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Tax Rates, Government Spending and TFP A Quantitative Assessment of their Role in the Greek Depression: 1979-2001

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Tax Rates, Government Spending and TFP
A Quantitative Assessment of their Role in the Greek Depression: 1979-2001

Stylianos G. Gogos* Dimitris Papageorgiou† Vanghelis Vassilatos‡

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Abstract

This paper provides a quantitative assessment of the role of government policy and total factor productivity (TFP) in Greek economic performance during the period 1979-2001. According to Kehoe and Prescott (2002, 2007) this period can be characterized as a Great Depression. Our methodology, based upon the work of Cole and Ohanian (1999) and Kehoe and Prescott (2002, 2007), employes growth accounting and a dynamic general equilibrium model. We introduce to the neoclassical growth model a government sector with distortionary taxation, and given the exogenous paths of tax rates, government consumption, TFP, and population, we ask whether our model economy can produce growth accounting characteristics which are similar to that in the data. Our results suggest, that our model economy qualitatively matches the path of key macroeconomic variables (real per capita GDP, capital deepening, and labour hours per capita) of the Greek economy for the period 1979-2001. However, quantitatively and in terms of timing and turning points, there are subperiods were our artificial economy diverges from the data. Furthermore, the presence of distortionary taxation and government spending improves the performance of our model compared to the case of a standard neoclassical setting (see Gogos et al. (2014)). As a result, we conclude that the government sector is important in accounting for Greece's economic performance over the period 1979-2001.

Keywords: Growth Accounting, Total Factor Productivity, Tax Rates, Government Spending, Dynamic General Equilibrium.

JEL: E32, E62, N10, O40

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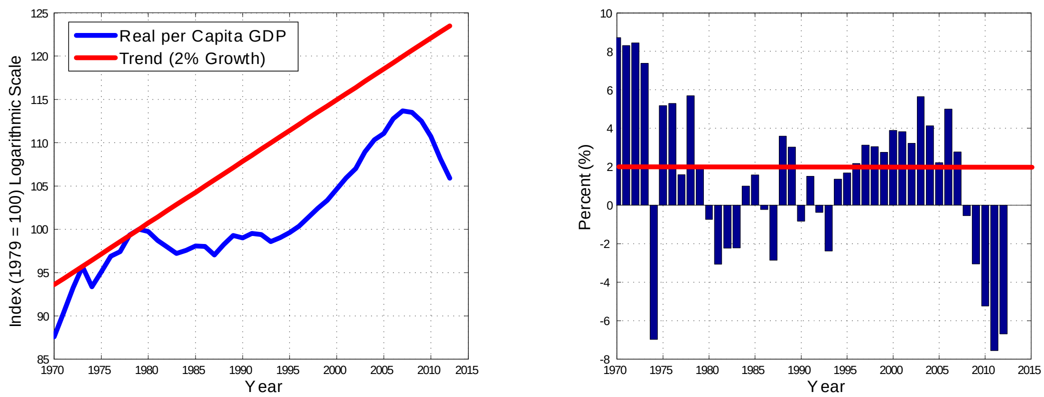
1 Introduction

In this paper we examine whether the neoclassical growth model, augmented with a government sector, can mimic the path of key macroeconomic variables of the Greek economy for the period 1979-2001.[1] Doing this exercise helps us to shed some light on the quantitative role of government policy and TFP for Greece's economic performance.

Following the Kehoe and Prescott (2002, 2007) tradition, we characterize the period 1979-2001 as a great depression. According to their studies, a period of large, rapid, and sustained deviation of real per capita GDP from trend can be characterized as a great depression. Looking at Figure 1 we observe that from 1979 to 2001 the Greek economy experienced such a path (see Gogos et al. (2014) for quantitative details). From 1979 to 1995, detrended real per capita GDP fell by 27.99%, and in 2001, after following a recovery trajectory, it was still far behind, that is 22.84% below its 1979 value. Furthermore, it is worth pointing out, that from the end of 2007 until today Greece is experiencing a new economic depression. The more recently updated data show that in 2012 detrended real per capita GDP was already 28% below its 2007 value. This magnitude is similar with the trough of the first great depression episode. However, the timing is different. The ongoing crisis in much more steep. It took only one third, of the time period of the first crisis, for detrended real per capita GDP to reach the same level.



(a) Real per Capita GDP (b) Growth Rate of Real per Capita GDP

Figure 1: Aggregate Economic Performance 1970-2012

Since we measure economic performance relative to trend, we define detrended real per capita GDP as follows:

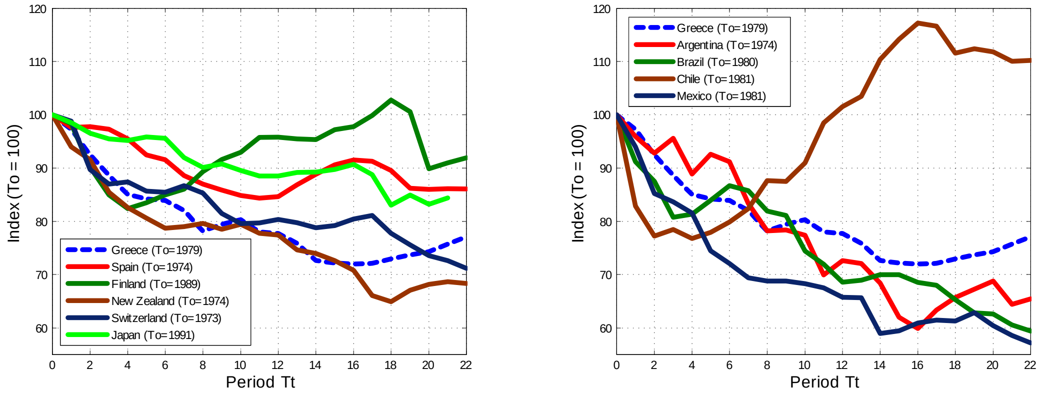
$$\widetilde{y_t} = \frac{y_t}{g^{t-T_0} y_{T_0}} \tag{1}$$

where g is the gross trend growth rate and T_0 is the starting year of the detrending period.[2] As in Kehoe and Prescott (2002), we define the trend growth rate as the average annual real per capita GDP growth rate of the industrial leader of the world economy. In the 20th century this was the United States of America with an average annual growth rate of real per capita GDP of 2 %. Hence, in our case, trend real per capita GDP is assumed to grow at this 2% rate.

Looking at Figure 2 we observe that other countries as well have experienced great depression events during the last forty years. These are: Japan, New Zealand, Spain, Switzerland, Finland, Argentina, Mexico, Brazil, and Chile. From these 10 countries (including Greece), only Chile and Finland managed to return, and also to pass by, their detrending real per capita GDP value in the start of their depression. All the other countries experienced a poor economic performance for at least one decade or more. The Latin America countries had the deepest depressions, while in Japan and Spain the fall of detrended real per capita GDP was not so severe. Greece, New Zealand, and Switzerland, are more close to the first group than in the second.

[1] We focus on the equilibrium paths of key macroeconomic variables and not in their statistical properties as is the case in the standard DSGE literature.

[2] In our case $T_0 = 1979$.

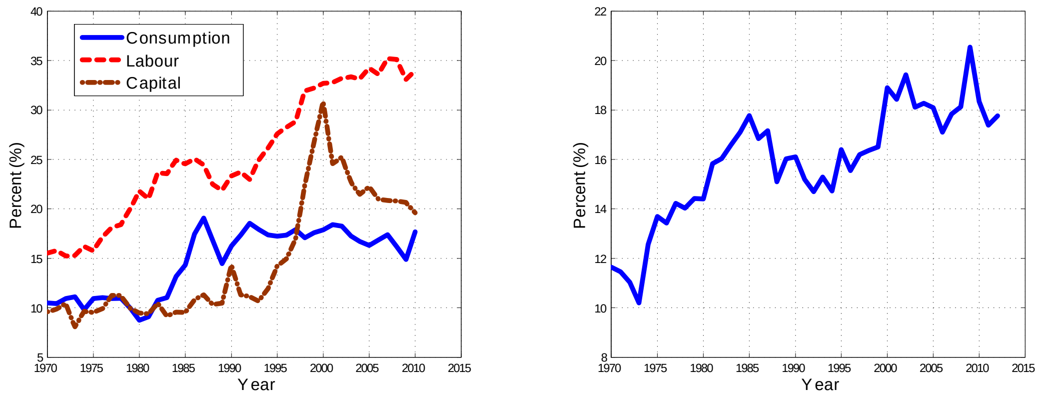


(a) Detrended Real per Capita GDP (b) Detrended Real per Capita GDP

Figure 2: Great Depressions of the 20th Century

The above economic events have been well studied in the literature. Following the seminal work of Cole and Ohanian (1999) a series of studies analyze these great depression episodes using a common analytical framework, that is, neoclassical growth theory and extensions of it. The majority of results point out the important role of TFP and government policy in accounting for poor economic performance. For example, Conesa and Kehoe (2007) find that the evolution of tax rates can explain more than 70% of the fall in labour hours per capita which led the Spanish economy to stagnate between 1974 and 1986. Furthermore, Conesa et al. (2007) conclude that the sharp drop in Finnish real per capita GDP over the period 1990-1993 was driven by a combination of a drop in TFP during 1990-1992 and of increases in taxes on labour and consumption and increases in government consumption during 1989-1994, which drove down hours worked in Finland. Moreover, Kehoe and Ruhl (2007), Kydland and Zarazaga (2002), and Kehoe (2003) support the idea that the evolution of TFP can account rather well for the economic performance of New Zealand and Switzerland for the period 1973-2000, and Argentina for the period 1974-2002. Finally, Bergoeing et al. (2002) conclude that the difference in timing of government policy reforms, in terms of banking and bankruptcy procedures, can explain the fact that the economy of Chile exploded in the mid 80's while, for the same period, the Mexican economy stagnated.

To study Greece's economic performance we employ similar tools of macroeconomic analysis as that in the above studies. In our analysis, government policy takes the form of tax rates, on consumption expenditures and income (labour and capital), and government consumption expenditures.



(a) Marginal Effective Tax Rates (b) Government Consumption Over GDP

Figure 3: Government Sector 1970-2012

Looking at Figure 3 and Table 1 we observe the following facts in terms of the paths of government policy variables:[3] First, government consumption over GDP and the marginal effective tax rate on labour income show clearly an upward trend, with the former variable to have a higher degree of variance than the latter one.[4]

[3]We follow Gogos et al. (2014) and we decompose the period 1973-2012 into five subperiods, that is 1973-1979, 1979-1995, 1995-2001, 2001-2007, 2007-2012 (see section 4). This decomposition is not a trivial one. The period 1979-2001 strictly meets the Kehoe and Prescott (2002, 2007) criteria for it to be named as a great depression, and in the end of 2007 we observe a turning point in economic activity which marks the beggining of a new depression episode.

[4]See Appendix A for the methodology that we adopt to construct the marginal effective tax rates. In Appendix B we present the sources of our data.

Second, during the depression period, government consumption over GDP shows an upward and downward path behaviour. From 1979 to 1985 it increases from 14.41% to 17.77%, then in 1994 it falls to a level of 14.73%, and finally in 2001 it increases to a level of 18.43%. The marginal effective tax rate on labour income follows a somewhat similar pattern. From 1979 to 1986 it increases from 20.4% to 25.08%, then in 1992 it reaches a level of 22.98%, and in 2001 it increases to a level of 32.79%. Third, in terms of the path of the marginal effective tax rate on capital income, we observe a big jump from 1993 to 2000 (10.69% to 30.84%) and a big fall from 2000 to 2010 (30.84% to 19.6%). Finally, the effective tax rate on consumption expenditures increases remarkably between 1980 to 1987 (8.74% to 19.08%), and then, between 1993 to 2003, it follows an almost constant path (an average value of 17.66%).

Table 1: Government Policy Variables (% Values)

	1973	1979	1995	2001	2007	2012 2010 (τ_t^c, τ_t^l, τ_t^k)
τ_t^c	11.1	9.96	17.24	18.41	17.39	17.67
τ_t^l	15.31	20.4	27.58	32.79	35.21	34
τ_t^k	8.09	9.96	14.25	24.59	20.85	19.6
$\frac{G_t}{Y_t}$	10.2	14.41	16.4	18.43	17.83	17.75

Except of examining the role of government policy we also take into account that of TFP. As is depicted at Figure 4 the proportional change of TFP factor and that of real per capita GDP show a strong positive correlation (correlation coefficient equal to 86.44%).[5] In a similar study, that is, Gogos et al. (2014), the authors, examine the role of TFP in accounting for Greece's economic performance (for the same period as we do) in a standard neoclassical setting.[6] Their conclusions reveal that the path of TFP can account rather well for the overall performance of the Greek economy. Our purpose in this study is to move this research one step further by introducing a government sector to the neoclassical growth model. This exercise helps us to quantitatively assess the combined role of tax rates, government consumption, and TFP in Greece's economic performance during the period 1979-2001.

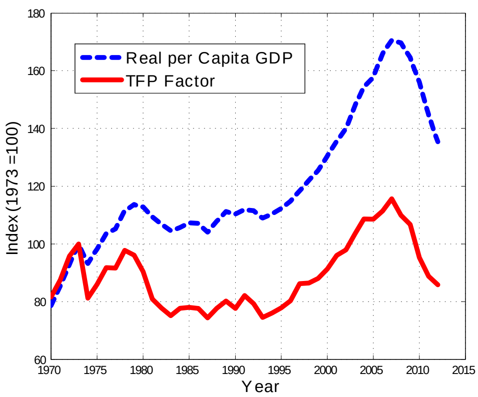


Figure 4: Real per Capita GDP and TFP Factor

Our methodology, developed by Cole and Ohanian (1999) and Kehoe and Prescott (2002, 2007) for studying "Great Depression" economic episodes, employes the technique of growth accounting and a dynamic general equilibrium model. As a first step, we perform the growth accounting exercise. There, by employing a standard neoclassical production function, we decompose the growth rate of real per capita GDP into three components. These are, TFP factor, capital deepening, and labour hours per capita. Then, by simulating a calibrated dynamic general equilibrium model, we ask whether given the path of the exogenous variables of the model (tax rates, government consumption, TFP and population) our artificial economy produces growth accounting characteristics which are close to the data. Our results suggest, that our model qualitatively matches the path of the key macroeconomic variables of the Greek economy for the period 1979-2001. However, quantitatively, there are subperiods were our artificial economy diverges from the data. Furthermore, the presence of distortionary taxation and government spending improves the performance of our model compared to the case of a standard neoclassical setting (see Gogos et al. (2013) for the latter case). As a result, we conclude that the government sector is important in accounting for Greece's economic performance over the period 1979-2001.

The paper is organized as follows: Section 2 presents the structure of our model along with the conditions that characterized the decentralized competitive equilibrium. Section 3 presents the procedures that we adopt for calibration of the parameters and for computing the exogenous variables of the model. Section 4 presents

[5] See section 4 for the definition of the TFP factor and section 2.2 for that of TFP.

[6] Since we use the same methodology and the same data as in Gogos et al. (2014), our results are comparable with this study.

the growth accounting exercise. Section 5 presents the transition dynamics. Section 6 presents the results. Finally, section 7 concludes.

2 The Model

Our model is the neoclassical growth model, augmented with a government sector. The artificial economy consists of a large number of infinitively live identical households, a large number of identical firms, and a government sector. There is no uncertainty (we assume perfect foresight) and all markets operate under perfect competition. The representative household chooses paths of consumption, capital and labour. The representative firm produces a homogenous product using capital, labour, and the available technology. The government levies distortionary taxes and uses the revenues to finance government consumption and lump-sum transfers to households. We solve for a symmetric decentralized competitive equilibrium where: (i) each individual household and each individual firm maximize respectively their own utility and profits by taking as given market prices and government policy, (ii) the government budget constraint is satisfied and (iii) all markets clear through price flexibility.

2.1 Households

Each period t there are N_t identical households ($h = 1, 2, 3...N_t$). Their population grows at a constant rate $\frac{N_{t+1}}{N_t} = n$. The lifetime utility of the representative household h is:

$$\sum_{t=T_o}^{\infty} {\beta^*}^t U\left(C_t^h, H_t^h\right) \tag{2}$$

where $0 < \beta^* < 1$ is the time discount factor, C_t^h is real consumption expenditure, and H_t^h is hours of leisure. For the instant utility function, we use a loglinear form:

$$U(C_t^h, H_t^h; \gamma) = \gamma \log C_t^h + (1-\gamma) \log H_t^h \ , \ 0 < \gamma < 1 \tag{3}$$

where γ is the consumption share parameter.

The representative household h receives a real rental rate of capital, r_t, and a real wage rate, w_t, for its capital, K_t^h, and labour services, L_t^h. Furthermore, it receives a share of profits, Π_t^h, as a shareholder of firms, and lump-sum transfers from the government, T_t^h. Thus, the household's budget constraint is:

$$(1+\tau_t^c)C_t^h + I_t^h = (1-\tau_t^l)w_t L_t^h + r_t K_t^h - \tau_t^k (r_t - \delta) K_t^h + \Pi_t^h + T_t^h \tag{4}$$

where $0 < \tau_t^c < 1$, $0 < \tau_t^l < 1$, and $0 < \tau_t^k < 1$, are the common effective tax rates on consumption, labour income, and net capital income respectively.

Finally, for every period t it has at its disposal $\overline{h}$ available hours for leisure and work activities.[7] Thus:

$$\overline{h} = H_t^h + L_t^h \tag{5}$$

The capital stock evolves according to the following equation:

$$K_{t+1}^h = (1-\delta) K_t^h + I_t^h \tag{6}$$

where I_t^h is real investment expenditure.

Each household h acts competitively by taking prices, policy and economy-wide variables as given. To solve for household's optimization behaviour we work as follows: First we solve equation (6) for I_t^h and we insert this result to equation (4) and then solve for consumption, C_t^h. Thus:

$$(1+\tau_t^c)C_t^h + K_{t+1}^h = (1-\tau_t^l)w_t n_t^h L_t^h + (1 + (1-\tau_t^k)(r_t - \delta))K_t^h + \Pi_t^h + T_t^h$$

$$\Rightarrow C_t^h = \left(\frac{1}{1+\tau_t^c}\right)\left((1-\tau_t^l)w_t n_t^h L_t^h + (1 + (1-\tau_t^k)(r_t - \delta))K_t^h - K_{t+1}^h + \Pi_t^h + T_t^h\right) \tag{7}$$

Second, we solve equation (5) for leisure time, H_t^h, thus:

$$H_t^h = \overline{h} - L_t^h \tag{8}$$

[7] Here we make the following assumption: Each day the household has 14 hours available for market activities. Then each year the available hours for market activities for each household are 14*7*52=5096.

Substituting equations (7) and (8) into equation (2) the problem of the representative household can be written as follows:

$$\max_{\{K_{t+1}^h, L_t^h\}_{t=T_0}^{\infty}} \sum_{t=T_o}^{\infty} {\beta^*}^t U\left(\frac{1}{1+\tau_t^c}\left((1-\tau_t^l)w_t n_t^h L_t^h + (1+(1-\tau_t^k)(r_t-\delta))K_t^h - K_{t+1}^h + \Pi_t^h + T_t^h\right), \overline{h} - L_t^h\right) \tag{9}$$

subject to:

$$C_t^h, I_t^h, K_t^h, H_t^h, L_t^h, K_{T_0}^h > 0$$

$$K_{T_0}^h > 0 \text{ given}$$

Taking the first order necessary conditions with respect to K_{t+1}^h and L_t^h we obtain:

$$-{\beta^*}^t U_{C_t^h}\left(C_t^h, H_t^h\right)\frac{1}{1+\tau_t^c} + {\beta^*}^{t+1} U_{C_{t+1}^h}\left(C_{t+1}^h, H_{t+1}^h\right)\frac{1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)}{1+\tau_{t+1}^c} = 0$$

$$\Rightarrow \frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta^*\left(1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)\right) = \frac{U_{C_t^h}\left(C_t^h, H_t^h\right)}{U_{C_{t+1}^h}\left(C_{t+1}^h, H_{t+1}^h\right)} \tag{10}$$

and

$${\beta^*}^t\left(U_{C_t^h}\left(C_t^h, H_t^h\right)\frac{1-\tau_t^l}{1+\tau_t^c}w_t - U_{H_t^h}\left(C_t^h, H_t^h\right)\right) = 0$$

$$\Rightarrow \frac{1-\tau_t^l}{1+\tau_t^c}w_t = \frac{U_{H_t^h}\left(C_t^h, H_t^h\right)}{U_{C_t^h}\left(C_t^h, H_t^h\right)} \tag{11}$$

The optimality conditions are completed with the transversality condition for the one asset of our economy which is capital:

$$\lim_{t\to\infty} {\beta^*}^t U_{C_t^h}\left(C_t^h, H_t^h\right) K_{t+1} = 0 \tag{12}$$

If we substitute the instant utility function into household's optimality conditions and the transversality condition, equations (10) to (12) become:

$$\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta^*\left(1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)\right) = \frac{\gamma\frac{1}{C_t^h}}{\gamma\frac{1}{C_{t+1}^h}}$$

$$\Rightarrow \frac{C_{t+1}^h}{C_t^h} = \frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta^*\left(1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)\right) \tag{13}$$

$$\frac{1-\tau_t^l}{1+\tau_t^c}w_t = \frac{(1-\gamma)\frac{1}{\overline{h}-L_t^h}}{\gamma\frac{1}{C_t^h}}$$

$$\Rightarrow \frac{1-\gamma}{\gamma}\frac{C_t^h}{\overline{h}-L_t^h} = \frac{1-\tau_t^l}{1+\tau_t^c}w_t \tag{14}$$

$$\lim_{t\to\infty} {\beta^*}^t \frac{\gamma}{C_t^h} K_{t+1}^h = 0 \tag{15}$$

2.2 Firms

Each period of time t there are M_t identical firms ($f = 1, 2, 3...M_t$). Firms operate in perfectly competitive markets (price takers), using a Cobb-Douglas constant returns to scale technology:

$$Y_t^f = A_t\left(K_t^f\right)^{\alpha}\left(L_t^f\right)^{1-\alpha} \tag{16}$$

where Y_t^f is the output of the representative firm f, $0 < \alpha < 1$ is the capital share, and A_t is total factor productivity (TFP) which grows at an exogenously given rate $\frac{A_{t+1}}{A_t} = g^{1-\alpha}$.

The representative firm f chooses, in each period t, the quantity of labour, L_t^f, and capital, K_t^f, in order to maximize profits, Π_t^f:

$$\max_{L_t^f,\ K_t^f} \Pi_t^f = Y_t^f - w_t L_t^f - r_t K_t^f \tag{17}$$

subject to equation (16).

Taking the first order necessary conditions with respect to L_t^f and K_t^f we get the following two optimality conditions:

$$w_t = (1-a)A_t \left(K_t^f\right)^{\alpha} \left(L_t^f\right)^{-\alpha} \tag{18}$$

and

$$r_t = aA_t \left(K_t^f\right)^{\alpha-1} \left(L_t^f\right)^{1-\alpha} \tag{19}$$

2.3 Government

The government collects tax revenues, R_t, by taxing consumption expenditures, labour income, and net capital income. Then, it uses the tax revenues to finance per capita consumption expenditures, G_t^h, and per capita lump-sum transfers, T_t^h. Thus, the government budget constraint is:

$$\sum_{h=1}^{N_t} G_t^h + \sum_{h=1}^{N_t} T_t^h = R_t \tag{20}$$

where

$$R_t = \tau_t^l w_t \sum_{h=1}^{N_t} L_t^h + \tau_t^k \left(r_t - \delta\right) \sum_{h=1}^{N_t} K_t^h + \tau_t^c \sum_{h=1}^{N_t} C_t^h \tag{21}$$

2.4 The Decentralized Competitive Equilibrium (DCE)

The DCE consists of a vector of quantities for the representative household, $\{Y_t^h, C_t^h, I_t^h, \Pi_t^h, K_{t+1}^h, L_t^h, H_t^h, T_t^h\}_{t=T_0}^{\infty}$, a vector of quantities for the representative firm $\{Y_t^f, K_t^f, L_t^f, \Pi_t^f\}_{t=T_0}^{\infty}$ and a vector of prices $\{w_t, r_t\}_{t=T_0}^{\infty}$, such that, given sequences for the exogenous variables $\{A_t, N_t, G_t, \tau_t^c, \tau_t^l, \tau_t^k\}_{t=T_0}^{\infty}$and the initial real capital stock $K_{T_0}^h$:

(a) Given prices $\{w_t, r_t\}_{t=T_0}^{\infty}$, the vector of quantities for the household,$\{Y_t^h, C_t^h, I_t^h, \Pi_t^h, K_{t+1}^h, L_t^h, H_t^h, T_t^h\}_{t=T_0}^{\infty}$ solves the household's maximization problem.

(b) Given prices $\{w_t, r_t\}_{t=T_0}^{\infty}$, the vector of quantities for the firm $\{Y_t^f, K_t^f, L_t^f, \Pi_t^f\}_{t=T_0}^{\infty}$ solves the firm's maximization problem.

(c) Given prices $\{w_t, r_t\}_{t=T_0}^{\infty}$, the vector of quantities for the household,$\{C_t^h, K_{t+1}^h, L_t^h, T_t^h\}_{t=T_0}^{\infty}$ satisfies the government budget constraint.

(d) Given the vectors of quantities for households and firms, $\{Y_t^h, C_t^h, I_t^h, \Pi_t^h, K_{t+1}^h, L_t^h, H_t^h, T_t^h\}_{t=T_0}^{\infty}$, $\{Y_t^f, K_t^f, L_t^f, \Pi_t^f\}_{t=T_0}^{\infty}$, the vector of prices $\{w_t, r_t\}_{t=T_0}^{\infty}$ is such that all markets clear. Thus, in each period t, the market clearing conditions for the goods market, the labour market, the capital market, and profits market, are respectively:

$$\sum_{f=1}^{M_t} Y_t^f = \sum_{h=1}^{N_t} Y_t^h \tag{22}$$

$$\sum_{f=1}^{M_t} L_t^f = \sum_{h=1}^{N_t} L_t^h \tag{23}$$

$$\sum_{f=1}^{M_t} K_t^f = \sum_{h=1}^{N_t} K_t^h \tag{24}$$

$$\sum_{f=1}^{M_t} \Pi_t^f = \sum_{h=1}^{N_t} \Pi_t^h = 0 \tag{25}$$

Hence, the decentralized competitive equilibrium is summarized by equations (5), (6), (7), (13), (14), and (16) to (25). This is a system of fifteen equations in fifteen unknowns, that is:

$$Y_t^h, C_t^h, I_t^h, \Pi_t^h, K_{t+1}^h, L_t^h, H_t^h, T_t^h, Y_t^f, K_t^f, L_t^f, \Pi_t^f, R_t, w_t, r_t$$

in each period t.

2.5 The Aggregate Economy

In terms of aggregate quantities, the DCE can be reduced to a system in ten equations and ten unknowns. These are:

Wage rate:

$$w_t = (1-a)A_t K_t^{\alpha} L_t^{-\alpha} \tag{26}$$

Rental rate of capital:

$$r_t = aA_t K_t^{\alpha-1} L_t^{1-\alpha} \tag{27}$$

Production function:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{28}$$

Budget constraint:

$$(1+\tau_t^c)C_t + K_{t+1} = (1-\tau_t^l)w_t L_t + (1+(1-\tau_t^k)(r_t-\delta))K_t + T_t \tag{29}$$

Time constraint:

$$N_t\overline{h} = H_t + L_t \tag{30}$$

Law of motion of capital Stock:

$$K_{t+1} = (1-\delta)\,K_t + I_t \tag{31}$$

Euler equation:

$$\frac{C_{t+1}}{C_t} = \frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta\left(1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)\right) \tag{32}$$

Trade off between labour and leisure time:

$$\frac{1-\gamma}{\gamma}\frac{C_t}{N_t\overline{h}-L_t} = \frac{1-\tau_t^l}{1+\tau_t^c}w_t \tag{33}$$

Government budget constraint:

$$G_t + T_t = R_t \tag{34}$$

Revenues equation:

$$R_t = \tau_t^l w_t L_t + \tau_t^k\,(r_t-\delta)\,K_t + \tau_t^c C_t \tag{35}$$

where $\beta = \beta^* n$. Hence, the decentralized competitive equilibrium in aggregate terms is summarized by equations (26) to (35). This is a system of ten equations in ten unknowns, that is:

$$Y_t, C_t, I_t, K_{t+1}, L_t, H_t, T_t, R_t, w_t, r_t$$

in each period t.

3 Data and Model

To perform the growth accounting exercise and then to simulate our model economy, we must first calibrate the values of the parameters, and assign values to the exogenous variables, and to the initial real capital stock K_{T_0}. To do so we work as follows: First, we match up model's variables and data. Second, we compute series for the real capital stock, K_t, along with a value for the depreciation rate, δ. Third, we produce an estimate for the labour share parameter, $1-\alpha$. Fourth, we calibrate the values for the parameters β and γ. Finally, we produce series for TFP, A_t.

3.1 Match up Model's Variables and Data

All data have been extracted from OECD and Groningen Growth Development Center (GGDC) databases. Since our model economy is a closed one with a government sector, the income identity takes the form $Y_t = C_t + I_t + G_t$. We define Y_t as real gross domestic product (at factor prices), I_t as real gross fixed capital formation, and G_t as real general government final consumption expenditure.[8]

Thus, using the income identity we obtain households real consumption expenditure, C_t, residually. That is:

$$C_t = Y_t - I_t - G_t \tag{36}$$

[8] In order to convert real gross domestic product from market prices to factor prices we subtract from it net indirect taxes, that is taxes less subsidies on production and imports.

Given the structure of our model, this specification implies that government consumption is wasted or alternatively finances the provision of public goods that enter separably in the utility function of the representative household, that is $U(C_t^h, H_t^h; \gamma, \eta) = \gamma \log C_t^h + (1-\gamma)\log H_t^h + \eta \log G_t^h$. Furthermore, we also run numerical experiments under the hypothesis that all tax proceeds are rebated to households as lump-sum transfers. Under this specification we set $G_t = 0$ in the income identity and in the government budget constraint. This implies that all government revenues go to transfers, such as pensions or unemployment subsidies, or to purchases of goods and services that would otherwise be provided privately, such as education or health care.[9]

3.2 Capital Stock and Input Shares

3.2.1 Capital Stock

To obtain series for the real capital stock we apply the perpetual inventory method by employing the law of motion of real capita stock (eq. 31) and data for real investment expenditures, I_t. To do so, we impose two restrictions in order to obtain a value for the depreciation rate parameter, δ, and the initial real capital stock K_{T_0}. The restrictions have as follows: First, for the period 1970-2012, the ratio of consumption of fixed capital over GDP must be equal with that in the data (11.34% for Greece). Hence:

$$\frac{1}{43}\sum_{t=1970}^{2012}\frac{\delta K_t}{Y_t} = 11.34\% \tag{37}$$

Second, the capital - output ratio in the initial period (in our case 1960) must be equal to the average capital - output ratio over the period 1961-1970. Thus:

$$\frac{K_{1960}}{Y_{1960}} = \frac{1}{10}\sum_{t=1961}^{1970}\frac{K_t}{Y_t} \tag{38}$$

Equations (31), (37), and (38) constitute a system of 54 equations in 54 uknowns(K_0, K_1,...K_{2012}, and δ). The solution of this system, along with the real capital stock series, implies $\delta = 3.63\%$ and $\frac{K_{1960}}{Y_{1960}} = 1.7244$.[10]

3.2.2 Input Shares

In order to get values for the input shares we work as follows: Given the fact that the self-employed are a considerable fraction of total employment (well above 30% over the period 1970-2012) we produce an estimate of total compensation for the self-employed. This is done by dividing total compensation of employees (net of employer's contributions to social security) with total dependent employment and then multiplying this with total self employment. The result is the imputed total compensation of the self-employed. To compute the labour share in output, we add total compensation of self-employed to total compensation of employees and then divide this number with real GDP at factor prices.[11] Hence:

$$\text{Labour Share} = \frac{TCE_t^{DE} + TCE_t^{SE}}{Y_t - NIT_t} \tag{39}$$

where TCE^{DE} is total compensation of employees that belong to dependent employment, TCE^{SE} is the imputed total compensation of the self-employed, and NIT is net indirect taxes, i.e. indirect taxes less subsidies on production and imports. Taking the average of equation (39) over the period 1970-2010, we compute a value for the labour share parameter, $1-\alpha$, equal to 56.69%.[12]

3.3 Calibration for β, γ

The time discount factor is calibrated using the Euler equation (eq. 32). This is written in the following way:

$$\beta = \frac{\frac{C_{t+1}}{C_t}}{\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\left(1 + (1-\tau_{t+1}^k)(a\frac{Y_{t+1}}{K_{t+1}} - \delta)\right)} \tag{40}$$

[9] Conesa et al. (2007), Conesa and Kehoe (2007), and Prescott (2002), use similar specification in terms of allocating government revenues to transfers and government consumption.

[10] Since we examine the economic performance of Greece for the period 1979-2001, by choosing 1960 as our initial period for computing capital stock series we decrease the effect of our choice on the constructed series. By 1970 (starting year of our simulations) 30.9% of the 1960 capital stock will have been depreciated.

[11] This method has been proposed by Gollin (2002).

[12] Similar values can also be found in Papageorgiou (2012). Furthermore, the Groningen Growth and Development Center (GGDC) database, for the period 1990-2010, provides an average for the labour share parameter equal to 54.73%. In our series the average for the same period is 55.69%.

The consumption share parameter is calibrated using the labour - leisure trade-off equation (eq. 33). This is written in the following way:

$$\gamma = \frac{1}{\frac{1-\tau_t^l}{1+\tau_t^c}\frac{Y_t}{C_t}\frac{N_t\overline{h}-L_t}{L_t}(1-a)+1} \tag{41}$$

Given data on C_t, Y_t, K_t, L_t, τ_t^c, τ_t^l, τ_t^k and values for α, δ, and h, we take the average of equations (40, 41) over the period 1970-2009 and we compute a value for β and γ. Since we run numerical experiments under two different specifications in terms of allocating government revenues to transfers and government consumption, for each case we obtain different calibrated values for β and γ. Furthermore, we also examine two different cases in terms of the paths of the marginal effective tax rates. In the first, we hold constant the tax rates in their average value during the period 1970-2010, and in the second we use their actual paths (see Figure 3(a)). The calibrated values for β and γ (given α, δ, and h) have as follows:[13]

Table 3: Calibration

		β	γ
Tax Rates	Average (1970-2010)		
Income Identity	$Y_t = C_t + I_t$	0.949	0.3954
	$Y_t = C_t + I_t + G_t$	0.947	0.3342
Tax Rates	Actual Paths		
Income Identity	$Y_t = C_t + I_t$	0.9499	0.3956
	$Y_t = C_t + I_t + G_t$	0.9479	0.3343

3.4 Total Factor Productivity, A_t

As in Conesa et al. (2007) the exogenous TFP series which we feed into the model are obtained using GDP at factor prices. That is:

$$A_t = \frac{Y_t}{K_t^\alpha L_t^{1-\alpha}} \tag{42}$$

Hence, given data on Y_t, K_t, L_t, and a value for α, we obtain series for A_t.

However, in the growth accounting exercise, when we report the contribution of TFP to growth we calculate TFP as conventionally measured, that is using GDP at market prices. Since our model economy will produce an output Y_t which is measured at factor prices, to make our results comparable with the data, we convert this into market prices. This is done by writing output at market prices as:

$$\widehat{Y_t} = (1+\tau_{\overline{T}}^c)C_t + I_t + G_t \tag{43}$$

and

$$\widehat{A_t} = \frac{\widehat{Y_t}}{K_t^\alpha L_t^{1-\alpha}} \tag{44}$$

where $\overline{T}$ is the base year (for Greece this is 2005).

4 Growth Accounting

Our growth accounting exercise follows the approach adopted by the "Great Depressions Methodology". More specifically, we decompose real per capita GDP into three factors: The TFP Factor, $A_t^{\frac{1}{1-a}}$, the capital factor (capital deepening), $\left(\frac{K_t}{Y_t}\right)^{\frac{a}{1-a}}$, and the labour factor, $\frac{L_t}{N_t}$. This is done by writing the production function (eq. 28) of our model in the following equivalent form:

$$\frac{Y_t}{N_t} = A_t^{\frac{1}{1-a}}\left(\frac{K_t}{Y_t}\right)^{\frac{a}{1-a}}\frac{L_t}{N_t} \tag{45}$$

or in natural logarithms:

$$\ln\frac{Y_t}{N_t} = \frac{1}{1-a}\ln A_t + \frac{a}{1-a}\ln\frac{K_t}{Y_t} + \ln\frac{L_t}{N_t} \tag{46}$$

[13] The average (1970-2010) value for τ_t^c, τ_t^l, and τ_t^k is 14.73%, 25.4%, and 14.76% respectively.

Since it is well known that our model economy converges to a balanced growth path, the above decomposition of real per capita GDP, implies, that along that path all growth of real per capita GDP is attributed exclusively to the trend growth rate of the TFP factor, that is g.

Table 2: Accounting for Growth - Average Annual Changes (%)

Growth Accounting Components	Before Depression 1973-1979	"Great Depression" Crisis 1979-1995	"Great Depression" Recovery 1995-2001	Post Depression 2001-2007	New Crisis 2007-2012
Real per Capita GDP	2.13	-0.07	3.13	3.83	-4.62
TFP Factor	-0.66	-1.32	3.5	3.1	-5.97
Capital Factor	3.4	1.82	-1.12	-0.61	5.07
Labour Factor	-0.62	-0.57	0.75	1.34	-3.72

In Table 2 we present the growth accounting characteristics of the Greek economy for the period 1973-2012. The data, indicate an economic performance far from that of a balanced growth path. This means, that the capital factor and the labour factor had not a negligible role in accounting for growth of real per capita GDP. More specifically, during the "crisis" phase the fall of real per capita GDP was caused by a combination of negative growth of the TFP factor (-1.32%) and that of the labour factor (-0.57%). The downfall in economic activity was partially offset by a positive contribution of the capital factor (1.82%). In the "recovery" phase the positive growth rate of real per capita GDP (3.13%) was driven by an increase in the growth rate of the TFP factor (3.5%) and in the labour factor (0.75%). The contribution of the capital factor turned to negative with a growth rate equal to -1.12%. Finally, during the "new crisis" subperiod, we observe a steep downfall of the TFP factor (-5.97%) and of the labour factor (-3.72%).

In the following sections we examine whether our model, given the exogenous paths of government policy variables and that of the TFP, can reproduce the above growth accounting characteristics of the Greek economy. We focus on the period 1979-2001, but we also present results for the other subperiods as well.

5 Solving for the DCE Path

Since our aim is to obtain the series for K_t, L_t, and Y_t along the DCE path of the artificial economy and then compare them with the actual data we work as follows: First we insert equations (26) and (27) into the revenues equation (eq. 35). Thus, we obtain:

$$R_t = \tau_t^l (1-a) A_t K_t^\alpha L_t^{1-\alpha} + \tau_t^k \left(a A_t K_t^{\alpha-1} L_t^{1-\alpha} - \delta \right) K_t + \tau_t^c C_t \tag{47}$$

Second, we insert equation (47) into the government budget constraint and we solve for lump-sum transfers, T_t:

$$T_t = \tau_t^l (1-a) A_t K_t^\alpha L_t^{1-\alpha} + \tau_t^k \left(a A_t K_t^{\alpha-1} L_t^{1-\alpha} - \delta \right) K_t + \tau_t^c C_t - G_t \tag{48}$$

Third, we insert equations (26), (27), and (48) into the aggregate budget constraint and derive the resource constraint of our economy:

$$\begin{aligned}(1+\tau_t^c) C_t + K_{t+1} &= (1-\tau_t^l)(1-a) A_t K_t^\alpha L_t^{1-\alpha} + K_t + (1-\tau_t^k) \left(a A_t K_t^\alpha L_t^{1-\alpha} - \delta K_t \right) \\ &+ \tau_t^l (1-a) A_t \left(K_t\right)^\alpha \left(L_t\right)^{1-\alpha} + \tau_t^k \Big(a A_t \left(K_t\right)^\alpha \left(L_t\right)^{1-\alpha} - \delta K_t \Big) + \tau_t^c C_t - G_t\end{aligned}$$

$$\Rightarrow C_t + K_{t+1} - (1-\delta) K_t + G_t = A_t K_t^\alpha L_t^{1-\alpha} \tag{49}$$

Fourth, we solve equation (49) for consumption, C_t:

$$C_t = A_t K_t^\alpha L_t^{1-\alpha} - K_{t+1} + (1-\delta) K_t - G_t \tag{50}$$

Fifth, we insert equations (26), (27), and (50) into equations (32) and (33):

$$\frac{A_{t+1} K_{t+1}^\alpha L_{t+1}^{1-\alpha} - K_{t+2} + (1-\delta) K_{t+1} - G_{t+1}}{A_t K_t^\alpha L_t^{1-\alpha} - K_{t+1} + (1-\delta) K_t - G_t} = \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \beta \left(1 + (1-\tau_{t+1}^k)(a A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^{1-\alpha} - \delta) \right) \tag{51}$$

and

$$\frac{1-\gamma}{\gamma} \frac{A_t K_t^\alpha L_t^{1-\alpha} - K_{t+1} + (1-\delta) K_t - G_t}{N_t \bar{h} - L_t} = \frac{1-\tau_t^l}{1+\tau_t^c} (1-a) A_t K_t^\alpha L_t^{-\alpha} \tag{52}$$

Solving for the DCE equilibrium path involves choosing sequences of K_{t+1} and L_t, such that the system of equations (51) and (52) has a unique solution, given sequences of $\{A_t, N_t, G_t, \tau_t^c, \tau_t^l, \tau_t^k\}_{t=T_0}^{\infty}$, the initial real capital stock K_{T_0}, and the transversality condition in aggregate terms.

In order to convert the above system of infinite equations with infinite unknowns into a tractable dynamic system, we follow Conesa et al. (2007) and assume that our economy converges to the balanced growth path and some finite date T_1. Our system is thus reduced to:

For $t = T_0, T_0 + 1, ...T_1 - 1$

$$\frac{A_{t+1}K_{t+1}^{\alpha}L_{t+1}^{1-\alpha} - K_{t+2} + (1-\delta)K_{t+1} - G_{t+1}}{A_t K_t^{\alpha} L_t^{1-\alpha} - K_{t+1} + (1-\delta)K_t - G_t} = \frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta\left(1 + (1-\tau_{t+1}^k)(aA_{t+1}K_{t+1}^{\alpha-1}L_{t+1}^{1-\alpha} - \delta)\right) \tag{53}$$

For $t = T_0, T_0 + 1, ...T_1$

$$\frac{1-\gamma}{\gamma}\frac{A_t K_t^{\alpha} L_t^{1-\alpha} - K_{t+1} + (1-\delta)K_t - G_t}{N_t\overline{h} - L_t} = \frac{1-\tau_t^l}{1+\tau_t^c}(1-a)A_t K_t^{\alpha} L_t^{-\alpha} \tag{54}$$

and

$$K_{T_1+1} = gnK_{T_1} \tag{55}$$

This is a system of $2(T_1 - T_0 + 1)$ equations, in $2(T_1 - T_0 + 1)$ uknowns (the respective capital and labour sequences).

In order to select the time distance, $T_1 - T_0$, we follow Gogos et al. (2014) and we set $T_0 = 1970$ and $T_1 = 2039$. Hence, we solve the system over the period 1970-2039. Since data, for government consumption and TFP are available until 2012, for population until 2011, and for the marginal effective tax rates until 2010, we make the following assumption for the path of their values for the period 2010, 2012, - 2039. In what concerns population, for the years 2012 and 2013 we use OECD projections, and then we assume that it grows at its annual average growth rate over the period 1970-2011. We match our model's population with working age population in the data and compute a value for n equal to 1.0065. For government consumption we make the same assumption as Conesa et al. (2007) do. We assume that after 2012 it grows at a constant growth rate equal to gn. This assumptions is necessary for our equilibrium to converge to a balanced growth path. For TFP we assume that for 2013 and 2014 follows a proportionally similar path to the respective OECD projections for real per capita GDP and after 2014 increases smoothly until 2020 when it reaches its trend growth rate $\frac{A_{t+1}}{A_t} = g^{1-\alpha}$, where $g = 1.02$. Finally, for the tax rates we assume that for the period 2011-2039, they retain the same values as they had in 2010, that is $\tau_t^c = 17.67\%$, $\tau_t^l = 33.99\%$, and $\tau_t^k = 19.6\%$.

6 Numerical Experiments

In this section we compare the growth accounting from the data with that from our artificial economy. Our results are presented in Tables 4 (growth rates) and 5 (Levels) as well as in Figure 5. More specifically, Table 5 presents the index values corresponding to the growth accounting exercise. It shows the index values of detrended real per capita GDP, of detrended TFP factor, of capital factor and of labour factor, relative to their respective values in the beginning of each of the five subperiods. In what concerns Figure 5, the left hand side corresponds to the 1973-2001 period (which includes the 1979-2001 great depression episode), while the right hand side presents the 2001-2012 period.

For convenience in presenting the analysis of our results we numerate the four cases of our numerical experiments. Hence, experiments 1 and 2 correspond to the case where the tax rates take their average values (1970-2010), while in experiments 3 and 4 we use their actual paths (see Figure 3(a)). Finally, in experiments 1 and 3 all tax proceeds are rebated to households as lump-sum transfers, while in experiments 2 and 4 they also finance government consumption. This specification affects mostly the behaviour of the labour factor.

Looking at Tables 4, 5 and Figure 5, we observe that our model economy qualitatively matches the path of key macroeconomic variables (real per capita GDP, capital deepening, and labour hours per capita) of the Greek economy for the period 1979-2001. However, quantitatively, and in terms of timing and turning points, there are subperiods were our artificial economy diverges from the data. This fact, is clearly observed during the subperiod 1993-1999.[14]

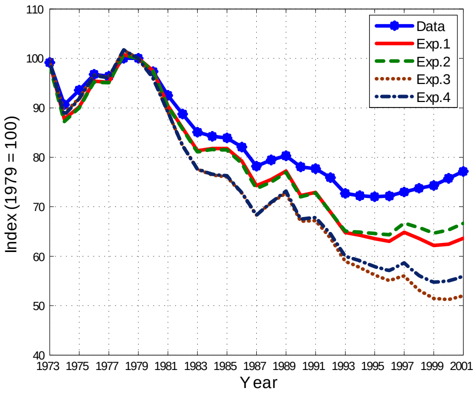
[14]In Table 4 the column with the title "Neoclassical Growth Model" was taken from Tables 5 and 7 in Gogos et al. (2014).

Table 4: Average Annual Changes in Real per Capita GDP (%)

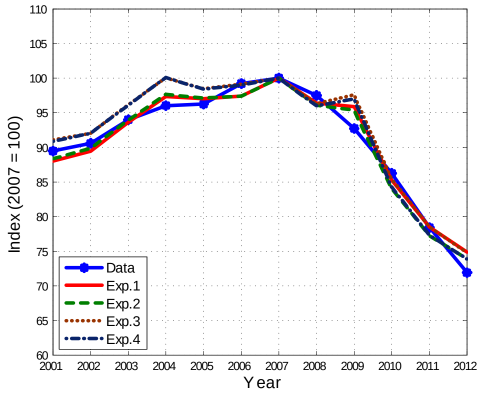
Growth Accounting Components	Data	*Neoclassical Growth Model*	Government Sector Constant $\tau_t^c, \tau_t^l, \tau_t^k$		Government Sector Actual Paths $\tau_t^c, \tau_t^l, \tau_t^k$	
			$R_t = T_t$	$R_t = T_t + G_t$	$R_t = T_t$	$R_t = T_t + G_t$
1973-1979			1	2	3	4
Real per Capita GDP	2.13	*1.78*	2.13	2.21	2.05	2.08
TFP Factor	-0.66	*-0.66*	-0.57	-0.68	-0.42	-0.54
Capital Factor	3.4	*3.83*	3.98	3.87	4.81	4.73
Labour Factor	-0.62	*-1.39*	-1.28	-0.99	-2.35	-2.11
1979-1995						
Real per Capita GDP	-0.07	*-1.09*	-0.85	-0.75	-1.62	-1.43
TFP Factor	-1.32	*-1.32*	-1.24	-1.33	-1.15	-1.29
Capital Factor	1.82	*1.19*	1.46	1.45	1.6	1.61
Labour Factor	-0.57	*-0.95*	-1.08	-0.87	-2.08	-1.76
1995-2001						
Real per Capita GDP	3.13	*3.02*	2	2.5	0.69	1.39
TFP Factor	3.5	*3.5*	2.41	2.36	2.37	2.28
Capital Factor	-1.12	*-1.63*	-1.26	-1.21	-1.46	-1.39
Labour Factor	0.75	*1.14*	0.86	1.35	-0.22	0.5
2001-2007						
Real per Capita GDP	3.83	*3.97*	4.1	4.04	3.54	3.58
TFP Factor	3.1	*3.1*	3	3.11	2.91	3.03
Capital Factor	-0.61	*-0.25*	-0.56	-0.68	-0.9	-1.03
Labour Factor	1.34	*1.13*	1.66	1.61	1.52	1.58
2007-2012						
Real per Capita GDP	-4.62	*-4.37*	-3.81	-4.07	-3.82	-4.06
TFP Factor	-5.97	*-5.97*	-5.02	-5.21	-4.98	-5.21
Capital Factor	5.07	*5.02*	4.76	4.74	4.34	4.31
Labour Factor	-3.72	*-3.42*	-3.55	-3.59	-3.18	-3.16

6.1 Data vs Model: 1973-2001

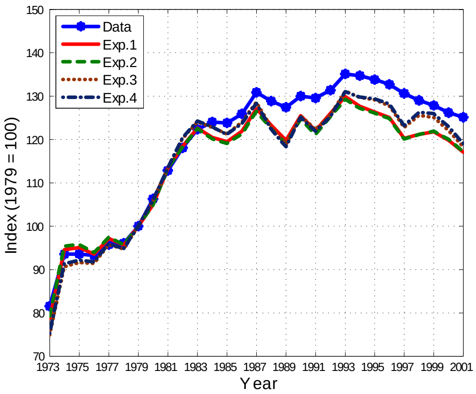
During the period 1979-1995, all experiments overestimate the fall of detrended real per capita GDP. The two polar cases are experiments 2 and 3. The former predicts an average fall of real per capita GDP equal to -1.62% (in levels this accounts to a 43.81% decrease of detrended real per capita GDP, see Table 5), while the latter predicts the mildest depression from all the experiments, that is -0.75% (-35.39% in levels). In the data the fall of real per capita GDP was -0.07% (-27.99% in levels). During the recovery phase (1995-2001), our model now underestimates the increase in real per capita GDP. As in the previous subperiod, experiments 1 and 2 (constant tax rates) are more close to the data (2%, 2.5% vs 3.13%) than experiments 3 and 4 (0.69%, 1.39% vs 3.13). Moreover, the specification that government revenues finance not only transfers but also government consumption, improves the performance of our model for the period 1979-2001. Finally, it is worth pointing out that experiments 3 and 4, in terms of timing, miss the trough of the Greek depression. In our model, the trough comes in the year 1999, while in data the trough comes in the year 1995.



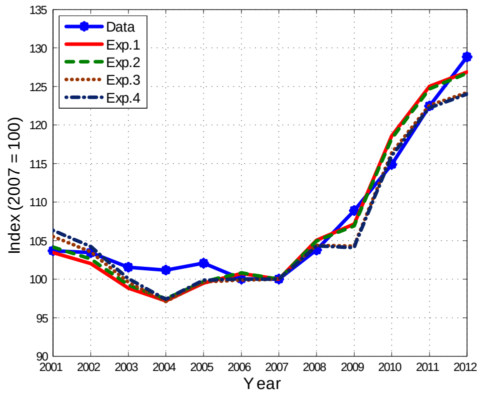
(a) Detrended Real per Capita GDP



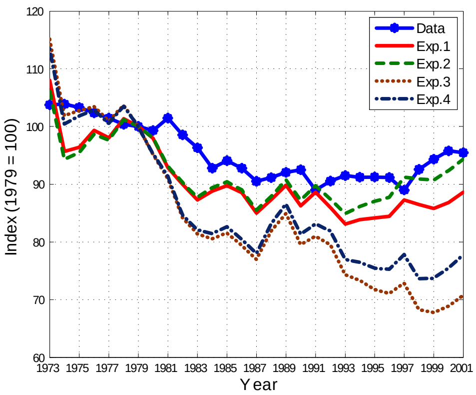
(b) Detrended Real per Capita GDP



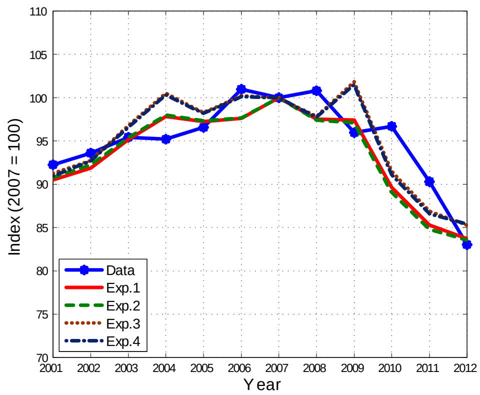
(c) Capital Factor



(d) Capital Factor



(e) Labour Factor



(f) Labour Factor

Figure 5: Data vs Model: 1973-2012

In what concerns the labour factor we observe the following facts. During the crisis phase (1979-1995), all the experiments overestimate the fall of labour hours per capita. Experiment 3 predicts an average fall of -2.08% (-28.26% in levels), while experiment 2 is much closer to the data, that is -0.87% (-15.84% in levels) compared to -0.57% (-8.74% in levels). Generally speaking, the increase in the tax rate of labour income, during the first half of the 80's and during the 90's, along with the fall of TFP, create stronger substitution effects than negative wealth effects and as a result experiments 3 and 4 (actual paths for the tax rates) predict a large fall of the labour factor. Notice that the specification in which tax revenues are not all rebated to households ($R_t = T_t + G_t$) increases the negative wealth effect and as a result the fall in labour hours per capita decreases (-0.87 vs -1.08 for Exp 2, 1, and -1.76 vs -2.08 for Exp 4, 3).

For the period 1995-2001, experiment 3, predicts a fall of the labour factor (-0.22%), while in the data we observe an increase of 0.75%. This is the only case, in all of our experiments, where our model qualitatively does not match data behaviour. Furthermore, the experiment which is closer to the data is the one with constant tax rates and all government revenues rebated to households (Exp.1, 0.86% vs 0.75%). Almost equally successful is experiment 4 (0.5% vs 0.75%).

In terms of the path of the capital factor, for the period 1979-1995, all the experiments underestimate its increase (1.82%), while for the period 1995-2001 all cases overestimate its decrease (-1.12%). Moreover, during the crisis phase, the experiments with variable tax rates (3 and 4) perform better than those with constant tax rates (1 and 2). Things are reversed for the recovery phase. There, experiments 1 and 2 dominate. Finally, it worth pointing out, that the allocation of government revenues ($R_t = T_t$ or $R_t = T_t + G_t$) does not play a significant role for the path of the capital factor (especially in the 1979-1995 period, but also in the recovery phase). This does not hold for the labour factor.[15]

Table 5: Levels (Indexes)

Growth Accounting Components	Data	Government Sector			
		Average (1970-2010) $\tau^c_t, \tau^l_t, \tau^k_t$		Actual Paths $\tau^c_t, \tau^l_t, \tau^k_t$	
		$R_t = T_t$	$R_t = T_t + G_t$	$R_t = T_t$	$R_t = T_t + G_t$
1979 (1973=100)		1	2	3	4
Real per Capita GDP	100.88	100.89	101.41	100.4	100.59
TFP Factor	85.37	85.8	85.27	86.61	85.95
Capital Factor	122.63	126.99	126.16	133.49	132.8
Labour Factor	96.36	92.59	94.26	86.84	88.13
1995 (1979=100)					
Real per Capita GDP	72.01	63.53	64.61	56.19	57.94
TFP Factor	58.96	59.76	58.88	60.63	59.31
Capital Factor	133.83	126.33	126.05	129.18	129.44
Labour Factor	91.26	84.16	87.05	71.74	75.48
2001 (1995=100)					
Real per Capita GDP	107.15	100.13	103.14	92.55	96.54
TFP Factor	109.58	102.59	102.32	102.38	101.82
Capital Factor	93.48	92.7	92.98	91.62	92
Labour Factor	104.6	105.29	108.41	98.67	103.06
2007 (2001=100)					
Real per Capita GDP	111.76	113.59	113.14	109.78	110.05
TFP Factor	106.92	106.34	106.99	105.76	106.47
Capital Factor	96.43	96.67	96	94.74	94.02
Labour Factor	108.39	110.49	110.16	109.57	109.93
2012 (2007=100)					
Real per Capita GDP	71.91	74.88	73.9	74.81	73.92
TFP Factor	67.21	70.48	69.79	70.6	69.79
Capital Factor	128.85	126.9	126.74	124.25	124.05
Labour Factor	83.03	83.72	83.55	85.29	85.39

If we compare our results with those in Gogos et al. (2014), we observe that in terms of the path of the capital factor, the presence of distortionary taxation and government spending moves our artificial economy closer to the data compared to the case of a pure Walrasian environment. Furthermore, in terms of the behaviour of the labour factor, there is an improvement for the period 1979-1995, under the regime of constant tax rates and government consumption (Exp. 2), and this also holds for the period 1995-2001 under the regimes of experiments 1 and 4. However, when we use the actual paths for the tax rates (Exp. 3, 4), especially for the period 1993-1999 (see Figure 6(e)), our artificial labour hours per capita diverge significantly from the data.

6.2 Data vs Model: 2001-2012

Looking at Figure 6 (right hand side) we observe the performance of our model for the period 2001-2012. For the period 2001-2007, our artificial economy performs quite well in terms of the path of real per capita GDP. Experiments 3 and 4 underestimate its growth rate (3.54%, 3.58% vs 3.83%), while experiments 1 and 2 overestimate it (4.1%, 4.04). In what concerns the labour factor all the experiments overestimate its increase. The two polar cases are experiments 1 and 3. The former predicts an increase of 1.66% (1.34% in data) and the latter an increase of 1.52%. Finally, in terms of the path of the capital factor, experiments 1 and 2 are very

[15] See Table 2 in Conesa et al. (2007) for similar results (in qualitative terms).

close to the data (-0.56%, -0.68% Vs -0.61%), while 3 and 4 quantitatively diverge. Hence, when we use the actual paths for the tax rates our model economy is closer to the data in terms of the behaviour of the labour factor and further in terms of the behaviour of the capital factor.

Finally, for the period 2007-2012 we must be very careful in analyzing the performance of our model. The current crisis is still ongoing and as a result we need to wait for better data to become available to draw any firm conclusions about this economic event. Nevertheless, it is worthwhile to present our model's results. As is depicted at Figure 6(b), all the experiments predict a steep fall in detrended real per capita GDP for the period 2007-2012. In fact, all cases underestimate, in absolute terms, the negative growth rate that we observe in the data (-3.81%, -4.07%, -3.82%, -4.06, vs -4.62%). Finally, in terms of the labour and the capital factor our model performs quite well.

7 Concluding Remarks

In this paper we have examined whether neoclassical growth theory, augmented with a government sector, can mimic the path of key macroeconomic variables of the Greek economy for the period 1979-2001. This exercise helps us to shed some light on the quantitative role of government policy and TFP for Greece's economic performance. Our results suggest, that our model qualitatively matches the path of the key macroeconomic variables of the Greek economy for the period 1979-2001. However, quantitatively, there are subperiods were our artificial economy diverges from the data. This fact, is clearly observed during the subperiod 1993-1999. Furthermore, the presence of distortionary taxation and government spending improves the performance of our model compared to the case of a standard neoclassical setting (see Gogos et al. (2014) for the latter case). As a result, we conclude that the government sector is important in accounting for Greece's economic performance over the period 1979-2001.

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Appendix A.

EffectiveTax Rates $\left(\tau_t^c, \tau_t^l, \tau_t^k\right)$

To compute series for the effective tax rates τ_t^c, τ_t^l, and τ_t^k, we adopt a variation from the methodology of Mendoza et al. (1994). First, when we compute the tax base on labour income we take into account the labour income earned from the self-employed. Doing this, makes the specific tax rate series consistent with our labour share parameter estimate. Second, since in our theoretical framework decisions, from households and firms, are taken at the margin we set the income tax rates, τ_t^l and τ_t^k, equal to their effective marginal rates. In order to convert the effective average taxes rates to marginal, we follow Prescott (2002) and we simply multiply the first by a factor of 1.6.

Given data on tax bases (consumption, income, and investment) and tax revenues, the marginal effective tax rates are computed as follows:

Effective Consumption Tax Rate (τ_t^c)

We define the tax base as the sum of households (H) and nonprofit institutions serving households (NPISH'S) final consumption expenditures (FCE). The tax revenues are general taxes (GT 2100) and excises (EXC 5121).[16]

$$\tau_t^c = \frac{\text{GT (5110) + EXC (5121)}}{\text{HFCE + NPISH'S FCE - GT (2100) - EXC (5121)}} \tag{56}$$

Effective Income Tax Rates $\left(\tau_t^h\right)$

To compute series for labour and capital income tax rates, we begin by computing the aggregate marginal tax rate on household income. We define the tax base as the sum of compensation of employees (net of employer's (2200) and employees (2100) contributions to social security (SSC)), imputed compensation of the self-employed (net of self-employed or non-employed contributions to social security (SSC 2300)), and households non labour income. The last component is taken residually by subtracting from households net operating surplus and mixed income (HGOSMI - HCFC) compensation of the self-employed. The tax revenues are taxes on income, profits, and capital gains of individuals (TIPCGI 1100).

$$\tau_t^h = \mu \frac{\text{TIPCGI (1100)}}{\text{TCE}^{DE}\text{-SSC (2200+2100) + TCE}^{SE}\text{-SSC (2300) + HGOSMI - HCFC- TCE}^{SE}} \tag{57}$$

where HCFC is households consumption of fixed capital.

The progressivity of the income tax system implies that marginal tax rates tend to be larger than the average tax rates we are computing. The term μ is an adjustment factor that transforms average tax rates to marginal tax rates. We follow Prescott (2002) and we set $\mu = 1.6$.

Effective Labour Tax Rate $\left(\tau_t^l\right)$

The tax revenues are computed as follows: We add to tax revenues from households labour income, social security contributions (SSC 2000) and taxes on payroll and workforce (TPW 3000). The tax base is simply the total labour income.

$$\tau_t^l = \frac{\tau_t^h \left(\text{TCE}^{DE}\text{-SSC (2200+2100) +TCE}^{SE}\text{-SSC (2300)}\right) \text{ + SSC (2000) + TPW (3000)}}{\text{TCE}^{DE} + \text{TCE}^{SE}} \tag{58}$$

Effective Capital Tax Rate $\left(\tau_t^k\right)$

The tax revenues are computed as follows: We add to tax revenues from households capital income, taxes on income , profits, and capital gains of corporations (TIPCGC 1200), recurrent taxes on immovable property (RTIP 4100), and taxes on financial and capital transactions (TFCT 4400). The tax base is simply the total net capital income.

$$\tau_t^k = \frac{\tau_t^h \left(\text{HGOSMI - HCFC- TCE}^{SE}\right) \text{ + TIPCGC (1200) + RTIP (4100) + TFCT (4400)}}{\text{GDP - NIT - CFC - TCE}^{DE}\text{ - TCE}^{SE}} \tag{59}$$

where CFC is consumption of fixed capital.

[16] The numbers in the parentheses are the codes of the specific tax revenues in OECD tax statistics database.

Appendix B.

All data have been extracted from two sources, OECD and Groningen Growth Development Center Databases:

a) OECD (2010), "Aggregate National Accounts: Gross domestic product", OECD National Accounts Statistics (database).

b) OECD (2010), "Aggregate National Accounts: Disposable income and net lending/borrowing", OECD National Accounts Statistics (database).

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j) The Conference Board Total Economy Database (January 2012), "Growth Accounting and Total Factor Productivity, Country Details 1950-2011".

Tax Rates, Government Spending and TFP A Quantitative Assessment of their Role in the Greek Depression: 1979-2001

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March 30, 2014

Abstract

This paper provides a quantitative assessment of the role of government policy and total factor productivity (TFP) in Greek economic performance during the period 1979-2001. According to Kehoe and Prescott (2002, 2007) this period can be characterized as a Great Depression. Our methodology, based upon the work of Cole and Ohanian (1999) and Kehoe and Prescott (2002, 2007), employes growth accounting and a dynamic general equilibrium model. We introduce to the neoclassical growth model a government sector with distortionary taxation, and given the exogenous paths of tax rates, government consumption, TFP, and population, we ask whether our model economy can produce growth accounting characteristics which are similar to that in the data. Our results suggest, that our model economy qualitatively matches the path of key macroeconomic variables (real per capita GDP, capital deepening, and labour hours per capita) of the Greek economy for the period 1979-2001. However, quantitatively and in terms of timing and turning points, there are subperiods were our artificial economy diverges from the data. Furthermore, the presence of distortionary taxation and government spending improves the performance of our model compared to the case of a standard neoclassical setting (see Gogos et al. (2014)). As a result, we conclude that the government sector is important in accounting for Greece's economic performance over the period 1979-2001.

Keywords: Growth Accounting, Total Factor Productivity, Tax Rates, Government Spending, Dynamic General Equilibrium.

JEL: E32, E62, N10, O40

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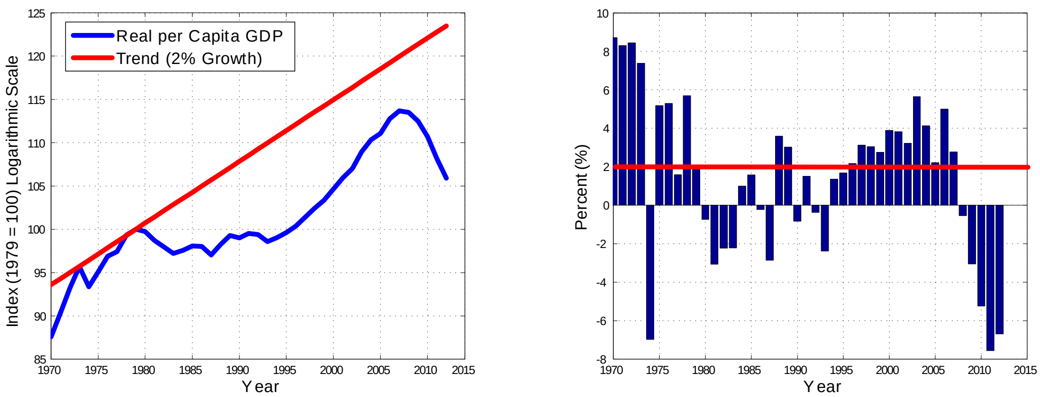
1 Introduction

In this paper we examine whether the neoclassical growth model, augmented with a government sector, can mimic the path of key macroeconomic variables of the Greek economy for the period 1979-2001.[1] Doing this exercise helps us to shed some light on the quantitative role of government policy and TFP for Greece's economic performance.

Following the Kehoe and Prescott (2002, 2007) tradition, we characterize the period 1979-2001 as a great depression. According to their studies, a period of large, rapid, and sustained deviation of real per capita GDP from trend can be characterized as a great depression. Looking at Figure 1 we observe that from 1979 to 2001 the Greek economy experienced such a path (see Gogos et al. (2014) for quantitative details). From 1979 to 1995, detrended real per capita GDP fell by 27.99%, and in 2001, after following a recovery trajectory, it was still far behind, that is 22.84% below its 1979 value. Furthermore, it is worth pointing out, that from the end of 2007 until today Greece is experiencing a new economic depression. The more recently updated data show that in 2012 detrended real per capita GDP was already 28% below its 2007 value. This magnitude is similar with the trough of the first great depression episode. However, the timing is different. The ongoing crisis in much more steep. It took only one third, of the time period of the first crisis, for detrended real per capita GDP to reach the same level.



(a) Real per Capita GDP (b) Growth Rate of Real per Capita GDP

Figure 1: Aggregate Economic Performance 1970-2012

Since we measure economic performance relative to trend, we define detrended real per capita GDP as follows:

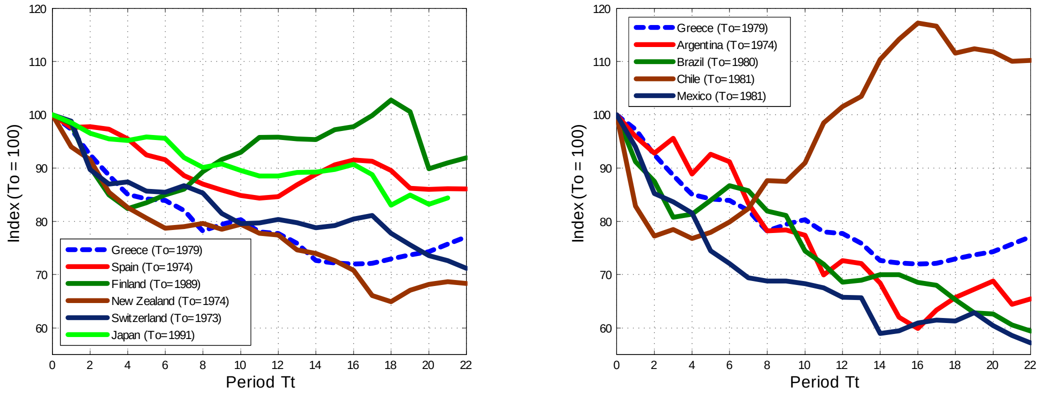
$$\widetilde{y_t} = \frac{y_t}{g^{t-T_0} y_{T_0}} \tag{1}$$

where g is the gross trend growth rate and T_0 is the starting year of the detrending period.[2] As in Kehoe and Prescott (2002), we define the trend growth rate as the average annual real per capita GDP growth rate of the industrial leader of the world economy. In the 20th century this was the United States of America with an average annual growth rate of real per capita GDP of 2 %. Hence, in our case, trend real per capita GDP is assumed to grow at this 2% rate.

Looking at Figure 2 we observe that other countries as well have experienced great depression events during the last forty years. These are: Japan, New Zealand, Spain, Switzerland, Finland, Argentina, Mexico, Brazil, and Chile. From these 10 countries (including Greece), only Chile and Finland managed to return, and also to pass by, their detrending real per capita GDP value in the start of their depression. All the other countries experienced a poor economic performance for at least one decade or more. The Latin America countries had the deepest depressions, while in Japan and Spain the fall of detrended real per capita GDP was not so severe. Greece, New Zealand, and Switzerland, are more close to the first group than in the second.

[1] We focus on the equilibrium paths of key macroeconomic variables and not in their statistical properties as is the case in the standard DSGE literature.

[2] In our case $T_0 = 1979$.

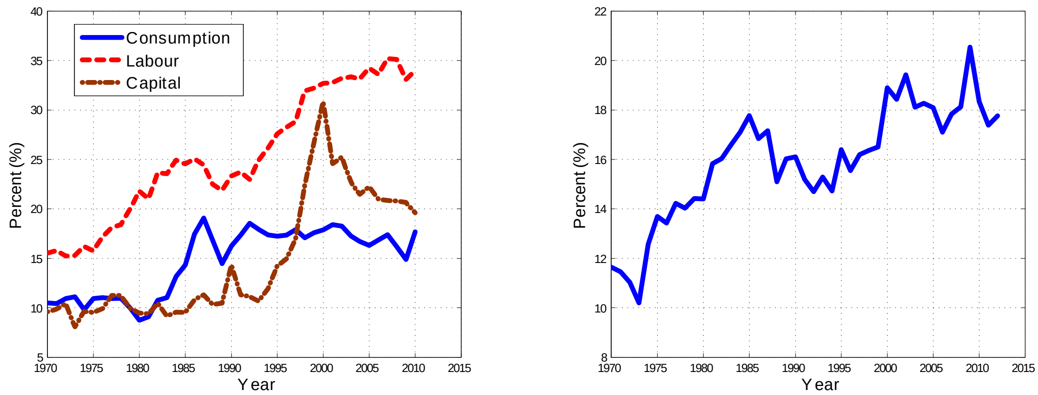


(a) Detrended Real per Capita GDP (b) Detrended Real per Capita GDP

Figure 2: Great Depressions of the 20th Century

The above economic events have been well studied in the literature. Following the seminal work of Cole and Ohanian (1999) a series of studies analyze these great depression episodes using a common analytical framework, that is, neoclassical growth theory and extensions of it. The majority of results point out the important role of TFP and government policy in accounting for poor economic performance. For example, Conesa and Kehoe (2007) find that the evolution of tax rates can explain more than 70% of the fall in labour hours per capita which led the Spanish economy to stagnate between 1974 and 1986. Furthermore, Conesa et al. (2007) conclude that the sharp drop in Finnish real per capita GDP over the period 1990-1993 was driven by a combination of a drop in TFP during 1990-1992 and of increases in taxes on labour and consumption and increases in government consumption during 1989-1994, which drove down hours worked in Finland. Moreover, Kehoe and Ruhl (2007), Kydland and Zarazaga (2002), and Kehoe (2003) support the idea that the evolution of TFP can account rather well for the economic performance of New Zealand and Switzerland for the period 1973-2000, and Argentina for the period 1974-2002. Finally, Bergoeing et al. (2002) conclude that the difference in timing of government policy reforms, in terms of banking and bankruptcy procedures, can explain the fact that the economy of Chile exploded in the mid 80's while, for the same period, the Mexican economy stagnated.

To study Greece's economic performance we employ similar tools of macroeconomic analysis as that in the above studies. In our analysis, government policy takes the form of tax rates, on consumption expenditures and income (labour and capital), and government consumption expenditures.



(a) Marginal Effective Tax Rates (b) Government Consumption Over GDP

Figure 3: Government Sector 1970-2012

Looking at Figure 3 and Table 1 we observe the following facts in terms of the paths of government policy variables:[3] First, government consumption over GDP and the marginal effective tax rate on labour income show clearly an upward trend, with the former variable to have a higher degree of variance than the latter one.[4]

[3]We follow Gogos et al. (2014) and we decompose the period 1973-2012 into five subperiods, that is 1973-1979, 1979-1995, 1995-2001, 2001-2007, 2007-2012 (see section 4). This decomposition is not a trivial one. The period 1979-2001 strictly meets the Kehoe and Prescott (2002, 2007) criteria for it to be named as a great depression, and in the end of 2007 we observe a turning point in economic activity which marks the beggining of a new depression episode.

[4]See Appendix A for the methodology that we adopt to construct the marginal effective tax rates. In Appendix B we present the sources of our data.

Second, during the depression period, government consumption over GDP shows an upward and downward path behaviour. From 1979 to 1985 it increases from 14.41% to 17.77%, then in 1994 it falls to a level of 14.73%, and finally in 2001 it increases to a level of 18.43%. The marginal effective tax rate on labour income follows a somewhat similar pattern. From 1979 to 1986 it increases from 20.4% to 25.08%, then in 1992 it reaches a level of 22.98%, and in 2001 it increases to a level of 32.79%. Third, in terms of the path of the marginal effective tax rate on capital income, we observe a big jump from 1993 to 2000 (10.69% to 30.84%) and a big fall from 2000 to 2010 (30.84% to 19.6%). Finally, the effective tax rate on consumption expenditures increases remarkably between 1980 to 1987 (8.74% to 19.08%), and then, between 1993 to 2003, it follows an almost constant path (an average value of 17.66%).

Table 1: Government Policy Variables (% Values)

	1973	1979	1995	2001	2007	2012 2010 (τ_t^c, τ_t^l, τ_t^k)
τ_t^c	11.1	9.96	17.24	18.41	17.39	17.67
τ_t^l	15.31	20.4	27.58	32.79	35.21	34
τ_t^k	8.09	9.96	14.25	24.59	20.85	19.6
$\frac{G_t}{Y_t}$	10.2	14.41	16.4	18.43	17.83	17.75

Except of examining the role of government policy we also take into account that of TFP. As is depicted at Figure 4 the proportional change of TFP factor and that of real per capita GDP show a strong positive correlation (correlation coefficient equal to 86.44%).[5] In a similar study, that is, Gogos et al. (2014), the authors, examine the role of TFP in accounting for Greece's economic performance (for the same period as we do) in a standard neoclassical setting.[6] Their conclusions reveal that the path of TFP can account rather well for the overall performance of the Greek economy. Our purpose in this study is to move this research one step further by introducing a government sector to the neoclassical growth model. This exercise helps us to quantitatively assess the combined role of tax rates, government consumption, and TFP in Greece's economic performance during the period 1979-2001.

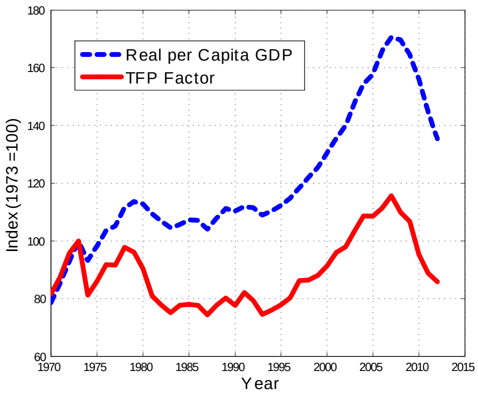


Figure 4: Real per Capita GDP and TFP Factor

Our methodology, developed by Cole and Ohanian (1999) and Kehoe and Prescott (2002, 2007) for studying "Great Depression" economic episodes, employes the technique of growth accounting and a dynamic general equilibrium model. As a first step, we perform the growth accounting exercise. There, by employing a standard neoclassical production function, we decompose the growth rate of real per capita GDP into three components. These are, TFP factor, capital deepening, and labour hours per capita. Then, by simulating a calibrated dynamic general equilibrium model, we ask whether given the path of the exogenous variables of the model (tax rates, government consumption, TFP and population) our artificial economy produces growth accounting characteristics which are close to the data. Our results suggest, that our model qualitatively matches the path of the key macroeconomic variables of the Greek economy for the period 1979-2001. However, quantitatively, there are subperiods were our artificial economy diverges from the data. Furthermore, the presence of distortionary taxation and government spending improves the performance of our model compared to the case of a standard neoclassical setting (see Gogos et al. (2013) for the latter case). As a result, we conclude that the government sector is important in accounting for Greece's economic performance over the period 1979-2001.

The paper is organized as follows: Section 2 presents the structure of our model along with the conditions that characterized the decentralized competitive equilibrium. Section 3 presents the procedures that we adopt for calibration of the parameters and for computing the exogenous variables of the model. Section 4 presents

[5] See section 4 for the definition of the TFP factor and section 2.2 for that of TFP.

[6] Since we use the same methodology and the same data as in Gogos et al. (2014), our results are comparable with this study.

the growth accounting exercise. Section 5 presents the transition dynamics. Section 6 presents the results. Finally, section 7 concludes.

2 The Model

Our model is the neoclassical growth model, augmented with a government sector. The artificial economy consists of a large number of infinitively live identical households, a large number of identical firms, and a government sector. There is no uncertainty (we assume perfect foresight) and all markets operate under perfect competition. The representative household chooses paths of consumption, capital and labour. The representative firm produces a homogenous product using capital, labour, and the available technology. The government levies distortionary taxes and uses the revenues to finance government consumption and lump-sum transfers to households. We solve for a symmetric decentralized competitive equilibrium where: (i) each individual household and each individual firm maximize respectively their own utility and profits by taking as given market prices and government policy, (ii) the government budget constraint is satisfied and (iii) all markets clear through price flexibility.

2.1 Households

Each period t there are N_t identical households ($h = 1, 2, 3...N_t$). Their population grows at a constant rate $\frac{N_{t+1}}{N_t} = n$. The lifetime utility of the representative household h is:

$$\sum_{t=T_o}^{\infty} {\beta^*}^t U\left(C_t^h, H_t^h\right) \tag{2}$$

where $0 < \beta^* < 1$ is the time discount factor, C_t^h is real consumption expenditure, and H_t^h is hours of leisure. For the instant utility function, we use a loglinear form:

$$U(C_t^h, H_t^h; \gamma) = \gamma \log C_t^h + (1-\gamma) \log H_t^h \ , \ 0 < \gamma < 1 \tag{3}$$

where γ is the consumption share parameter.

The representative household h receives a real rental rate of capital, r_t, and a real wage rate, w_t, for its capital, K_t^h, and labour services, L_t^h. Furthermore, it receives a share of profits, Π_t^h, as a shareholder of firms, and lump-sum transfers from the government, T_t^h. Thus, the household's budget constraint is:

$$(1+\tau_t^c)C_t^h + I_t^h = (1-\tau_t^l)w_t L_t^h + r_t K_t^h - \tau_t^k (r_t - \delta) K_t^h + \Pi_t^h + T_t^h \tag{4}$$

where $0 < \tau_t^c < 1$, $0 < \tau_t^l < 1$, and $0 < \tau_t^k < 1$, are the common effective tax rates on consumption, labour income, and net capital income respectively.

Finally, for every period t it has at its disposal $\overline{h}$ available hours for leisure and work activities.[7] Thus:

$$\overline{h} = H_t^h + L_t^h \tag{5}$$

The capital stock evolves according to the following equation:

$$K_{t+1}^h = (1-\delta) K_t^h + I_t^h \tag{6}$$

where I_t^h is real investment expenditure.

Each household h acts competitively by taking prices, policy and economy-wide variables as given. To solve for household's optimization behaviour we work as follows: First we solve equation (6) for I_t^h and we insert this result to equation (4) and then solve for consumption, C_t^h. Thus:

$$(1+\tau_t^c)C_t^h + K_{t+1}^h = (1-\tau_t^l)w_t n_t^h L_t^h + (1 + (1-\tau_t^k)(r_t - \delta))K_t^h + \Pi_t^h + T_t^h$$

$$\Rightarrow C_t^h = \left(\frac{1}{1+\tau_t^c}\right)\left((1-\tau_t^l)w_t n_t^h L_t^h + (1 + (1-\tau_t^k)(r_t - \delta))K_t^h - K_{t+1}^h + \Pi_t^h + T_t^h\right) \tag{7}$$

Second, we solve equation (5) for leisure time, H_t^h, thus:

$$H_t^h = \overline{h} - L_t^h \tag{8}$$

[7] Here we make the following assumption: Each day the household has 14 hours available for market activities. Then each year the available hours for market activities for each household are 14*7*52=5096.

Substituting equations (7) and (8) into equation (2) the problem of the representative household can be written as follows:

$$\max_{\left\{K_{t+1}^h,L_t^h\right\}_{t=T_0}^{\infty}} \sum_{t=T_o}^{\infty} {\beta^*}^t U\left(\frac{1}{1+\tau_t^c}\left((1-\tau_t^l)w_t n_t^h L_t^h + (1+(1-\tau_t^k)(r_t-\delta))K_t^h - K_{t+1}^h + \Pi_t^h + T_t^h\right), \overline{h} - L_t^h\right) \tag{9}$$

subject to:

$$C_t^h, I_t^h, K_t^h, H_t^h, L_t^h, K_{T_0}^h > 0$$

$$K_{T_0}^h > 0 \text{ given}$$

Taking the first order necessary conditions with respect to K_{t+1}^h and L_t^h we obtain:

$$-{\beta^*}^t U_{C_t^h}\left(C_t^h, H_t^h\right)\frac{1}{1+\tau_t^c} + {\beta^*}^{t+1} U_{C_{t+1}^h}\left(C_{t+1}^h, H_{t+1}^h\right)\frac{1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)}{1+\tau_{t+1}^c} = 0$$

$$\Rightarrow \frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta^*\left(1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)\right) = \frac{U_{C_t^h}\left(C_t^h, H_t^h\right)}{U_{C_{t+1}^h}\left(C_{t+1}^h, H_{t+1}^h\right)} \tag{10}$$

and

$${\beta^*}^t\left(U_{C_t^h}\left(C_t^h, H_t^h\right)\frac{1-\tau_t^l}{1+\tau_t^c}w_t - U_{H_t^h}\left(C_t^h, H_t^h\right)\right) = 0$$

$$\Rightarrow \frac{1-\tau_t^l}{1+\tau_t^c}w_t = \frac{U_{H_t^h}\left(C_t^h, H_t^h\right)}{U_{C_t^h}\left(C_t^h, H_t^h\right)} \tag{11}$$

The optimality conditions are completed with the transversality condition for the one asset of our economy which is capital:

$$\lim_{t\to\infty} {\beta^*}^t U_{C_t^h}\left(C_t^h, H_t^h\right) K_{t+1} = 0 \tag{12}$$

If we substitute the instant utility function into household's optimality conditions and the transversality condition, equations (10) to (12) become:

$$\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta^*\left(1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)\right) = \frac{\gamma\frac{1}{C_t^h}}{\gamma\frac{1}{C_{t+1}^h}}$$

$$\Rightarrow \frac{C_{t+1}^h}{C_t^h} = \frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta^*\left(1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)\right) \tag{13}$$

$$\frac{1-\tau_t^l}{1+\tau_t^c}w_t = \frac{(1-\gamma)\frac{1}{\overline{h}-L_t^h}}{\gamma\frac{1}{C_t^h}}$$

$$\Rightarrow \frac{1-\gamma}{\gamma}\frac{C_t^h}{\overline{h}-L_t^h} = \frac{1-\tau_t^l}{1+\tau_t^c}w_t \tag{14}$$

$$\lim_{t\to\infty} {\beta^*}^t \frac{\gamma}{C_t^h}K_{t+1}^h = 0 \tag{15}$$

2.2 Firms

Each period of time t there are M_t identical firms ($f = 1, 2, 3...M_t$). Firms operate in perfectly competitive markets (price takers), using a Cobb-Douglas constant returns to scale technology:

$$Y_t^f = A_t\left(K_t^f\right)^{\alpha}\left(L_t^f\right)^{1-\alpha} \tag{16}$$

where Y_t^f is the output of the representative firm f, $0 < \alpha < 1$ is the capital share, and A_t is total factor productivity (TFP) which grows at an exogenously given rate $\frac{A_{t+1}}{A_t} = g^{1-\alpha}$.

The representative firm f chooses, in each period t, the quantity of labour, L_t^f, and capital, K_t^f, in order to maximize profits, Π_t^f:

$$\max_{L_t^f\ ,\ K_t^f} \Pi_t^f = Y_t^f - w_t L_t^f - r_t K_t^f \tag{17}$$

subject to equation (16).

Taking the first order necessary conditions with respect to L_t^f and K_t^f we get the following two optimality conditions:

$$w_t = (1-a)A_t \left(K_t^f\right)^{\alpha} \left(L_t^f\right)^{-\alpha} \tag{18}$$

and

$$r_t = aA_t \left(K_t^f\right)^{\alpha-1} \left(L_t^f\right)^{1-\alpha} \tag{19}$$

2.3 Government

The government collects tax revenues, R_t, by taxing consumption expenditures, labour income, and net capital income. Then, it uses the tax revenues to finance per capita consumption expenditures, G_t^h, and per capita lump-sum transfers, T_t^h. Thus, the government budget constraint is:

$$\sum_{h=1}^{N_t} G_t^h + \sum_{h=1}^{N_t} T_t^h = R_t \tag{20}$$

where

$$R_t = \tau_t^l w_t \sum_{h=1}^{N_t} L_t^h + \tau_t^k (r_t - \delta) \sum_{h=1}^{N_t} K_t^h + \tau_t^c \sum_{h=1}^{N_t} C_t^h \tag{21}$$

2.4 The Decentralized Competitive Equilibrium (DCE)

The DCE consists of a vector of quantities for the representative household, $\{Y_t^h, C_t^h, I_t^h, \Pi_t^h, K_{t+1}^h, L_t^h, H_t^h, T_t^h\}_{t=T_0}^{\infty}$, a vector of quantities for the representative firm $\{Y_t^f, K_t^f, L_t^f, \Pi_t^f\}_{t=T_0}^{\infty}$ and a vector of prices $\{w_t, r_t\}_{t=T_0}^{\infty}$, such that, given sequences for the exogenous variables $\{A_t, N_t, G_t, \tau_t^c, \tau_t^l, \tau_t^k\}_{t=T_0}^{\infty}$and the initial real capital stock $K_{T_0}^h$:

(a) Given prices $\{w_t, r_t\}_{t=T_0}^{\infty}$, the vector of quantities for the household,$\{Y_t^h, C_t^h, I_t^h, \Pi_t^h, K_{t+1}^h, L_t^h, H_t^h, T_t^h\}_{t=T_0}^{\infty}$ solves the household's maximization problem.

(b) Given prices $\{w_t, r_t\}_{t=T_0}^{\infty}$, the vector of quantities for the firm $\{Y_t^f, K_t^f, L_t^f, \Pi_t^f\}_{t=T_0}^{\infty}$ solves the firm's maximization problem.

(c) Given prices $\{w_t, r_t\}_{t=T_0}^{\infty}$, the vector of quantities for the household,$\{C_t^h, K_{t+1}^h, L_t^h, T_t^h\}_{t=T_0}^{\infty}$ satisfies the government budget constraint.

(d) Given the vectors of quantities for households and firms, $\{Y_t^h, C_t^h, I_t^h, \Pi_t^h, K_{t+1}^h, L_t^h, H_t^h, T_t^h\}_{t=T_0}^{\infty}$, $\{Y_t^f, K_t^f, L_t^f, \Pi_t^f\}_{t=T_0}^{\infty}$, the vector of prices $\{w_t, r_t\}_{t=T_0}^{\infty}$ is such that all markets clear. Thus, in each period t, the market clearing conditions for the goods market, the labour market, the capital market, and profits market, are respectively:

$$\sum_{f=1}^{M_t} Y_t^f = \sum_{h=1}^{N_t} Y_t^h \tag{22}$$

$$\sum_{f=1}^{M_t} L_t^f = \sum_{h=1}^{N_t} L_t^h \tag{23}$$

$$\sum_{f=1}^{M_t} K_t^f = \sum_{h=1}^{N_t} K_t^h \tag{24}$$

$$\sum_{f=1}^{M_t} \Pi_t^f = \sum_{h=1}^{N_t} \Pi_t^h = 0 \tag{25}$$

Hence, the decentralized competitive equilibrium is summarized by equations (5), (6), (7), (13), (14), and (16) to (25). This is a system of fifteen equations in fifteen unknowns, that is:

$$Y_t^h, C_t^h, I_t^h, \Pi_t^h, K_{t+1}^h, L_t^h, H_t^h, T_t^h, Y_t^f, K_t^f, L_t^f, \Pi_t^f, R_t, w_t, r_t$$

in each period t.

2.5 The Aggregate Economy

In terms of aggregate quantities, the DCE can be reduced to a system in ten equations and ten unknowns. These are:

Wage rate:

$$w_t = (1-a)A_t K_t^{\alpha} L_t^{-\alpha} \tag{26}$$

Rental rate of capital:

$$r_t = aA_t K_t^{\alpha-1} L_t^{1-\alpha} \tag{27}$$

Production function:

$$Y_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{28}$$

Budget constraint:

$$(1+\tau_t^c)C_t + K_{t+1} = (1-\tau_t^l)w_t L_t + (1+(1-\tau_t^k)(r_t-\delta))K_t + T_t \tag{29}$$

Time constraint:

$$N_t \overline{h} = H_t + L_t \tag{30}$$

Law of motion of capital Stock:

$$K_{t+1} = (1-\delta)\,K_t + I_t \tag{31}$$

Euler equation:

$$\frac{C_{t+1}}{C_t} = \frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta\left(1+(1-\tau_{t+1}^k)(r_{t+1}-\delta)\right) \tag{32}$$

Trade off between labour and leisure time:

$$\frac{1-\gamma}{\gamma}\frac{C_t}{N_t\overline{h}-L_t} = \frac{1-\tau_t^l}{1+\tau_t^c}w_t \tag{33}$$

Government budget constraint:

$$G_t + T_t = R_t \tag{34}$$

Revenues equation:

$$R_t = \tau_t^l w_t L_t + \tau_t^k\,(r_t-\delta)\,K_t + \tau_t^c C_t \tag{35}$$

where $\beta = \beta^* n$. Hence, the decentralized competitive equilibrium in aggregate terms is summarized by equations (26) to (35). This is a system of ten equations in ten unknowns, that is:

$$Y_t, C_t, I_t, K_{t+1}, L_t, H_t, T_t, R_t, w_t, r_t$$

in each period t.

3 Data and Model

To perform the growth accounting exercise and then to simulate our model economy, we must first calibrate the values of the parameters, and assign values to the exogenous variables, and to the initial real capital stock K_{T_0}. To do so we work as follows: First, we match up model's variables and data. Second, we compute series for the real capital stock, K_t, along with a value for the depreciation rate, δ. Third, we produce an estimate for the labour share parameter, $1-\alpha$. Fourth, we calibrate the values for the parameters β and γ. Finally, we produce series for TFP, A_t.

3.1 Match up Model's Variables and Data

All data have been extracted from OECD and Groningen Growth Development Center (GGDC) databases. Since our model economy is a closed one with a government sector, the income identity takes the form $Y_t = C_t + I_t + G_t$. We define Y_t as real gross domestic product (at factor prices), I_t as real gross fixed capital formation, and G_t as real general government final consumption expenditure.[8]

Thus, using the income identity we obtain households real consumption expenditure, C_t, residually. That is:

$$C_t = Y_t - I_t - G_t \tag{36}$$

[8] In order to convert real gross domestic product from market prices to factor prices we subtract from it net indirect taxes, that is taxes less subsidies on production and imports.

Given the structure of our model, this specification implies that government consumption is wasted or alternatively finances the provision of public goods that enter separably in the utility function of the representative household, that is $U(C_t^h, H_t^h; \gamma, \eta) = \gamma \log C_t^h + (1-\gamma) \log H_t^h + \eta \log G_t^h$. Furthermore, we also run numerical experiments under the hypothesis that all tax proceeds are rebated to households as lump-sum transfers. Under this specification we set $G_t = 0$ in the income identity and in the government budget constraint. This implies that all government revenues go to transfers, such as pensions or unemployment subsidies, or to purchases of goods and services that would otherwise be provided privately, such as education or health care.[9]

3.2 Capital Stock and Input Shares

3.2.1 Capital Stock

To obtain series for the real capital stock we apply the perpetual inventory method by employing the law of motion of real capita stock (eq. 31) and data for real investment expenditures, I_t. To do so, we impose two restrictions in order to obtain a value for the depreciation rate parameter, δ, and the initial real capital stock K_{T_0}. The restrictions have as follows: First, for the period 1970-2012, the ratio of consumption of fixed capital over GDP must be equal with that in the data (11.34% for Greece). Hence:

$$\frac{1}{43}\sum_{t=1970}^{2012}\frac{\delta K_t}{Y_t} = 11.34\% \tag{37}$$

Second, the capital - output ratio in the initial period (in our case 1960) must be equal to the average capital - output ratio over the period 1961-1970. Thus:

$$\frac{K_{1960}}{Y_{1960}} = \frac{1}{10}\sum_{t=1961}^{1970}\frac{K_t}{Y_t} \tag{38}$$

Equations (31), (37), and (38) constitute a system of 54 equations in 54 uknowns(K_0, K_1,...K_{2012}, and δ). The solution of this system, along with the real capital stock series, implies $\delta = 3.63\%$ and $\frac{K_{1960}}{Y_{1960}} = 1.7244$.[10]

3.2.2 Input Shares

In order to get values for the input shares we work as follows: Given the fact that the self-employed are a considerable fraction of total employment (well above 30% over the period 1970-2012) we produce an estimate of total compensation for the self-employed. This is done by dividing total compensation of employees (net of employer's contributions to social security) with total dependent employment and then multiplying this with total self employment. The result is the imputed total compensation of the self-employed. To compute the labour share in output, we add total compensation of self-employed to total compensation of employees and then divide this number with real GDP at factor prices.[11] Hence:

$$\text{Labour Share} = \frac{TCE_t^{DE} + TCE_t^{SE}}{Y_t - NIT_t} \tag{39}$$

where TCE^{DE} is total compensation of employees that belong to dependent employment, TCE^{SE} is the imputed total compensation of the self-employed, and NIT is net indirect taxes, i.e. indirect taxes less subsidies on production and imports. Taking the average of equation (39) over the period 1970-2010, we compute a value for the labour share parameter, $1-\alpha$, equal to 56.69%.[12]

3.3 Calibration for β, γ

The time discount factor is calibrated using the Euler equation (eq. 32). This is written in the following way:

$$\beta = \frac{\frac{C_{t+1}}{C_t}}{\frac{1+\tau_t^c}{1+\tau_{t+1}^c}\left(1 + (1-\tau_{t+1}^k)(a\frac{Y_{t+1}}{K_{t+1}} - \delta)\right)} \tag{40}$$

[9] Conesa et al. (2007), Conesa and Kehoe (2007), and Prescott (2002), use similar specification in terms of allocating government revenues to transfers and government consumption.

[10] Since we examine the economic performance of Greece for the period 1979-2001, by choosing 1960 as our initial period for computing capital stock series we decrease the effect of our choice on the constructed series. By 1970 (starting year of our simulations) 30.9% of the 1960 capital stock will have been depreciated.

[11] This method has been proposed by Gollin (2002).

[12] Similar values can also be found in Papageorgiou (2012). Furthermore, the Groningen Growth and Development Center (GGDC) database, for the period 1990-2010, provides an average for the labour share parameter equal to 54.73%. In our series the average for the same period is 55.69%.

The consumption share parameter is calibrated using the labour - leisure trade-off equation (eq. 33). This is written in the following way:

$$\gamma = \frac{1}{\frac{1-\tau_t^l}{1+\tau_t^c}\frac{Y_t}{C_t}\frac{N_t\overline{h}-L_t}{L_t}(1-a)+1} \tag{41}$$

Given data on C_t, Y_t, K_t, L_t, τ_t^c, τ_t^l, τ_t^k and values for α, δ, and h, we take the average of equations (40, 41) over the period 1970-2009 and we compute a value for β and γ. Since we run numerical experiments under two different specifications in terms of allocating government revenues to transfers and government consumption, for each case we obtain different calibrated values for β and γ. Furthermore, we also examine two different cases in terms of the paths of the marginal effective tax rates. In the first, we hold constant the tax rates in their average value during the period 1970-2010, and in the second we use their actual paths (see Figure 3(a)). The calibrated values for β and γ (given α, δ, and h) have as follows:[13]

Table 3: Calibration

		β	γ
Tax Rates	Average (1970-2010)		
Income Identity	$Y_t = C_t + I_t$	0.949	0.3954
	$Y_t = C_t + I_t + G_t$	0.947	0.3342
Tax Rates	Actual Paths		
Income Identity	$Y_t = C_t + I_t$	0.9499	0.3956
	$Y_t = C_t + I_t + G_t$	0.9479	0.3343

3.4 Total Factor Productivity, A_t

As in Conesa et al. (2007) the exogenous TFP series which we feed into the model are obtained using GDP at factor prices. That is:

$$A_t = \frac{Y_t}{K_t^{\alpha} L_t^{1-\alpha}} \tag{42}$$

Hence, given data on Y_t, K_t, L_t, and a value for α, we obtain series for A_t.

However, in the growth accounting exercise, when we report the contribution of TFP to growth we calculate TFP as conventionally measured, that is using GDP at market prices. Since our model economy will produce an output Y_t which is measured at factor prices, to make our results comparable with the data, we convert this into market prices. This is done by writing output at market prices as:

$$\widehat{Y_t} = (1+\tau_{\overline{T}}^c)C_t + I_t + G_t \tag{43}$$

and

$$\widehat{A_t} = \frac{\widehat{Y_t}}{K_t^{\alpha} L_t^{1-\alpha}} \tag{44}$$

where $\overline{T}$ is the base year (for Greece this is 2005).

4 Growth Accounting

Our growth accounting exercise follows the approach adopted by the "Great Depressions Methodology". More specifically, we decompose real per capita GDP into three factors: The TFP Factor, $A_t^{\frac{1}{1-a}}$, the capital factor (capital deepening), $\left(\frac{K_t}{Y_t}\right)^{\frac{a}{1-a}}$, and the labour factor, $\frac{L_t}{N_t}$. This is done by writing the production function (eq. 28) of our model in the following equivalent form:

$$\frac{Y_t}{N_t} = A_t^{\frac{1}{1-a}} \left(\frac{K_t}{Y_t}\right)^{\frac{a}{1-a}} \frac{L_t}{N_t} \tag{45}$$

or in natural logarithms:

$$\ln\frac{Y_t}{N_t} = \frac{1}{1-a}\ln A_t + \frac{a}{1-a}\ln\frac{K_t}{Y_t} + \ln\frac{L_t}{N_t} \tag{46}$$

[13] The average (1970-2010) value for τ_t^c, τ_t^l, and τ_t^k is 14.73%, 25.4%, and 14.76% respectively.

Since it is well known that our model economy converges to a balanced growth path, the above decomposition of real per capita GDP, implies, that along that path all growth of real per capita GDP is attributed exclusively to the trend growth rate of the TFP factor, that is g.

Table 2: Accounting for Growth - Average Annual Changes (%)

Growth Accounting Components	Before Depression 1973-1979	"Great Depression" Crisis 1979-1995	Recovery 1995-2001	Post Depression 2001-2007	New Crisis 2007-2012
Real per Capita GDP	2.13	-0.07	3.13	3.83	-4.62
TFP Factor	-0.66	-1.32	3.5	3.1	-5.97
Capital Factor	3.4	1.82	-1.12	-0.61	5.07
Labour Factor	-0.62	-0.57	0.75	1.34	-3.72

In Table 2 we present the growth accounting characteristics of the Greek economy for the period 1973-2012. The data, indicate an economic performance far from that of a balanced growth path. This means, that the capital factor and the labour factor had not a negligible role in accounting for growth of real per capita GDP. More specifically, during the "crisis" phase the fall of real per capita GDP was caused by a combination of negative growth of the TFP factor (-1.32%) and that of the labour factor (-0.57%). The downfall in economic activity was partially offset by a positive contribution of the capital factor (1.82%). In the "recovery" phase the positive growth rate of real per capita GDP (3.13%) was driven by an increase in the growth rate of the TFP factor (3.5%) and in the labour factor (0.75%). The contribution of the capital factor turned to negative with a growth rate equal to -1.12%. Finally, during the "new crisis" subperiod, we observe a steep downfall of the TFP factor (-5.97%) and of the labour factor (-3.72%).

In the following sections we examine whether our model, given the exogenous paths of government policy variables and that of the TFP, can reproduce the above growth accounting characteristics of the Greek economy. We focus on the period 1979-2001, but we also present results for the other subperiods as well.

5 Solving for the DCE Path

Since our aim is to obtain the series for K_t, L_t, and Y_t along the DCE path of the artificial economy and then compare them with the actual data we work as follows: First we insert equations (26) and (27) into the revenues equation (eq. 35). Thus, we obtain:

$$R_t = \tau_t^l (1-a) A_t K_t^{\alpha} L_t^{1-\alpha} + \tau_t^k \left(a A_t K_t^{\alpha-1} L_t^{1-\alpha} - \delta \right) K_t + \tau_t^c C_t \tag{47}$$

Second, we insert equation (47) into the government budget constraint and we solve for lump-sum transfers, T_t:

$$T_t = \tau_t^l (1-a) A_t K_t^{\alpha} L_t^{1-\alpha} + \tau_t^k \left(a A_t K_t^{\alpha-1} L_t^{1-\alpha} - \delta \right) K_t + \tau_t^c C_t - G_t \tag{48}$$

Third, we insert equations (26), (27), and (48) into the aggregate budget constraint and derive the resource constraint of our economy:

$$\begin{aligned}(1+\tau_t^c) C_t + K_{t+1} &= (1-\tau_t^l)(1-a) A_t K_t^{\alpha} L_t^{1-\alpha} + K_t + (1-\tau_t^k) \left(a A_t K_t^{\alpha} L_t^{1-\alpha} - \delta K_t \right) \\ &+ \tau_t^l (1-a) A_t \left(K_t \right)^{\alpha} \left(L_t \right)^{1-\alpha} + \tau_t^k \Big(a A_t \left(K_t \right)^{\alpha} \left(L_t \right)^{1-\alpha} - \delta K_t \Big) + \tau_t^c C_t - G_t\end{aligned}$$

$$\Rightarrow C_t + K_{t+1} - (1-\delta) K_t + G_t = A_t K_t^{\alpha} L_t^{1-\alpha} \tag{49}$$

Fourth, we solve equation (49) for consumption, C_t:

$$C_t = A_t K_t^{\alpha} L_t^{1-\alpha} - K_{t+1} + (1-\delta) K_t - G_t \tag{50}$$

Fifth, we insert equations (26), (27), and (50) into equations (32) and (33):

$$\frac{A_{t+1} K_{t+1}^{\alpha} L_{t+1}^{1-\alpha} - K_{t+2} + (1-\delta) K_{t+1} - G_{t+1}}{A_t K_t^{\alpha} L_t^{1-\alpha} - K_{t+1} + (1-\delta) K_t - G_t} = \frac{1+\tau_t^c}{1+\tau_{t+1}^c} \beta \left(1 + (1-\tau_{t+1}^k)(a A_{t+1} K_{t+1}^{\alpha-1} L_{t+1}^{1-\alpha} - \delta) \right) \tag{51}$$

and

$$\frac{1-\gamma}{\gamma} \frac{A_t K_t^{\alpha} L_t^{1-\alpha} - K_{t+1} + (1-\delta) K_t - G_t}{N_t \overline{h} - L_t} = \frac{1-\tau_t^l}{1+\tau_t^c} (1-a) A_t K_t^{\alpha} L_t^{-\alpha} \tag{52}$$

Solving for the DCE equilibrium path involves choosing sequences of K_{t+1} and L_t, such that the system of equations (51) and (52) has a unique solution, given sequences of $\{A_t, N_t, G_t, \tau_t^c, \tau_t^l, \tau_t^k\}_{t=T_0}^{\infty}$, the initial real capital stock K_{T_0}, and the transversality condition in aggregate terms.

In order to convert the above system of infinite equations with infinite unknowns into a tractable dynamic system, we follow Conesa et al. (2007) and assume that our economy converges to the balanced growth path and some finite date T_1. Our system is thus reduced to:

For $t = T_0, T_0 + 1, ...T_1 - 1$

$$\frac{A_{t+1}K_{t+1}^{\alpha}L_{t+1}^{1-\alpha} - K_{t+2} + (1-\delta)K_{t+1} - G_{t+1}}{A_t K_t^{\alpha} L_t^{1-\alpha} - K_{t+1} + (1-\delta)K_t - G_t} = \frac{1+\tau_t^c}{1+\tau_{t+1}^c}\beta\left(1 + (1-\tau_{t+1}^k)(aA_{t+1}K_{t+1}^{\alpha-1}L_{t+1}^{1-\alpha} - \delta)\right) \tag{53}$$

For $t = T_0, T_0 + 1, ...T_1$

$$\frac{1-\gamma}{\gamma}\frac{A_t K_t^{\alpha} L_t^{1-\alpha} - K_{t+1} + (1-\delta)K_t - G_t}{N_t \overline{h} - L_t} = \frac{1-\tau_t^l}{1+\tau_t^c}(1-a)A_t K_t^{\alpha} L_t^{-\alpha} \tag{54}$$

and

$$K_{T_1+1} = gnK_{T_1} \tag{55}$$

This is a system of $2(T_1 - T_0 + 1)$ equations, in $2(T_1 - T_0 + 1)$ uknowns (the respective capital and labour sequences).

In order to select the time distance, $T_1 - T_0$, we follow Gogos et al. (2014) and we set $T_0 = 1970$ and $T_1 = 203\dot{9}$. Hence, we solve the system over the period 1970-2039. Since data, for government consumption and TFP are available until 2012, for population until 2011, and for the marginal effective tax rates until 2010, we make the following assumption for the path of their values for the period 2010, 2012, - 2039. In what concerns population, for the years 2012 and 2013 we use OECD projections, and then we assume that it grows at its annual average growth rate over the period 1970-2011. We match our model's population with working age population in the data and compute a value for n equal to 1.0065. For government consumption we make the same assumption as Conesa et al. (2007) do. We assume that after 2012 it grows at a constant growth rate equal to gn. This assumptions is necessary for our equilibrium to converge to a balanced growth path. For TFP we assume that for 2013 and 2014 follows a proportionally similar path to the respective OECD projections for real per capita GDP and after 2014 increases smoothly until 2020 when it reaches its trend growth rate $\frac{A_{t+1}}{A_t} = g^{1-\alpha}$, where $g = 1.02$. Finally, for the tax rates we assume that for the period 2011-2039, they retain the same values as they had in 2010, that is $\tau_t^c = 17.67\%$, $\tau_t^l = 33.99\%$, and $\tau_t^k = 19.6\%$.

6 Numerical Experiments

In this section we compare the growth accounting from the data with that from our artificial economy. Our results are presented in Tables 4 (growth rates) and 5 (Levels) as well as in Figure 5. More specifically, Table 5 presents the index values corresponding to the growth accounting exercise. It shows the index values of detrended real per capita GDP, of detrended TFP factor, of capital factor and of labour factor, relative to their respective values in the beginning of each of the five subperiods. In what concerns Figure 5, the left hand side corresponds to the 1973-2001 period (which includes the 1979-2001 great depression episode), while the right hand side presents the 2001-2012 period.

For convenience in presenting the analysis of our results we numerate the four cases of our numerical experiments. Hence, experiments 1 and 2 correspond to the case where the tax rates take their average values (1970-2010), while in experiments 3 and 4 we use their actual paths (see Figure 3(a)). Finally, in experiments 1 and 3 all tax proceeds are rebated to households as lump-sum transfers, while in experiments 2 and 4 they also finance government consumption. This specification affects mostly the behaviour of the labour factor.

Looking at Tables 4, 5 and Figure 5, we observe that our model economy qualitatively matches the path of key macroeconomic variables (real per capita GDP, capital deepening, and labour hours per capita) of the Greek economy for the period 1979-2001. However, quantitatively, and in terms of timing and turning points, there are subperiods were our artificial economy diverges from the data. This fact, is clearly observed during the subperiod 1993-1999.[14]

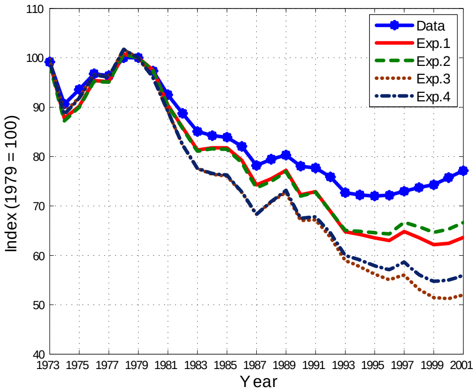
[14] In Table 4 the column with the title "Neoclassical Growth Model" was taken from Tables 5 and 7 in Gogos et al. (2014).

Table 4: Average Annual Changes in Real per Capita GDP (%)

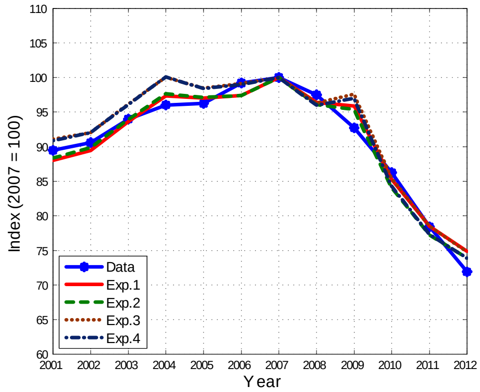
Growth Accounting Components	Data	*Neoclassical Growth Model*	Government Sector: Constant $\tau_t^c, \tau_t^l, \tau_t^k$ $R_t = T_t$	Constant $\tau_t^c, \tau_t^l, \tau_t^k$ $R_t = T_t + G_t$	Actual Paths $\tau_t^c, \tau_t^l, \tau_t^k$ $R_t = T_t$	Actual Paths $\tau_t^c, \tau_t^l, \tau_t^k$ $R_t = T_t + G_t$
1973-1979			1	2	3	4
Real per Capita GDP	2.13	*1.78*	2.13	2.21	2.05	2.08
TFP Factor	-0.66	*-0.66*	-0.57	-0.68	-0.42	-0.54
Capital Factor	3.4	*3.83*	3.98	3.87	4.81	4.73
Labour Factor	-0.62	*-1.39*	-1.28	-0.99	-2.35	-2.11
1979-1995						
Real per Capita GDP	-0.07	*-1.09*	-0.85	-0.75	-1.62	-1.43
TFP Factor	-1.32	*-1.32*	-1.24	-1.33	-1.15	-1.29
Capital Factor	1.82	*1.19*	1.46	1.45	1.6	1.61
Labour Factor	-0.57	*-0.95*	-1.08	-0.87	-2.08	-1.76
1995-2001						
Real per Capita GDP	3.13	*3.02*	2	2.5	0.69	1.39
TFP Factor	3.5	*3.5*	2.41	2.36	2.37	2.28
Capital Factor	-1.12	*-1.63*	-1.26	-1.21	-1.46	-1.39
Labour Factor	0.75	*1.14*	0.86	1.35	-0.22	0.5
2001-2007						
Real per Capita GDP	3.83	*3.97*	4.1	4.04	3.54	3.58
TFP Factor	3.1	*3.1*	3	3.11	2.91	3.03
Capital Factor	-0.61	*-0.25*	-0.56	-0.68	-0.9	-1.03
Labour Factor	1.34	*1.13*	1.66	1.61	1.52	1.58
2007-2012						
Real per Capita GDP	-4.62	*-4.37*	-3.81	-4.07	-3.82	-4.06
TFP Factor	-5.97	*-5.97*	-5.02	-5.21	-4.98	-5.21
Capital Factor	5.07	*5.02*	4.76	4.74	4.34	4.31
Labour Factor	-3.72	*-3.42*	-3.55	-3.59	-3.18	-3.16

6.1 Data vs Model: 1973-2001

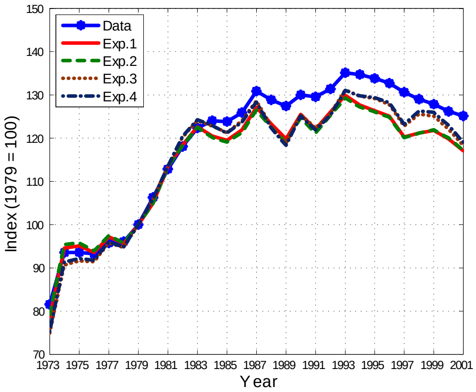
During the period 1979-1995, all experiments overestimate the fall of detrended real per capita GDP. The two polar cases are experiments 2 and 3. The former predicts an average fall of real per capita GDP equal to -1.62% (in levels this accounts to a 43.81% decrease of detrended real per capita GDP, see Table 5), while the latter predicts the mildest depression from all the experiments, that is -0.75% (-35.39% in levels). In the data the fall of real per capita GDP was -0.07% (-27.99% in levels). During the recovery phase (1995-2001), our model now underestimates the increase in real per capita GDP. As in the previous subperiod, experiments 1 and 2 (constant tax rates) are more close to the data (2%, 2.5% vs 3.13%) than experiments 3 and 4 (0.69%, 1.39% vs 3.13). Moreover, the specification that government revenues finance not only transfers but also government consumption, improves the performance of our model for the period 1979-2001. Finally, it is worth pointing out that experiments 3 and 4, in terms of timing, miss the trough of the Greek depression. In our model, the trough comes in the year 1999, while in data the trough comes in the year 1995.



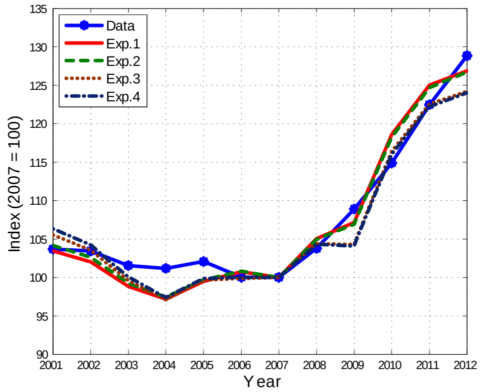
(a) Detrended Real per Capita GDP



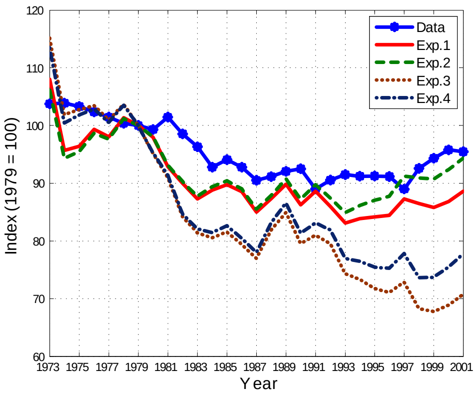
(b) Detrended Real per Capita GDP



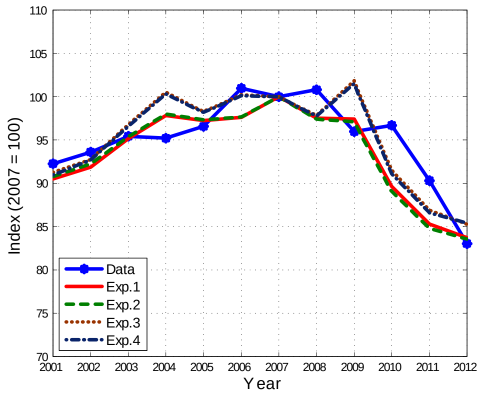
(c) Capital Factor



(d) Capital Factor



(e) Labour Factor



(f) Labour Factor

Figure 5: Data vs Model: 1973-2012

In what concerns the labour factor we observe the following facts. During the crisis phase (1979-1995), all the experiments overestimate the fall of labour hours per capita. Experiment 3 predicts an average fall of -2.08% (-28.26% in levels), while experiment 2 is much closer to the data, that is -0.87% (-15.84% in levels) compared to -0.57% (-8.74% in levels). Generally speaking, the increase in the tax rate of labour income, during the first half of the 80's and during the 90's, along with the fall of TFP, create stronger substitution effects than negative wealth effects and as a result experiments 3 and 4 (actual paths for the tax rates) predict a large fall of the labour factor. Notice that the specification in which tax revenues are not all rebated to households ($R_t = T_t + G_t$) increases the negative wealth effect and as a result the fall in labour hours per capita decreases (-0.87 vs -1.08 for Exp 2, 1, and -1.76 vs -2.08 for Exp 4, 3).

For the period 1995-2001, experiment 3, predicts a fall of the labour factor (-0.22%), while in the data we observe an increase of 0.75%. This is the only case, in all of our experiments, where our model qualitatively does not match data behaviour. Furthermore, the experiment which is closer to the data is the one with constant tax rates and all government revenues rebated to households (Exp.1, 0.86% vs 0.75%). Almost equally successful is experiment 4 (0.5% vs 0.75%).

In terms of the path of the capital factor, for the period 1979-1995, all the experiments underestimate its increase (1.82%), while for the period 1995-2001 all cases overestimate its decrease (-1.12%). Moreover, during the crisis phase, the experiments with variable tax rates (3 and 4) perform better than those with constant tax rates (1 and 2). Things are reversed for the recovery phase. There, experiments 1 and 2 dominate. Finally, it worth pointing out, that the allocation of government revenues ($R_t = T_t$ or $R_t = T_t + G_t$) does not play a significant role for the path of the capital factor (especially in the 1979-1995 period, but also in the recovery phase). This does not hold for the labour factor.[15]

Table 5: Levels (Indexes)

Growth Accounting Components	Data	Government Sector			
		Average (1970-2010) $\tau_t^c, \tau_t^l, \tau_t^k$		Actual Paths $\tau_t^c, \tau_t^l, \tau_t^k$	
		$R_t = T_t$	$R_t = T_t + G_t$	$R_t = T_t$	$R_t = T_t + G_t$
1979 (1973=100)		1	2	3	4
Real per Capita GDP	100.88	100.89	101.41	100.4	100.59
TFP Factor	85.37	85.8	85.27	86.61	85.95
Capital Factor	122.63	126.99	126.16	133.49	132.8
Labour Factor	96.36	92.59	94.26	86.84	88.13
1995 (1979=100)					
Real per Capita GDP	72.01	63.53	64.61	56.19	57.94
TFP Factor	58.96	59.76	58.88	60.63	59.31
Capital Factor	133.83	126.33	126.05	129.18	129.44
Labour Factor	91.26	84.16	87.05	71.74	75.48
2001 (1995=100)					
Real per Capita GDP	107.15	100.13	103.14	92.55	96.54
TFP Factor	109.58	102.59	102.32	102.38	101.82
Capital Factor	93.48	92.7	92.98	91.62	92
Labour Factor	104.6	105.29	108.41	98.67	103.06
2007 (2001=100)					
Real per Capita GDP	111.76	113.59	113.14	109.78	110.05
TFP Factor	106.92	106.34	106.99	105.76	106.47
Capital Factor	96.43	96.67	96	94.74	94.02
Labour Factor	108.39	110.49	110.16	109.57	109.93
2012 (2007=100)					
Real per Capita GDP	71.91	74.88	73.9	74.81	73.92
TFP Factor	67.21	70.48	69.79	70.6	69.79
Capital Factor	128.85	126.9	126.74	124.25	124.05
Labour Factor	83.03	83.72	83.55	85.29	85.39

If we compare our results with those in Gogos et al. (2014), we observe that in terms of the path of the capital factor, the presence of distortionary taxation and government spending moves our artificial economy closer to the data compared to the case of a pure Walrasian environment. Furthermore, in terms of the behaviour of the labour factor, there is an improvement for the period 1979-1995, under the regime of constant tax rates and government consumption (Exp. 2), and this also holds for the period 1995-2001 under the regimes of experiments 1 and 4. However, when we use the actual paths for the tax rates (Exp. 3, 4), especially for the period 1993-1999 (see Figure 6(e)), our artificial labour hours per capita diverge significantly from the data.

6.2 Data vs Model: 2001-2012

Looking at Figure 6 (right hand side) we observe the performance of our model for the period 2001-2012. For the period 2001-2007, our artificial economy performs quite well in terms of the path of real per capita GDP. Experiments 3 and 4 underestimate its growth rate (3.54%, 3.58% vs 3.83%), while experiments 1 and 2 overestimate it (4.1%, 4.04). In what concerns the labour factor all the experiments overestimate its increase. The two polar cases are experiments 1 and 3. The former predicts an increase of 1.66% (1.34% in data) and the latter an increase of 1.52%. Finally, in terms of the path of the capital factor, experiments 1 and 2 are very

[15] See Table 2 in Conesa et al. (2007) for similar results (in qualitative terms).

close to the data (-0.56%, -0.68% Vs -0.61%), while 3 and 4 quantitatively diverge. Hence, when we use the actual paths for the tax rates our model economy is closer to the data in terms of the behaviour of the labour factor and further in terms of the behaviour of the capital factor.

Finally, for the period 2007-2012 we must be very careful in analyzing the performance of our model. The current crisis is still ongoing and as a result we need to wait for better data to become available to draw any firm conclusions about this economic event. Nevertheless, it is worthwhile to present our model's results. As is depicted at Figure 6(b), all the experiments predict a steep fall in detrended real per capita GDP for the period 2007-2012. In fact, all cases underestimate, in absolute terms, the negative growth rate that we observe in the data (-3.81%, -4.07%, -3.82%, -4.06, vs -4.62%). Finally, in terms of the labour and the capital factor our model performs quite well.

7 Concluding Remarks

In this paper we have examined whether neoclassical growth theory, augmented with a government sector, can mimic the path of key macroeconomic variables of the Greek economy for the period 1979-2001. This exercise helps us to shed some light on the quantitative role of government policy and TFP for Greece's economic performance. Our results suggest, that our model qualitatively matches the path of the key macroeconomic variables of the Greek economy for the period 1979-2001. However, quantitatively, there are subperiods were our artificial economy diverges from the data. This fact, is clearly observed during the subperiod 1993-1999. Furthermore, the presence of distortionary taxation and government spending improves the performance of our model compared to the case of a standard neoclassical setting (see Gogos et al. (2014) for the latter case). As a result, we conclude that the government sector is important in accounting for Greece's economic performance over the period 1979-2001.

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Appendix A.

EffectiveTax Rates $\left(\tau_t^c, \tau_t^l, \tau_t^k\right)$

To compute series for the effective tax rates τ_t^c, τ_t^l, and τ_t^k, we adopt a variation from the methodology of Mendoza et al. (1994). First, when we compute the tax base on labour income we take into account the labour income earned from the self-employed. Doing this, makes the specific tax rate series consistent with our labour share parameter estimate. Second, since in our theoretical framework decisions, from households and firms, are taken at the margin we set the income tax rates, τ_t^l and τ_t^k, equal to their effective marginal rates. In order to convert the effective average taxes rates to marginal, we follow Prescott (2002) and we simply multiply the first by a factor of 1.6.

Given data on tax bases (consumption, income, and investment) and tax revenues, the marginal effective tax rates are computed as follows:

Effective Consumption Tax Rate $\left(\tau_t^c\right)$

We define the tax base as the sum of households (H) and nonprofit institutions serving households (NPISH'S) final consumption expenditures (FCE). The tax revenues are general taxes (GT 2100) and excises (EXC 5121).[16]

$$\tau_t^c = \frac{\text{GT (5110) + EXC (5121)}}{\text{HFCE + NPISH'S FCE - GT (2100) - EXC (5121)}} \tag{56}$$

Effective Income Tax Rates $\left(\tau_t^h\right)$

To compute series for labour and capital income tax rates, we begin by computing the aggregate marginal tax rate on household income. We define the tax base as the sum of compensation of employees (net of employer's (2200) and employees (2100) contributions to social security (SSC)), imputed compensation of the self-employed (net of self-employed or non-employed contributions to social security (SSC 2300)), and households non labour income. The last component is taken residually by subtracting from households net operating surplus and mixed income (HGOSMI - HCFC) compensation of the self-employed. The tax revenues are taxes on income, profits, and capital gains of individuals (TIPCGI 1100).

$$\tau_t^h = \mu \frac{\text{TIPCGI (1100)}}{\text{TCE}^{DE}\text{-SSC (2200+2100) + TCE}^{SE}\text{-SSC (2300) + HGOSMI - HCFC- TCE}^{SE}} \tag{57}$$

where HCFC is households consumption of fixed capital.

The progressivity of the income tax system implies that marginal tax rates tend to be larger than the average tax rates we are computing. The term μ is an adjustment factor that transforms average tax rates to marginal tax rates. We follow Prescott (2002) and we set $\mu = 1.6$.

Effective Labour Tax Rate $\left(\tau_t^l\right)$

The tax revenues are computed as follows: We add to tax revenues from households labour income, social security contributions (SSC 2000) and taxes on payroll and workforce (TPW 3000). The tax base is simply the total labour income.

$$\tau_t^l = \frac{\tau_t^h \left(\text{TCE}^{DE}\text{-SSC (2200+2100) +TCE}^{SE}\text{-SSC (2300)}\right) \text{ + SSC (2000) + TPW (3000)}}{\text{TCE}^{DE} + \text{TCE}^{SE}} \tag{58}$$

Effective Capital Tax Rate $\left(\tau_t^k\right)$

The tax revenues are computed as follows: We add to tax revenues from households capital income, taxes on income , profits, and capital gains of corporations (TIPCGC 1200), recurrent taxes on immovable property (RTIP 4100), and taxes on financial and capital transactions (TFCT 4400). The tax base is simply the total net capital income.

$$\tau_t^k = \frac{\tau_t^h \left(\text{HGOSMI - HCFC- TCE}^{SE}\right) \text{ + TIPCGC (1200) + RTIP (4100) + TFCT (4400)}}{\text{GDP - NIT - CFC - TCE}^{DE}\text{ - TCE}^{SE}} \tag{59}$$

where CFC is consumption of fixed capital.

[16] The numbers in the parentheses are the codes of the specific tax revenues in OECD tax statistics database.

Appendix B.

All data have been extracted from two sources, OECD and Groningen Growth Development Center Databases:

a) OECD (2010), "Aggregate National Accounts: Gross domestic product", OECD National Accounts Statistics (database).

b) OECD (2010), "Aggregate National Accounts: Disposable income and net lending/borrowing", OECD National Accounts Statistics (database).

c) OECD (2010), "Revenue Statistics: Greece", OECD Tax Statistics (database).

d) OECD (2010), "Labour Force Statistics: Population and labour force", OECD Employment and Labour Market Statistics (database).

e) OECD (2010), "Aggregate National Accounts: Population and employment by main activity", OECD National Accounts Statistics (database).

f) OECD (2012), "OECD Economic Outlook No. 92", OECD Economic Outlook: Statistics and Projections (database).

g) OECD (2011), "OECD Economic Outlook No. 91", OECD Economic Outlook: Statistics and Projections (database).

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i) The Conference Board Total Economy Database (January 2012), "Output, Labour, and Labour Productivity, Country Details 1950-2011".

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