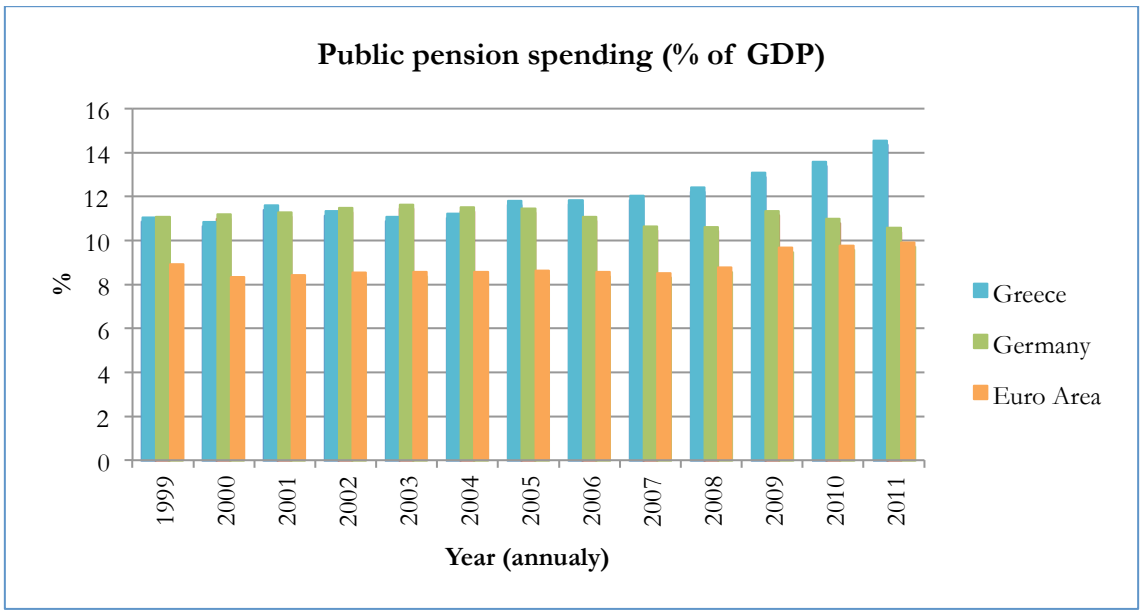
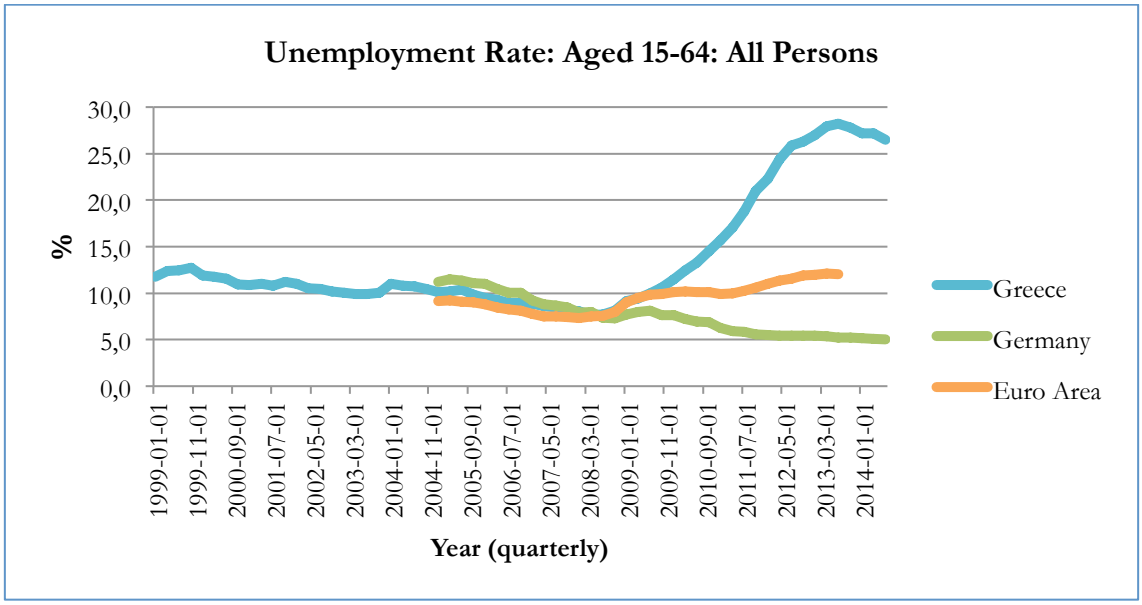


Figure 9: Unemployment Rate: Aged 15-64: All Persons



APPENDIX 2: MSV solution

Model: $Y_t = a_0 - a_1 R_t + u_t$ Income

$R_t = R^* + \mathrm{c}_1 E_t b_{t+1} + \varepsilon_t$ Interest rate

$b_t = b_{t-1} + \mathrm{d}_1(R_t - R^*) + \mathrm{d}_2 u_t$ Public debt

The objective of solving this model is to get the Minimal State Variables solution. The process I have applied to get the final result is the following:

1st Step: Classification of the different types of variables.

- Set of endogenous variables: Y_t, R_t, b_t
- Set of state variables:
  - Predetermined variables (lags): b_{t-1}
  - Exogenous variables: u_t, ε_t

2nd Step: Write down the model under the solution form.

$$Y_t = S_{10} + S_{11} b_{t-1} + S_{12} u_t + S_{13} \varepsilon_t$$

$$R_t = S_{20} + S_{21} b_{t-1} + S_{22} u_t + S_{23} \varepsilon_t$$

$$b_t = S_{30} + S_{31} b_{t-1} + S_{32} u_t + S_{33} \varepsilon_t$$

$$E_t(b_{t+1}) = E(S_{30} + S_{31} b_{t-1} + S_{32} u_t + S_{33} \varepsilon_t)$$

$$= S_{30} + S_{31} b_t + S_{32} E(u_t) + S_{33} E(\varepsilon_t)$$

$$= S_{30} + S_{31} b_t + S_{32} \rho_{\mathrm{u}} u_t + S_{33} \rho_{\varepsilon} \varepsilon_t$$

3rd Step: By applying the undetermined coefficient technique, the right side of each equation in step 2 must be equal to the right side of their corresponding equation in the initial model, after substituting in them the endogenous variables.

Income:

$$S_{10} + S_{11} b_{t-1} + S_{12} u_t + S_{13} \varepsilon_t = a_0 - a_1(S_{20} + S_{21} b_{t-1} + S_{22} u_t + S_{23} \varepsilon_t) + u_t$$

Interest rate:

$$S_{20} + S_{21}b_{t-1} + S_{22}u_t + S_{23}\varepsilon_t = R^* + \mathrm{c}_1(S_{30} + S_{31}b_t + S_{32}\rho_{\mathrm{u}}u_t + S_{33}\rho_{\varepsilon}\varepsilon_t) + \varepsilon_t$$

$$= R^* + \mathrm{c}_1[S_{30} + S_{31}(S_{30} + S_{31}b_{t-1} + S_{32}u_t + S_{33}\varepsilon_t)$$

$$+S_{32}\rho_{\mathrm{u}}u_t + S_{33}\rho_{\varepsilon}\varepsilon_t] + \varepsilon_t$$

$$S_{20} + S_{21}b_{t-1} + S_{22}u_t + S_{23}\varepsilon_t = R^* + \mathrm{c}_1(S_{30} + S_{31}S_{30} + S_{31}^2 b_{t-1} + S_{31}S_{32}u_t +$$

$$S_{31}S_{33}\varepsilon_t + S_{32}\rho_{\mathrm{u}}u_t + S_{33}\rho_{\varepsilon}\varepsilon_t] + \varepsilon_t$$

Public debt:

$$S_{30} + S_{31}b_{t-1} + S_{32}u_t + S_{33}\varepsilon_t = b_{t-1} + \mathrm{d}_1(S_{20} + S_{21}b_{t-1} + S_{22}u_t + S_{23}\varepsilon_t - R^*) +$$

$$\mathrm{d}_2 u_t$$

4th Step: Regarding each of the previous equations, each unknown parameter of the left side must be equal to all the parameter of the right side that contain the same endogenous and state variables.

Income:

1) $S_{10} = a_0 - a_1 S_{20}$

2) $S_{11} = -a_1 S_{21} b_{t-1}$

3) $S_{12} = -a_1 S_{22} + 1$

4) $S_{13} = -a_1 S_{23}$

Interest rate:

5) $S_{20} = R^* + \mathrm{c}_1 S_{30} + \mathrm{c}_1 S_{31} S_{30}$

6) $S_{21} = c_1 S_{31}^2$

7) $S_{22} = \mathrm{c}_1 S_{31} S_{32} + \mathrm{c}_1 S_{32}\rho_{\mathrm{u}}$

8) $S_{23} = \mathrm{c}_1 S_{31} S_{33} + \mathrm{c}_1 S_{33}\rho_{\varepsilon}$

Public debt:

9) $S_{30} = \mathrm{d}_1 S_{20} - \mathrm{d}_1 R^*$

10) $S_{31} = 1 + \mathrm{d}_1 S_{21}$

11) $S_{32} = \mathrm{d}_1 S_{22} + \mathrm{d}_2$

12) $S_{33} = \mathrm{d}_1 S_{23}$

5th Step: Solving for each unknown parameter, it must be obtained the formula that will give the exact value of each of the parameters.

I will start by solving equation (9), since it will bring the solution for S_{31}, the parameter that accompanies the state predetermined variable b_{t-1}, which is raised to the power two. This situation makes the solution more complicated than for the rest of parameters.

The initial formula for equation (9) is $S_{31} = 1 + \mathrm{d}_1 S_{21}$, by substituting S_{21} by the value given by equation (6), the following formula is obtained:

$$S_{31} = 1 + \mathrm{d}_1 c_1 S_{31}^2.$$

This equation can be reformulated as follows:

$$\mathrm{d}_1 c_1 S_{31}^2 - S_{31} + 1 = 0$$

By solving this second order equation, two possible solutions arise:

$$S_{31} = \frac{1 \pm \sqrt{1 - 4 d_1 c_1}}{2 d_1 c_1}$$

Nevertheless, the only correct solution is the so-called bubble free – MSV solution. This implies that the selected solution must fulfil two conditions:

1. Feasibility condition: The solution cannot have an imaginary root. This affects the numerator of the equation, which contains a square root. Consequently, this part of the equation must fulfill the following conditions:

   $1 - 4\mathrm{d}_1 c_1 \geq 0 \quad => \quad 4\mathrm{d}_1 c_1 \leq 1 \quad => \quad \mathrm{d}_1 c_1 \leq 0.25$

   If these conditions hold, the denominator would be indirectly affected in the following way:

   $2\mathrm{d}_1 c_1 \leq 0.5$

2. Stability condition: The fact that the unknown parameter S_{31} is raised to the power two can lead to a bubble response solution, which would imply that any tiny increase in b_{t-1} (public debt of the year before) would raise the public debt of the current year exponentially. This of course does not happen in reality, that is why the solution for this parameter must be bubble free.

   $S_{31}^{+} = \frac{1+\sqrt{1-4d_1c_1}}{2d_1c_1} => |S_{31}^{+}| > 1$ Bubble response

   $S_{31}^{-} = \frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1} => |S_{31}^{-}| < 1$ Bubble free solution

   Because the value of the parameter in absolute terms is lower or equal to 1, when rising to the power two, the value of the previous year public debt will increase in a diminishing way. As a result, this solution is the correct one.

As a result, the final solution is:

10) $S_{31} = \frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}$

After this result the remaining equations have been solved obtaining the following results:

1) $S_{10} = a_0 - a_1R^*$

5) $S_{20} = R^*$

9) $S_{30} = 0$

2) $S_{11} = -a_1c_1\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)^2$

6) $S_{21} = c_1\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)^2$

3) $S_{12} = -a_1\frac{c_1d_1\left[\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)+\rho_u\right]}{1-c_1d_1\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)-\rho_uc_1d_1} + 1$

7) $S_{22} = \frac{c_1d_2\left[\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)+\rho_u\right]}{1-c_1d_1\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)-\rho_uc_1d_1} + 1$

11) $S_{32} = d_1 \frac{c_1 d_2 \left[\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)+\rho_u\right]}{1-c_1d_1\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)-\rho_u c_1 d_1} + d_2$

4) $S_{13} = \frac{-a_1}{1-c_1d_1\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)-\rho_\varepsilon c_1 d_1}$

8) $S_{23} = \frac{1}{1-c_1d_1\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)-\rho_\varepsilon c_1 d_1}$

12) $S_{33} = \frac{d_1}{1-c_1d_1\left(\frac{1-\sqrt{1-4d_1c_1}}{2d_1c_1}\right)-\rho_\varepsilon c_1 d_1}$

APPENDIX 3: Calibration of the model, Matlab outputs

Output 3: OLS linear regression for estimating d_1

Number of observations 55
Number of regressors 1

"	' Estimator'	'SE'	'SE_robust'	't-stat'	'p-val'
'C(1)'	[0.9786]	[0.0339]	[0.0246]	[39.8067]	[0]

R2: 0.9401
Variance of s2: 0.00048268
Log likelihood: 132.9713
D-W statistics: 1.2742

Output 4: OLS linear regression for estimating d_2

Number of observations 54
Number of regressors 1

"	' Estimator'	'SE'	'SE_robust'	't-stat'	'p-val'
'C(1)'	[0.9168]	[0.0661]	[0.1230]	[7.4542]	[9.3470e-10]

R2: 0.78723
Variance of s2: 2.298e-05
Log likelihood: 212.7808
D-W statistics: 1.0069

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