PANTEION UNIVERSITY OF SOCIAL AND POLITICAL SCIENCES
DEPARTMENT OF ECONOMIC AND REGIONAL DEVELOPMENT
POSTGRADUATE PROGRAM OF APPLIED ECONOMICS
AND REGIONAL DEVELOPMENT
APPLIED ECONOMICS AND ADMINISTRATION

AN APPLICATION OF A KYDLAND-PRESCOTT MODEL ON THE GREEK ECONOMY

Krompas Ioannis

SUPERVISOR:
Siourounis Grigorios, Ph.D.

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Abstract

In this paper a reduced form model that follows the logic of the real business cycle theory, first introduced by Kydland and Prescott, is considered. The model is used to estimate the fluctuations in Greek GDP, associated with productivity shocks and their persistence factor. The elasticity of the productivity shock at time *t* with respect to productivity shock at time *t-1* is found to be 0.80 in a sample of quarterly data between the first quarter of 1998 and the second quarter of 2016 and 0.876 when annual data were used (1970-2014). The persistence factor is found to be rising throughout the sample. Additionally, the productivity shock from the residuals of the model seems consistent with other methods of obtaining the business cycle component of an economy. When estimated with quarterly data the model fails to consistently outperform naïve and ARMA models in forecasting. However, when the model is estimated over a prolonged period of annual data, it outperforms both models.

To my parents, without whom,

my journey in higher education would have never been possible.

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Introduction

Since the offset of the European debt crisis in 2008, Greece has been in the epicenter of macroeconomic and policy analysis, as to what caused and contributed to economic developments in Greek economy from that period onwards. Additionally, a substantial amount of analyses is focused on what policy makers in Greece and international institutions should do, in order to put the Greek economy back on the path of growth.

Of course, both parts of the analysis are equally important. However, in all this discussion a key macroeconomic concept has not been thoroughly examined as to the role it played in the development of Greek GDP from 2009 onwards. This is what the present paper attempts to do in the following chapters: To examine developments in Greece's GDP from a real business cycle perspective. Specifically, this paper will present the development of the Greek business cycle, as it is defined in the real business cycle concept, which Nobel laureates Finn E. Kydland and Edward C. Prescott introduced in their revolutionary paper "Time to Build and Aggregate Fluctuations" in 1982.

The questions the paper attempts to answer are: How much of the Greek GDP downfall in 2010-12 can be attributed to a downwards movement of the business cycle as measured in the real business cycle theory and if currently Greece's business cycle is in an uptrend or in a downtrend. Furthermore, it is examined if a simple real business cycle model could have predicted the developments in Greek GDP for the period 2010-2016 and if the principles Kydland and Prescott theorized about an economy's behavior hold in the case of Greece. In the end, a forecast of Greek GDP up to 2018 is attempted.

Additionally, a brief historic cross examination of the developments in Greek economy against major movements of the real business cycle will be presented in an attempt to understand what affects the Greek real business cycle.

The subject at hand will be discussed in the following chapters as follows: In the first chapter a literature overview is made on the model of Kydland and Prescott and the real business cycle theory. In the second chapter the data that are used in the analysis are presented. The third chapter covers the methodology that was followed and the forth chapter presents the results of the analysis. In the fifth and final chapter, the results of the analysis are discussed.

Review of Literature

In 1982 Finn E. Kydland and Edward C. Prescott introduced a model to explain cyclical fluctuations in output and other macroeconomic variables. Among the innovations of the model introduced, were the maximizing utility function of the households in the model's structure and the inclusion of long run growth and short run variations of GDP in one model (The royal Swedish Academy of Sciences, 2004)

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Kydland and Prescott theorized that the shocks to an economy could not be monetary in nature but could better be described as technological shocks (even though this assumption was challenged later on, but it is yet to be determined with certainty what drives the fluctuations-business cycle of an economy), stochastic in nature, which showed some persistence over time. Those fluctuations in output affect the efficiency of the factors of production (mainly labor), which in its turn affects the decisions of economy's agents in regard to investment and consumption and have an impact back to the economy's output.

A year later (1983) Long and Plosser introduced the term Real Business Cycle theory, which was in essence the description of an economy's behavior according to what Kydland and Prescott had theorized in their model. According to Real Business Cycle theory employment fluctuations are a result of intertemporal substitution of leisure and in times that an economy is under a negative shock, productivity is lower than it used to, causing wages to drop, and thus people prefer to substitute their working time with leisure. Two other hypotheses of the Real Business Cycle theory are that in times of recession the capital is consumed in order for consumption to be smoothed out and that money play no role in business cycles (even though in more recent models monetary surprises are included as shocks).

What makes Real Business Cycle an appealing theory is that the theorized behavior is observed in the data: When examining a set of core macroeconomic variables of an economy it is observed that they have volatility with repetitive patterns over time. Additionally, most patterns are towards the same direction, at the same point in time, with the exception of capital stock. Finally if a given variable is below or above its long term trend, the chances are that it will continue to be under or above the trend at the next time period; meaning that the stochastic shock comes with a persistence factor, which, however, wears out over time (Deng 2009).

Even though Kydland and Prescott theorized, in their model that the shocks are technological in nature, it has later been later modified to simulate shocks in the economy generated from government spending and tax policy (Ramey and Shapiro 1998, Burnside, Eichenbaum, Fisher 2004), monetary shocks (Bernanke, Gertler, Gilchrist 1999, Gali, Lopez-Salido, Valles 2004), shocks generated from changes in oil prices (Finn 2000), even news shocks (Cochrane 1994, Beaudry and Portier 2004) have been considered. However, what actually moves business cycles is an ongoing debate in macroeconomics.

The shock as a variable is often associated with the Total Factor Productivity, the excess increase of output over a given increase of inputs of a production process. Other ways to obtain the stochastic shock without modeling is the Hodrick-Prescott Filter and other types of filters, which separate the cyclical from the linear component of a time series.

The Data

A. Introductive notes

The analysis is performed over two periods, a short run period, in which quarterly data are used, and a long run period in which annual data are used. The short run analysis sample covers a time period of 18 years, starting from the first quarter of 1998 and going up to the second quarter of 2016, whereas the long term analysis sample covers the period between 1970 and 2014.

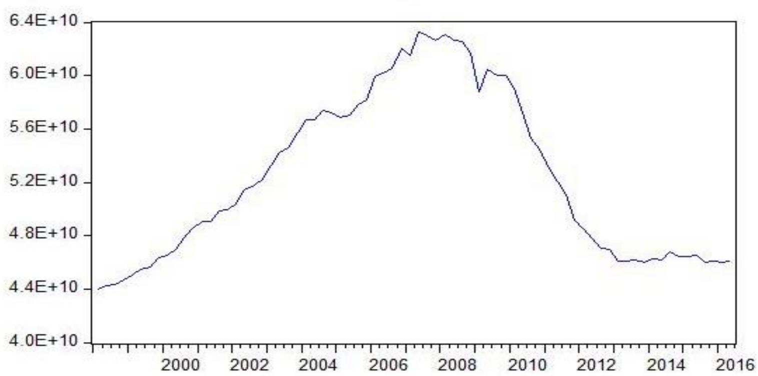
The variables used in the analysis are real GDP of Greece, as a variable representing output of the economy, a proxy for the capital that participates in production and total hours worked, which represents the labor input in the production function. It must be mentioned, however, that when estimating productivity, the most suitable variable for capital input is a capital services volume index (OECD 2001) and additionally, hours worked should be weighted in order to account for the fact that not all hours worked are equally productive (the usual way to account for this is by weighting the hours worked of each educational level with the respective average wage) (OECD 2001). In the case of Greece there was not a capital services volume index available, nor were there sufficient data to construct one. Furthermore, weighting the labor input would lead to a dramatic reduction of the sample period. Hence, in the short term analysis, the OECD's estimates of productive capital in the economy are used as capital input and the labor input is constructed by multiplying the average weekly hours worked per person employed by 52, transforming it to an annual base, interpolating it to quarterly format and then multiplying it again with the number of peopled employed in the respective time period. For the long run analysis all data were drawn from the Penn World Tables. Data for real GDP is also taken form the Eurostat database and from the Penn World Tables for the short term analysis and the long term analysis respectively.

B. Presenting the short term analysis data

In this section the time series used in the short term analysis and their respective descriptive statistics are presented:

First is the real GDP, in 2010 prices seasonally adjusted. From the figure 1 we observe that it follows an uptrend, which reaches its peak in the second quarter of 2007. From there it decreases until 2012, after which it seems to be relatively stagnant.

Figure 1 : Real GDP



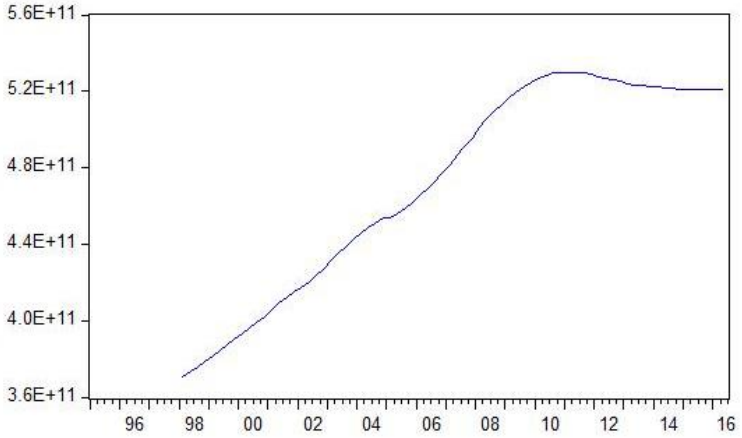
Source: Eurostat

Table 1: Real GDP Descriptive Statistics (quarterly data)

observations	**74**
Mean	5.24*e^{10}
Median	5.13*e^{10}
Maximum	6.33*e^{10}
Minimum	4.40*e^{10}
Standard Deviation	6.24*e^{10}

In figure 2 we observe the OECD's estimates for productive capital in Greece. The time series follows an uptrend up to 2010, after which there is a mild decrease. In OECD database productive capital is estimated in an annual base but in order to match the data with the other variables an interpolation process has been applied.

Figure 2: Productive Capital



Source: OECD

Table 2: Productive Capital Descriptive Statistics (quarterly data)

observations	**74**
Mean	$4.72*e^{11}$
Median	$4.84*e^{11}$
Maximum	$5.30*e^{11}$
Minimum	$3.71*e^{11}$
Standard Deviation	$5.38*e^{11}$

In figure 3 hours worked are observed. The series has also been seasonally adjusted. What we observe in this figure is a rather volatile uptrend from 1998 to 2009 and then a sharp and abrupt decrease with a small rebound in the last observations.

Figure 3 : Hours Worked

Source: Eurostat

Table 3: Hours Worked Descriptive Statistics (quarterly data)

observations	**74**
Mean	$8.74*e^{09}$
Median	$8.97*e^{09}$
Maximum	$9.68*e^{09}$
Minimum	$7.29*e^{09}$
Standard Deviation	$8.02*e^{08}$

It is worth noting that even before the analysis starts, in the figures we observe that the variables behave in a way similar to the one Kydland and Prescott assumed. Developments in GDP are mostly driven by developments in labor which is a more volatile variable than capital stock. Additionally capital stock is reduced in times of GDP recession, possibly in an attempt to smooth over consumption.

C. Presenting the long term analysis data

In the present section the annual data for the long term analysis are presented. Time series of real GDP (at constant national prices) and capital stock were obtained in 2011 U.S. Dollars from the Penn World Tables and transformed into 2011 Euros.

In Figure 4 we observe that real GDP follows the same developments that are shown in Figure 1, Additionally, we observe that going back to the 1950's the GDP of Greece has had only a few mild shortfalls compared to the one observe from 2008 onwards.

Figure 4: Real GDP Annual

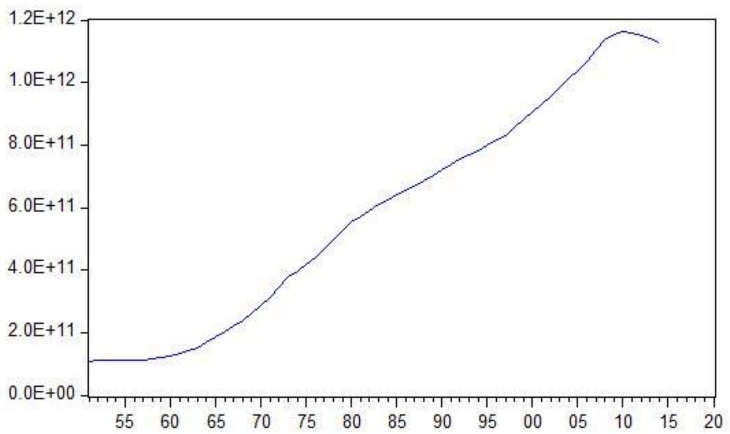
Source: Penn World Tables

Table 4: Real GDP Annual Descriptive Statistics

observations	64
Mean	$1.23*e^{11}$
Median	$1.31*e^{11}$
Maximum	$2.38*e^{11}$
Minimum	$2.41*e^{10}$
Standard Deviation	$6.30*e^{10}$

In figure 5 the capital stock of the economy is displayed. Yet again we observe an uptrend with very mild fluctuations. However, in the last six years capital stock has reached a threshold after which, a slight decrease is observed.

Figure 5: Capital Stock Annual



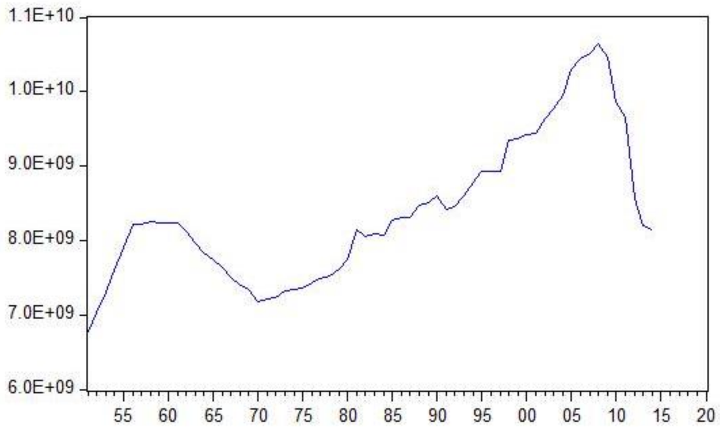
Source: Penn World Tables

Table 5: Capital Stock annual Descriptive statistics

observations	64
Mean	$5.81*e^{11}$
Median	$6.01*e^{11}$
Maximum	$1.16*e^{12}$
Minimum	$1.06*e^{11}$
Standard Deviation	$3.60*e^{11}$

In Figure 6, the annual hours worked are presented. Similarly to the short term analysis, this time series is obtained by multiplying the average annual hours worked time series with the people employed time series. Unlike the other two variables of the long run analysis Hours worked has shown severe shortfalls in decades other than the most recent one and it seems to be the most volatile variable.

Figure 6: Hours Worked Annual



Source: Penn World Tables

Table 6: Hours Worked annual Descriptive statistics

observations	**64**
Mean	$8.38*e^{09}$
Median	$8.23*e^{09}$
Maximum	$1.06*e^{10}$
Minimum	$6.77*e^{09}$
Standard Deviation	$9.70*e^{08}$

By plotting the data two interesting facts are pointed out. First, the variables seem to follow the behavior Kydland and Prescott hypothesized and described in the structure of their model. The second interesting topic is that in figure 6 we observe the period 2009-2014 was not the first one for a sharp decrease in labor to be recorded, a similar downtrend is observed in the 1960's. The shortfall in the 1960's however was not accompanied by a shortfall in real GDP, as was the case in the early 2010's, but by a sharp increase.

Empirical Methodology

A. Introductory notes

For the purposes of this paper a reduced form of the real business cycle model is considered. A reduced form model over a calibrated model is chosen, since the cyclical component of output and its persistence factor are the primary interests of this paper, and can be extracted from the data along with testing whether or not the real business cycle assumptions exist in the data. Additionally, there are fewer judgment calls since the coefficients are estimated, rather than calibrated.

The reduced form of such a model is defined as the following Cobb-Douglas production function:

$Y_t = z_t K_t^a L_t^{1-a}$ (1)

In order for the production function to be estimated, a log transformation is necessary, thus:

$ln(Y_t) = ln(z_t) + aln(K_t) + (1-a)ln(L_t)$, (2)

Where $ln(z_t)$, follows an autoregressive procedure of order 1:

$ln(z_t) = \rho ln(z_{t-1}) + \varepsilon_t,\ 0 < \rho < 1$, (3)

$\varepsilon_t \sim N(0, \sigma^2)$.

Y_t= Output (GDP),
K_t= Capital stock,
L_t= Hours worked,
a= elasticity of output with respect to capital or percentage of participation of capital in the production process,
$1-a$= elasticity of output with respect to labor or percentage of participation of labor in the production process,
z_t= Business cycle component.
ρ= Persistence factor of *t-1* shock at time t.

The estimation process is similar to the one followed by Everaert and De Simone (2003) for France, except for the fact the model is estimated in logarithms rather than log differences, because if the model is estimated in log differences then the business cycle component cannot be plotted and there is no autocorrelation to estimate the persistence factor in the case of Greece.

B. Short Term Analysis

The analysis started with the estimation of the reduced form of the real business cycle model. However, in the case of Greece, a few modifications had to be made to the original model, thus:

$Y_t = cK_t^a L_t^b z_t$. (4)

Even though the Cobb-Douglas production function in literature is usually estimated without a constant, here one is included. This is because in the forecast section, where the model is estimated in a subsample, the coefficients of the model appear with opposite sings; additionally, when the business cycle component from the residuals of the equation (1) is plotted, the leftover residuals are not white noise. Including a constant solves these problems but by including it, the assumption that $b=1-a$ is forfeited, along with the interpretation of the coefficients as percentage of participation of each variable in the production process. For consistency reasons the model is estimated with a constant in all the short term analysis. A constant in production functions is often interpreted as a proxy for technological efficiency. The model is estimated in natural logarithms with least squares estimation. From the residuals, the shock equation is constructed; in order to be able to estimate the persistence factor recursively, using recursive least squares, the production shock must be estimated with OLS, using the first lag as an explanatory variable, which is similar to what R. Pancrazi and M. Vukotic did to measure changes in TFP persistence factor (Pancrazi, Vukotic 2012).

Having obtained the business cycle component, a crucial assumption of the model is tested: does the business cycle component have a systematic relationship with labor (hours worked)? To test this assumption the productivity shock cannot be regressed against the labor variable; this is because the residuals and the explanatory variables are supposed to be uncorrelated in OLS estimation, hence the results would be doubtful. A pairwise granger causality test is preferred to explore the possibility of a causal relationship between the two variables.

The next test that was performed was a comparison between different methods of extracting the business cycle component from the GDP. The goal is to examine whether or not the estimation of the business cycle obtained by the real business cycle model is consistent with other methods of extracting the cyclical component. The most common methods to measure the real business cycle (other than the real business cycle model) are the Hodrick-Prescott filter and the Baxter- King filter, two tools widely used in macro econometrics that separate cyclical components from their long run linear trends, along with the residuals from a deterministic trend regressed against the output, which is the simplest way to extract the non-linear component from a time series. The differences found between the cyclical components obtained from all those methods and between the respective linear components are then discussed.

The short term analysis concludes with an in-sample forecast evaluation of the model. The main objective of this section of the empirical analysis is to determine whether or not the real business cycle model could have predicted the developments in Greek GDP over the last few years. At first, the model is estimated up to the quarter of 2010 then two forecasting strategies are used; the first one is a long horizon forecast from the second quarter of 2010 to the second quarter of 2016. The second forecasting strategy applied is an expanding window, one step ahead forecasting, over the same forecasting sample. Additionally, the forecasting performance of the real business cycle model is compared with the forecasting performance of three other models: A random walk model, an ARMA model and a production function model which includes real money balances. The last model was chosen because a common critique against the real business models is that they do not take into consideration the monetary aspects of the economy. Furthermore, Sinai and Stokes (1972) argued that in fact, real money balances is an omitted variable from production functions.

C. Long Term Analysis

After the short terms analysis was completed it seemed worth the time to recreate the analysis and go further into the past. However, the long term analysis yielded some results that are in conflict with the results that the short term analysis delivered, thus it seemed that it would be constructive to include both analyses in the paper and discuss the controversies that appear between the two analyses.

The long term analysis followed the same steps of the short term analysis with some slight differences. First the real business cycle model is estimated without the constant since there is no need for it. In fact, if one is added it turns out to be statistically insignificant. Another difference is that the short term analysis was carried out with variables with 2010 as a base year, whereas the long term analysis was carried out with 2011 being the base year. Rescaling the base year was not an option because the nominal values of capital stock were not available for none of the analyses. Another difference between the two analyses is that in the long term analysis building a production function with real money balances to compare forecasting performance was not an option, because there are not monetary data available for Greece for the whole sample period. However, in the end of the long term analysis an out of sample forecast up to 2018 is attempted based on OECD's estimations for capital and labor developments for the years 2015-2018.

Another point to be mentioned regarding the long term analysis is that even though the available data ranges from 1950 to 2014, only the period 1970-2014 is used in the model; this is because the period between 1950 and 1970 seems to have extremely low quality of data and the model performs better without them.

Results

A. Short term analysis

i. The real business cycle model

Table 7: Main equation output

Dependent variable:	**Ln(Y)**		
Regressors:	C	Ln(K)	Ln(L)
Point estimation:	-17.51	0.54	1.21
std. Error:	1.33	0.03	0.04
t -statistic:	-13.15	18.05	32.39
Significance (p-value):	0.00	0.00	0.00
HAC (AIC lags) std Errors:	3.96	0.08	0.18
HAC (AIC lags) t-statistic:	-4.42	6.39	6.71
HAC (AIC lags) p-value:	0.00	0.00	0.00

Table 8: Main equation statistics

R squared	0.94102	Mean of dependent variable	24.67590
Adjusted R squared	0.93936	S.D. of dependent variable	0.11766
S.E. of regression	0.02898	Akaike info criterion	-4.20510
Sum squared residuals	0.05961	Schwarz criterion	-4.11169
Log likelihood	158.58850	Hannan-Quinn criterion	-4.16783
F-statistic	566.40990	Durbin-Watson stat	0.39918
Prob(F-statistic)	0.00000		

The main equation was estimated with ordinary least squares. However, it is evident by the Durbin-Watson statistic that there is a serious case of autocorrelation in the model, which of course was expected given that the residuals should follow an AR(1) process. When there is autocorrelation present in estimation the point estimations of the coefficients are not biased but this is not the case for their standard errors and subsequently, their t-statistics and statistical significances. In order to ensure that capital and labor inputs are statistically significant the regression was also estimated with heteroskedasticity and autocorrelation consistent standard errors. This is the only case where HAC standard errors were used. The rest of the analysis is based on the OLS estimation.

Both capital and labor are statistically significant at every reasonable significance level. Additionally, it seems that GDP is more sensitive to changes in labor that in capital. In other words, the Greek economy seems to be labor intensive. In terms of model stability, by running a recursive coefficients test, it is shown that the coefficients have a rather erratic behavior within the sample.

Figure 7: Capital recursive coefficient test

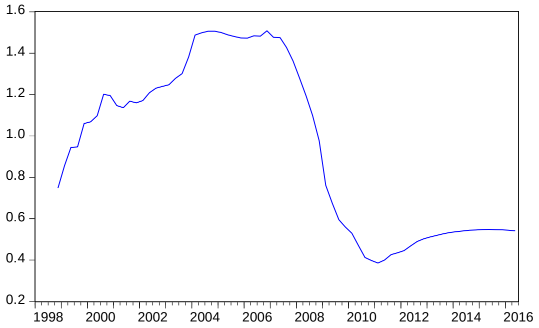
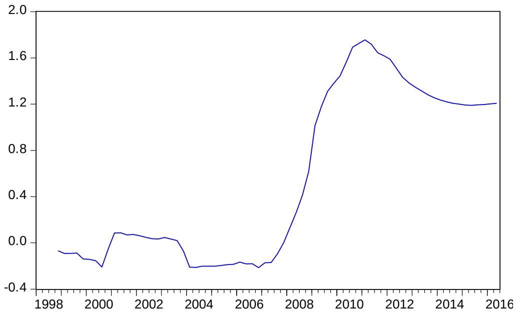


Figure 8: Labor recursive coefficient test



The test reveals that in the first observations of the sample changes in capital had a bigger impact than they have in the latter observations.

From the residuals of the main equation by implementing OLS the productivity shock equation is estimated:

Table 9: Productivity shock equation output

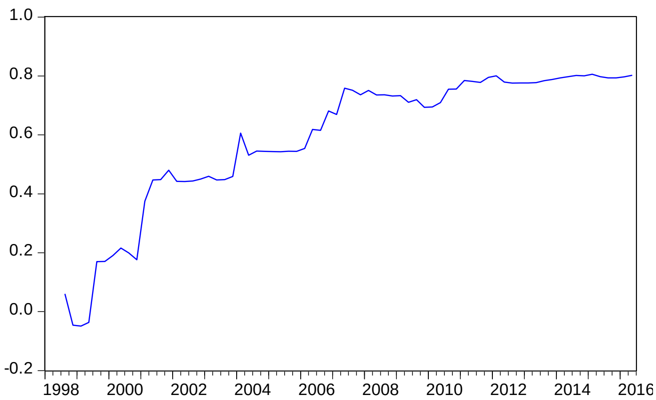
Dependent variable:	**$Ln(z_t)$**
Regressor:	$Ln(z_{t-1})$
Point estimation:	0.802204
std. Error:	0.071465
t -statistic:	11.22519
Significance (p-value):	0.0000

Table 10: Productivity Shock equation statistics

R squared	0.63633	Mean of dependent variable	-0,00295
Adjusted R squared	0.63133	S.D. of dependent variable	0.028659
S.E. of regression	0.017283	Akaike info criterion	-5.264616
Sum squared residuals	0.021506	Schwarz criterion	-5.233240
Log likelihood	193.1585	Hannan-Quinn criterion	-5.252112
Durbin-Watson stat	2.170692		

By estimating the equation recursively it can be found that the persistence factor has been increasing in the sample period:

Figure 9: Business Cycle Persistence factor changes



It is evident that the persistence factor shows periods of increase and periods of stability. It can also be seen that during the recent years, after the financial crisis the persistence factor has stopped increasing.

Furthermore, by applying a reverse logarithmic transformation to the residuals, the business cycle component is obtained:

Figure 10: Business Cycle component

Table 11: Business Cycle component descriptive statistics

Mean	**1.000403**
Median	1.001088
Maximum	1.073058
Minimum	0.937807
Std. Dev.	0.02856

From the productivity shock equation it is evident that for every 1% greater shock at time t, the shock at time t+1 will be 0,8% greater. By plotting the business cycle component an uptrend is evident up to 2007, followed by a downtrend with a rebound between 2012 and 2014.

ii. Productivity shock and intertemporal substitution of leisure

Kydland and Prescott theorized that productivity shocks affect labor rather that capital stock. Capital stock is only consumed when there is a need to smooth over consumption. Additionally, labor tends to be high when the wage is high and the opposite (an intertemporal substitution of leisure hypothesis). Since Kydland and Prescott introduced those hypotheses with structure into their model and the model in this paper is in reduced form, it would make sense to test if this hypothesis holds in the absence of structure.

A systematic relation is detected between the two variables (z and L) when a pairwise Granger causality test of four lags[1] is conducted, there is no reason to reject the null hypothesis that labor does not granger cause changes in the business cycle component but the null hypothesis that the productivity shock does not granger cause changes in labor at 1%, 5% and 10% levels of statistical significance can be rejected.

Table 12 : Pairwise Granger causality test (4 lags) between labor and productivity shock

Null Hypothesis:	Obs	F-Statistic	Prob.
z does not Granger Cause L	70	5.07190	0.0014
L does not Granger Cause z	70	0.63107	0.98434

Furthermore by regressing labor against the real (2010 prices) quarterly wage (W), a positive systematic relationship is also detected, meaning that labor and real wage do move towards the same direction too.

[1] The results do not change no matter how much the lags increase or decrease.

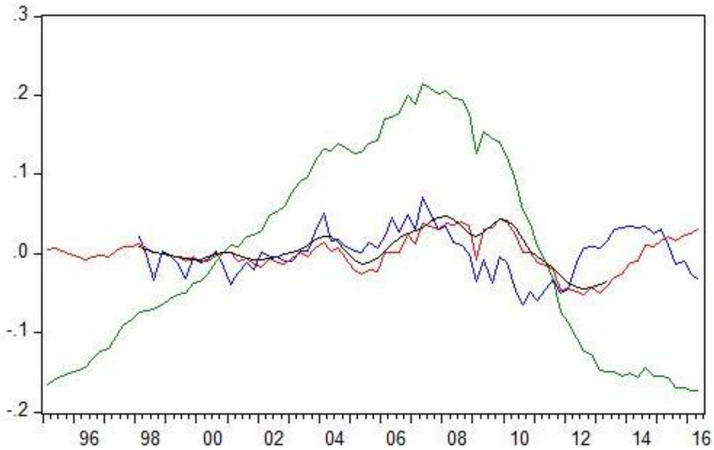
Table 13: Regression of labor against real wage

Dependent variable:	L		
Regressors:	W	Constant	Ar(1)
Point estimation:	654954.6	$5.23*e^{9}$	0.97652
std. Error:	167085	$9.83*e^{8}$	0.029339
t -statistic:	3.91989	5.326099	33.28387
Significance (p-value):	0.0002	0.0000	0.00000

iv. Analyzing and comparing the business cycle components.

In the next step of the analysis the business cycle component obtained from the main model is compared against other common methods of extracting a cyclical component from a GDP time series. Those methods include the regression of GDP against a deterministic time trend, The Hodrick-Prescott filter (with a smoothing parameter λ= 1600), and the Baxter-King filter. Given the fact that different methods produce results in different units of measurement (for instance the business cycle component is a number slightly above or below 1, whereas the residuals of a deterministic time trend are in billion euros), the cyclical component is extracted from the logarithmic transformation of GDP, so that the cyclical components can be easily compared with each other.

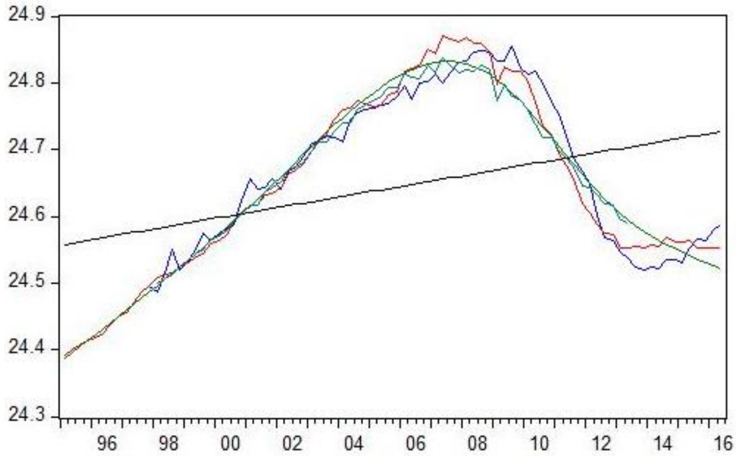
Figure 11: Cyclical components (in logarithms)



Blue: Business cycle component from real business cycle model,
Red: Cyclical component from Hodrick- Prescott filter,
Green: residuals from deterministic trend,
Black: Baxter-King filter.

In figure 11 it can be noticed that the Baxter-King filter and the Hodrick-Prescott filter produce almost identical results, the only difference is that the Baxter-King cyclical component seems to be smoother. The residuals of the deterministic trend produce an uptrend up to 2007 and a downtrend after that. The business cycle component from the real business cycle model is a more volatile than the HP and the Baxter-King filters. In periods 2003-2007 and 2012-2014, the business cycle component from the model is more optimistic than the filters, and between 2008-2011 it is more pessimistic than the filters but they all tend to move towards the same direction except for the period after 2014 where the HP filter's uptrend continues whereas the uptrend of the business cycle component comes to an end and reverses. Those differences between the methods can be explained by plotting the linear components that are left, when the cyclical component is extracted:

Figure 12: Linear Components (in logarithms)



Red: Actual output
Blue: Main model
Black: Deterministic trend
Green: HP filter
Light blue: BP filter

The linear components of GDP can be interpreted as the potential output[2], what the economy would have produced if there were no shocks, either positive or negative. By plotting the linear component it can be noticed that the differences between the two cyclical components (HP and the main model) occur because each method "interprets" differently the productive capabilities of the economy. For example, from 2008 to 2011 the potential output of the economy according to the real business cycle model is higher than the actual but according to HP filter the potential output is lower than the actual. Similarly, according to the real business cycle model there is an increase in the economy's capabilities from 2015 onwards, whereas, according to the HP filter the capabilities of the economy remain relatively stagnant[3].

v. Forecasting with the real business cycle model

The goal of this analysis is to test whether or not a simple real business cycle model could have predicted the developments in the Greek GDP during the Eurozone debt crisis and to assess its predictive abilities in general. The estimation sample was the period between the first quarter of 2000 up to the first quarter of 2010, and the forecasting sample was between the second quarters of 2010 up to the second quarter of 2016. The model is tested against three other models:

[2] The linear component of the model could be defined more accurately as output net of productive shocks. This is because when estimating potential output, the whole labor force must be considered, whereas in the linear component of the model only the workers employed at that time are taken into account (Havik et al. 2014).

[3] It is important to remember that in the real business cycle model the capital stock input is based on estimates, thus the deviations between the model's estimation and the HP filter may be result of the extra uncertainty rather than of the method applied.

A naïve random walk model:

$\ln(Y_t) = c + \ln(Y_{t-1}) + \varepsilon_t,$ [4] (5)

Table 14: Random walk model estimation output

Dependend variable:	**Ln(Y_t)**	
Regressors:	C	Ln(Y_{t-1})
Point estimation:	0.00591	1.00000
std. Error:	0.00226	N/a
t -statistic:	2.61149	N/a
Significance (p-value):	0.0126	N/a

Table15: Naive model Statistics

R squared	0.976332	Mean dependent variance	24.750700
Adjusted R squared	0.976332	S.D. dependent variance	0.094203
S.E. of regression	0.014493	Akaike info criterion	-5.606270
Sum squared residuals	0.008401	Schwarz criterion	-5.564475
Log likelihood	115.928500	Hannan-Quinn criterion	-5.591050
Durbin-Watson stat	2.023716		

An ARMA model, with a dummy variable (β_t) to account for a major downfall in 2009 Q1 that was causing non-normal and heteroskedastic residual statistics:

$ln(Y_t) = c + b_0\beta_t + e_t,$ (6)

$e_t = b_1 e_{t-1} + b_2 \varepsilon_{t-3} + \varepsilon_t$ (7)

$\varepsilon_t \sim N(0, \sigma^2)$

Table 16: ARMA model estimation output

Dependent variable:	**Ln(Y_t)**			
Regressors:	Constant	AR(1)	MA(3)	Dummy
Point estimation:	24.68	0.99	0.63	-0.0411
std. Error:	0.125562	0.0389	0.2041	0.00817
t -statistic:	196.58	25.445	310733	-5.04003
Significance (p-value):	0.0000	0.0000	0.0037	0.0000

[4] The residuals in this equation are not distributed normally according to the Jarque-Bera statistic.

Table 17: ARMA model statistics

R squared	0.986848	Mean of dependent variable	24.75070
Adjusted R squared	0.985387	S.D. of dependent variable	0.094203
S.E. of regression	0.011388	Akaike info criterion	-5.841559
Sum squared residuals	0.004668	Schwarz criterion	-5.632587
Log likelihood	124.7520	Hannan-Quinn criterion	-5.765463
Durbin-Watson stat	1.586417		

In 1972 Sinai and Stokes constructed a production function to discuss whether or not real money balances is an omitted variable in the production function. Their version of the production function included a capital input, a labor input and real money balances input as explanatory variables. Since Real business Cycle models have been criticized that they do not account for the monetary sector of the economy in makes sense to include a model that includes monetary variables. Since the creation of the Euro monetary union, statistics for monetary aggregates for each country are only included as a reference item in public databases. To solve this problem, stock of money in overnight deposits at the end of each quarter are used as a proxy (in 2010 prices).

The Sinai and stokes production function is defined as:

$\ln(Y_t) = C + b_1 \ln(K_t) + b_2\ln(L_t) + b_3\ln(RB_T) + \varepsilon_t$, (8)

$\varepsilon_\tau \sim N(0, \sigma^2)$.

Where RB_t is the real money balances proxy. In table 19 the output of the regression with correction for autocorrelation is presented:

Table 18: Sinai and Stokes production function estimation output

Dependent variable:	**Ln(Y)**					
Regressors:	C	Ln(K)	Ln(L)	Ln(RB)	AR(6)	AR(9)
Point estimation:	-20.27438	0.31038	1.47965	0.11427	-0.37217	-0.38982
std. Error:	3.20323	0.08980	0.17791	0.03153	0.19334	0.11859
t-statistic:	-6.32935	3.45626	8.31695	3.62418	-1.92491	-3.28723
Significance (p-value):	0.00000	0.00150	0.00000	0.00090	0.06260	0.00240

Table 19: Sinai and Stoke production function estimation statistics

R squared	0.96714	Mean of dependent variable	24.75070
Adjusted R squared	0.96134	S.D. of dependent variable	0.09420
S.E. of regression	0.01852	Akaike info criterion	-4.91679
Sum squared residuals	0.01167	Schwarz criterion	-4.62422
Log likelihood	107.79410	Hannan-Quinn criterion	-4.81025
F-statistic	166.75750	Durbin-Watson stat	1.50446
Prob(F-statistic)	0.000000		

Finally the estimation output of the real business cycle model when estimated in the sub-sample is:

Table 20: Sub-sample estimation output for the real business cycle model

Dependent variable:	**Ln(Y)**		
Regressors:	C	Ln(K)	Ln(L)
Point estimation:	-26.92669	0.47794	1.69229
std. Error:	3.26808	0.07237	0.20347
t-statistic:	-8.23930	6.60451	8.31705
Significance (p-value):	0.00000	0.00000	0.00000

Table 21: Real business cycle model main equation statistics (sub-sample)

R squared	0.94265	Mean of dependent variable	24.75070
Adjusted R squared	0.93963	S.D. of dependent variable	0.09420
S.E. of regression	0.02315	Akaike info criterion	-4.62370
Sum squared residuals	0.02036	Schwarz criterion	-4.49832
Log likelihood	97.78593	Hannan-Quinn criterion	-4.57805
F-statistic	312.31270	Durbin-Watson stat	1.01411
Prob(F-statistic)	0.000000		

To the main equation, the productivity shock equation is added, plotted from the residuals:

Table 22: Productivity shock estimation (sub-sample)

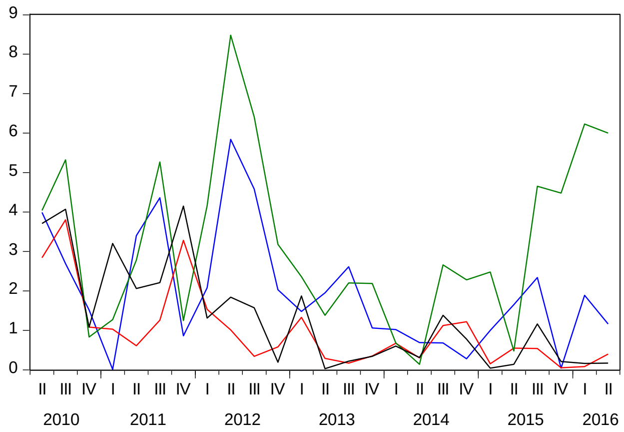
Dependent variable:	**Ln(z)**
Regressors:	$Ln(z_{t-1})$
Point estimation:	0.48126
std. Error:	0.19322
t-statistic:	2.49081
Significance (p-value):	0.01710

Table 23: Productivity shock estimation statistics (sub-sample)

R squared	0.24160	Mean of dependent variable	$5{,}03^{*}e^{-15}$
Adjusted R squared	0.22216	S.D. of dependent variable	0.02256
S.E. of regression	0.01990	Akaike info criterion	-4.94261
Sum squared residuals	0.01544	Schwarz criterion	-4.85902
Log likelihood	103.32350	Hannan-Quinn criterion	-4.91217
Durbin-Watson stat	2.14637		

At first, a one-step-ahead forecasting test was performed. Each model was estimated up to time t, forecasted time t+1 and then it was re-estimated up to t+1, to forecast period t+2. The procedure was repeated for the whole forecasting sample. For each forecast the mean absolute percentage error was calculated.

Figure 13: Mean absolute percentage errors of one step ahead forecasts



Blue: real business cycle model MAPE.
Red: ARMA model MAPE.
Green: Sinai and Stokes MAPE
Black: Naïve model MAPE

Table 24: Mean absolute percentage errors of one step ahead forecasts

Time	Real business cycle	ARMA	Sinai and Stokes	Naïve
2010Q2	3.99	2.84	4.04	3.71
2010Q3	2.69	3.8	5.32	4.07
2010Q4	1.52	1.08	0.83	1.08
2011Q1	0.01	1.03	1.27	3.2
2011Q2	3.4	0.61	2.78	2.06
2011Q3	4.36	1.26	5.27	2.21
2011Q4	0.86	3.28	1.25	4.15
2012Q1	2,08	1.53	4.16	1.31
2012Q2	5.84	1.01	8.48	1.84
2012Q3	4.58	0.34	6.41	1.57
2012Q4	2.03	0.58	3.18	0.19
2013Q1	1.48	1.33	2.36	1.87
2013Q2	1.95	0.29	1.38	0.03
2013Q3	2.61	0.17	2.2	0.22
2013Q4	1.06	0.35	2.19	0.34
2014Q1	1.02	0.67	0.68	0.6
2014Q2	0.69	0.3	0.14	0.31
2014Q3	0.68	1.12	2.66	1.38
2014Q4	0.28	1.22	2.28	0.78
2015Q1	1	0.15	2.48	0.04
2015Q2	1.65	0.55	0.48	0.14
2015Q3	2.34	0.54	4.65	1.16
2015Q4	0.04	0.05	4.48	0.21
2016Q1	1.89	0.08	6.23	0.16
2016Q2	1.16	0.4	6	0.17

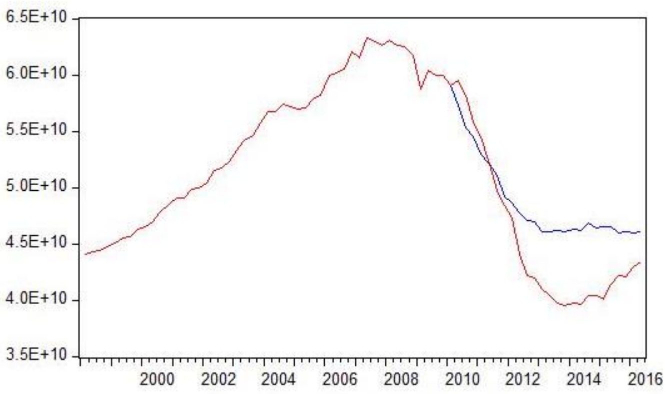
In this forecasting exercise the naïve model and the ARMA model performed the best. The real business cycle model was third best and the Sinai and Stokes production function performed worst of all. It must be noted, however, that during the re-estimation process before the forecasting of each period, the real business cycle model was the only model to retain all desirable properties at every step. The ARMA model towards the last estimations had inverted unit roots outside the unit circle and the AR components of the Sinai-stokes model turned statistically insignificant from a certain point onwards. Apart from the forecasting it must also be noted that according to the goodness of fit criteria the real business cycle model fits the data better than the other models.

The second forecasting exercise was a dynamic estimation of the whole forecasting sample:

Table 25: Mean absolute percentage error of long run forecast

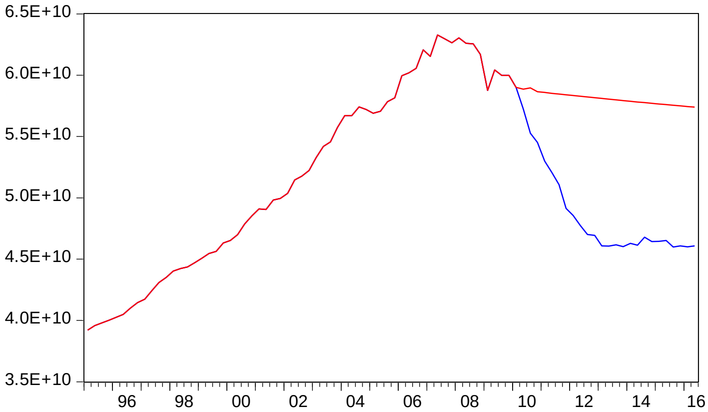
Model	Real business cycle	ARMA	Sinai and Stokes	Naïve
MAPE	8.44	20.49	6.96	32.69

Figure 14: Real business Cycle model dynamic forecast



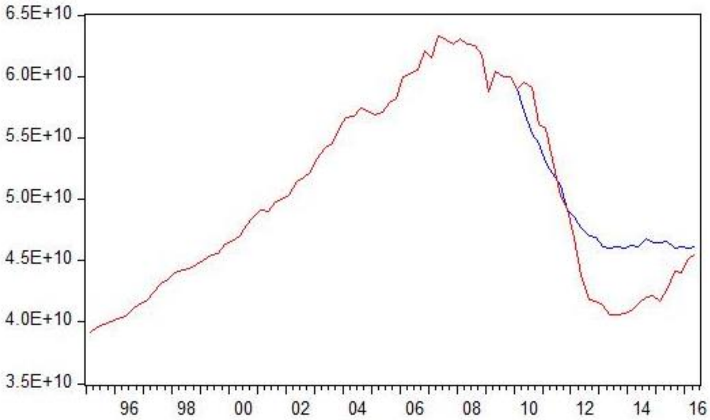
Blue:Actual
Red: Forecast estimate

Figure 15: ARMA model dynamic forecast



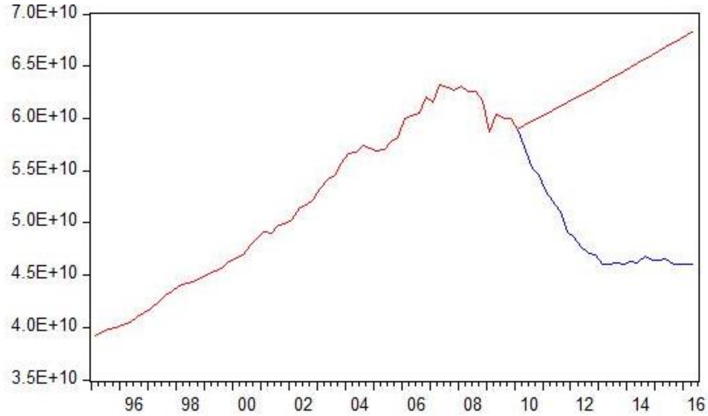
Blue: Actual
Red: Forecast Estimate

Figure 16: Sinai and Stokes model dynamic forecast



Blue: Actual
Red: Forecast Estimate

Figure 17: Naïve model dynamic forecast



Blue: Actual
Red: Forecast estimate

The naïve and the ARMA model completely miscalculate future developments in Greek GDP, which most likely is a result of the errors building up in those models, since the forecast is dynamic. The Sinai and Stokes production function performed slightly better than the real business cycle model. Both models, however, were pessimistic compared to the actual developments in Greek GDP.

From the two forecasting simulations we can conclude that the real business cycle model estimated on this sample may not be the best tool for forecasting.

B. Long term analysis

i. The main model

Table 26: Long run real business cycle model main equation output

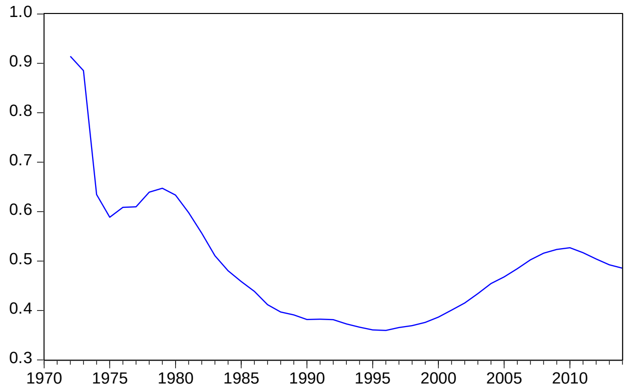
Dependent variable:	**Ln(Y)**	
Regressors:	Ln(K)	Ln(L)
Point estimation:	0.49	0.54
std. Error:	0.035308	0.042135
t -statistic:	13.74926	12.95923
Significance (p-value):	0.00000	0.00000
HAC std Errors:	0.131494	0154518
HAC t-statistic:	3.691885	3.533801
HAC p-value:	0.00006	0.00010

Table 27: Main equation of long run real business cycle model Statistics

R squared	0.942454	Mean of dependent variable	25.73983
Adjusted R squared	0.941115	S.D. of dependent variable	0.264619
S.E. of regression	0.064213	Akaike info criterion	-2.609799
Sum squared residuals	0.177302	Schwarz criterion	-2.529503
Log likelihood	60.72047	Hannan-Quinn criterion	-2.579865
Durbin-Watson stat	0.244682		

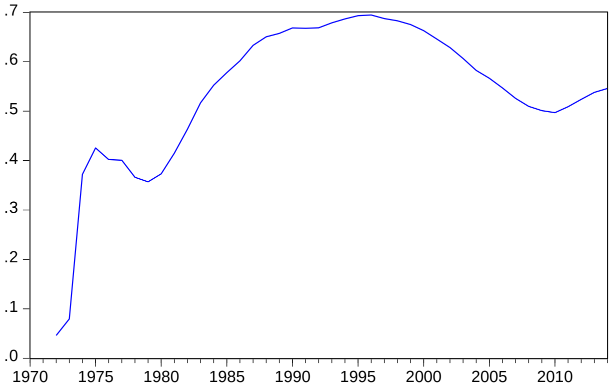
Similarly to how the model was estimated in the short term analysis, after the estimation with ordinary least squares is carried out, the results in terms of statistical significance are verified with a re-estimation with heteroskedasticity and autocorrelation consistent standard errors, in order to account for the autocorrelation inherent in the residuals. The results show that capital and labor are statistically significant at any level of significance. Unlike the estimation of the short run model here a constant is statistically insignificant and thus, it is not included. Additionally, contrary to what was found in the short term analysis, in the long run, the Greek economy seems to have somewhat equal capital and labor coefficients. The hypothesis that the model has constant returns to scale is verified by a Wald coefficient restriction test[5]. Furthermore, the results of a recursive coefficients test show that coefficients are relatively stable for the larger portion of the sample (from the 1965 onwards).

Figure 18: Recursive coefficient test for capital



[5] To properly test for constant returns to scale the model must have no autocorrelation. To ensure that the results of the Wald test are correct, they were performed on a model corrected for autocorrelation. When corrected for autocorrelation the model's coefficients stay the same and their standard errors are approximately the same with the HAC std. errors of table 27.

Figure 19: Recursive coefficient test for labor



From the residuals of the main equation the productivity shock is estimated.

Table 29: Productivity shock equation

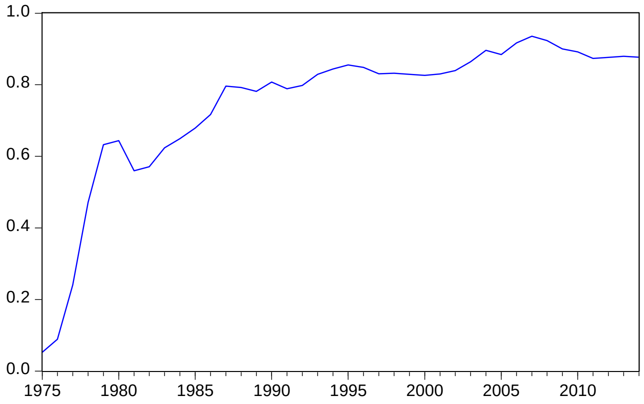
Depented variable:	**Ln(z)**
Regressors:	$Ln(z_{t-1})$
Point estimation:	0.876
std. Error:	0.073397
t -statistic:	11.94622
Significance (p-value):	0.00000

Table 28: Productivity shock equation statistics

R squared	0.768426	Mean of dependent variable	0.00007
Adjusted R squared	0.768426	S.D. of dependent variable	0.063944
S.E. of regression	0.039771	Akaike info criterion	-4.102000
Sum squared residuals	0.040716	Schwarz criterion	-4.061450
Log likelihood	91.24399	Hannan-Quinn criterion	-4.086962
Durbin-Watson stat	1.56		

The production shock persistence factor is the recursively estimated:

20: Figure Persistence factor recursive estimation



By applying a reverse logarithmic transformation on the main equation's residuals the business cycle component is also obtained:

Figure 21: Business cycle component

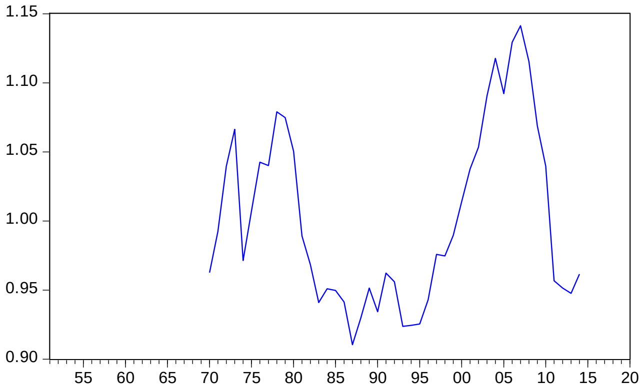


Table 29: Business cycle component descriptive statistics:

observations	**45**
mean	1.001880
median	0.975834
maximum	1.141302
minimum	0.0910423
Standard Deviation	0.064544

Observing the business cycle component over the last decades it can be seen that it was on the in downturn from 1975 to 1995. Then a sharp increase follows that ends in 2007 and it is followed by a sharp fall ending in a small rebound.

ii. Business cycle component and intertemporal substitution of leisure:

The same tests that were conducted in the short term analysis were conducted in the long term analysis as well, in order to explore whether or not the business cycle component has a systematic relationship with labor. The granger causality test of 4 (or any number of) lags shows that we can reject the null hypothesis that the business cycle component does not granger cause changes in labor.

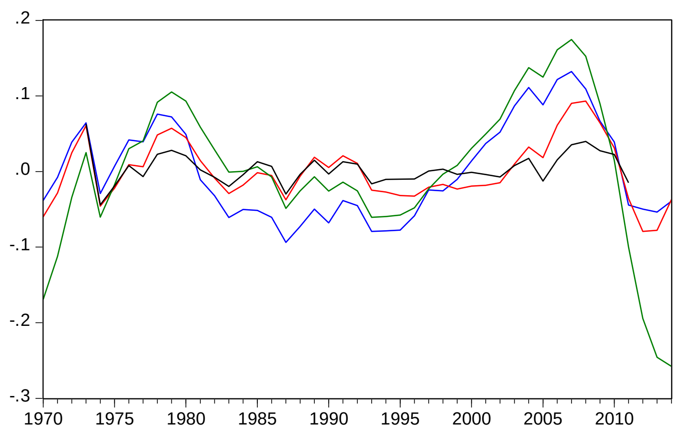
Table 30: Pairwise causality test (2 lags)

Null Hypothesis:	Obs	F-Statistic	Prob.
Z does not Granger Cause L	41	4.06185	0.0090
L does not Granger Cause Z	41	0.70855	0.5921

iv. Analysis and comparison of business cycle extracting methods:

By implementing the HP filter[6], the Baxter-King filter and by extracting the residuals of a regression of logarithmic GDP against a deterministic trend the cyclical components of logarithmic GDP were extracted:

Figure 22: Annual Business Cycle components



Blue: Real Business Cycle model Cyclical component
Green: Residuals from deterministic trend
Red: HP filter cyclical component
Black: Baxter-King cyclical component

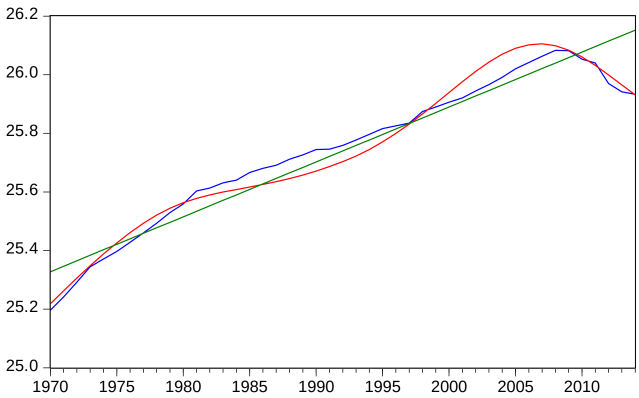
In figure 22 it is evident that the deterministic trend residuals, the cyclical component of the real business cycle model and the HP and Baxter-King filter generated business cycle components show similar trends in certain sub periods of the sample. All cyclical components

[6] Even though when handling quarterly data it is common place to set the smoothing parameter at 1600, when it comes to monthly or annual data literature adopts many different approaches. In this paper the smoothing parameter is set at λ=100, which is the value major institutions select when they process annual data (Maraval, Del Rio 2001).

tend to move towards the same direction. From 2008 onwards all cyclical components point a deterioration of the cyclical component, even if it is of different magnitude.

The potential outputs of the HP filter the real business cycle model and the deterministic trend are very similar too.

Figure 23: Potential outputs



Blue: Real business cycle model
Red: HP filter linear component
Green: Deterministic trend

Apart from the deterministic trend which assumes that potential output increases in a linear deterministic way, the other two linear components seem to be closely correlated, However the HP filter seems be crediting a higher portion of growth to potential output than the real business model for the time period between 1999-2009. From 2007 onwards both the main model and the HP filter seem not to be on an uptrend any more.

v. Forecast evaluation

In this section the forecasting performance of the real business cycle model is evaluated. As was done in the short term analysis, two forecasting exercises are carried out. The first exercise is an expanding window, one step ahead forecasting. The estimation sample is the time period from 1970 up to 2009 and the forecasting sample is the time period between 2010 and 2014. A naïve model and an ARMA model with a deterministic trend are also constructed for comparison. A Sinai and Stokes production function could not be constructed for this estimation period due to lack of data.

The second forecasting exercise is a long run forecast similar to the one performed in the short term analysis, the models are estimated up to 2009 and the period 2010-2014 is forecasted.

The naïve model is defined as:

$Ln(Y_t) = C + Ln(Y_{t-1}) + \varepsilon_t$, (9)

$\varepsilon_t \sim N(0, \sigma^2)$.

Table 31: Naïve model estimation output

Depented variable:	**Ln(Y)**	
Regressors:	C	Ln(Y_t-1)
Point estimation:	0.026872	1.00000
std. Error:	0.00552	N/A
t -statistic:	4.863747	N/A
Significance (p-value):	0.00000	N/A

Table 32: Naïve model statistics

R squared	0.982893	Mean of dependent variable	25.71257
Adjusted R squared	0.982893	S.D. of dependent variable	0.267168
S.E. of regression	0.034943	Akaike info criterion	-3.845487
Sum squared residuals	0.047621	Schwarz criterion	-3.803265
Log likelihood	77.90974	Hannan-Quinn criterion	-3.830221
Durbin-Watson stat	1.334923		

The ARMA model is estimated with a constant, a deterministic trend and two ARMA terms, an AR(1) and a MA(1) and a dummy to account for the oil crisis of 1974 that was causing non normal and heteroskedastic residual statistics. The model is defined as follows:

$Ln(Y_t) = c + b_1 T + b_2 \beta_t + e_t$, (10)

$e_t = d_1 e_{t-1} + d_2 \varepsilon_{t-1} + \varepsilon_t$, (11)

$\varepsilon_\tau \sim N(0, \sigma^2)$.

Table 33: ARMA model estimation output

Depented variable:	**Ln(Y)**				
Regressors:	C	Deterministic Trend	Ar(1)	MA(1)	Dummy
Point estimation:	24.79	0.023	0.828	0.538	-0.057
std. Error:	0.08633	0.002290	0.133313	0.204607	0.016733
t -statistic:	287.194	10.245897	6.2126	2.6322	-343971
Significance (p-value):	0.00	0.00	0.00	0.012	0.0016

Table 34: ARMA model statistics

R squared	0.9902	Mean of dependent variable	25.71257
Adjusted R squared	0.98886	S.D. dependent variable	0.267168
S.E. of regression	0.028198	Akaike info criterion	-4.105690
Sum squared residuals	0.027034	Schwarz criterion	-3.852358
Log likelihood	88.11380	Hannan-Quinn criterion	-4.014093
F-statistic	693.4083	Durbin-Watson stat	1.84
Prob(F-statistic)	0.000000		

Finally the real business cycle model is estimated for the sub-sample:

Table 35: Real business cycle model (sub-sample estimation output)

Depented variable:	**Ln(Y)**	
Regressors:	Ln(K)	Ln(L)
Point estimation:	0.52346	0.5009
std. Error:	0.044278	0.052733
t -statistic:	11.82206	9.499767
Significance (p-value):	0.00000	0.00000

To the main equation of table 38, a productivity shock is added as regressed from the equation's residuals:

Table 36: Productivity Shock equation (sub-sample estimation)

Depented variable:	**Ln(z)**
Regressors:	Ln(z_{t-1})
Point estimation:	0.899744
std. Error:	0.0373463
t -statistic:	12.24763
Significance (p-value):	0.00000

Table 39 sums up the results of the one step ahead forecast based on the mean absolute percentage errors of the forecasts:

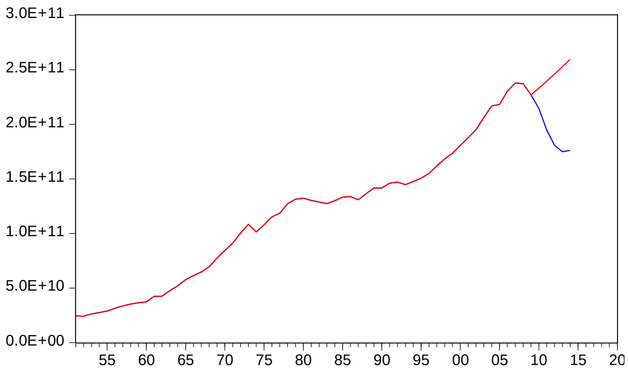
Table 39: Mean absolute percentage errors of expanding window, one step ahead forecasts

T	Naive	ARMA	Real business Cycle
2010	8.68	5.45	2.5
2011	12.81	10.61	8.6
2012	10.27	5.65	1.78
2013	5.36	3.81	1.33
2014	1.24	0.17	0.82

From the mean absolute percentage errors it is evident that the real business cycle model can systematically outperform both the naïve model and the ARMA model in a series of one-step-ahead forecasts.

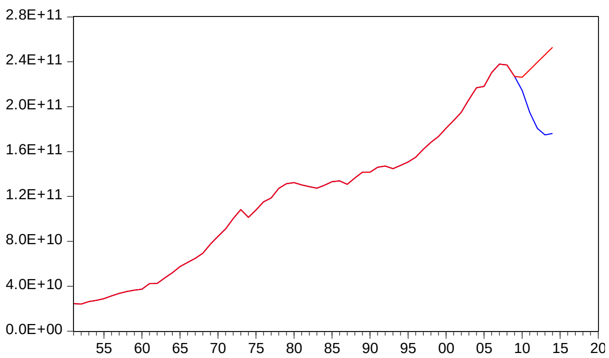
The long term forecasts produced the following results:

Figure 24: Naïve model long term forecast



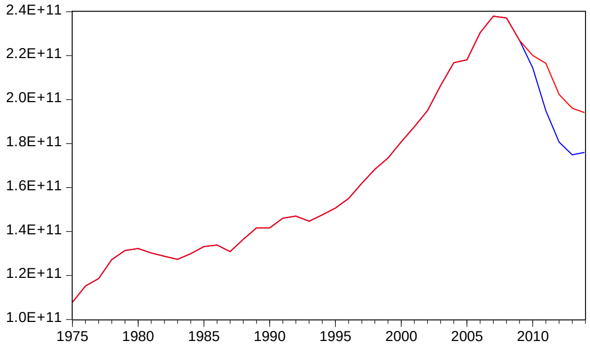
Red: Estimated forecast
Blue: Actual values

Figure 25: ARMA model long term forecast



Red: Estimated forecast
Blue: Actual values

Figure 26: Real business cycle model long term forecast



Red: Estimated forecast
Blue: Actual value

Table 37: Mean absolute percentage error of long term forecasts

Model	**Naïve**	**ARMA**	**Real business cycle**
MAPE	31,92	28,37	9.59

Due to the dynamic nature of the forecast both the naïve model and the ARMA model forecast an increase in Greek GDP. The real business cycle model, however, even though it forecasts a decrease in GDP, is still optimistic compared to the actual values.

In the long term analysis apart for the two forecast exercises mentioned above, a dynamic forecast up to 2018 is attempted.

Future values for capital stock and hours worked are calculated based on OECD's estimations

The model's GDP future estimates are displayed in table 42, in growth rates, along the respective OECD's and IMF's forecasts for comparison[7].

Table 41: Out of sample forecasts and comparison

Time	**Model**	**OECD**	**IMF**
2015	1.07%	-0.31%	-0.23%
2016	1.15%	0.04%	0.06%
2017	0.63%	1.32%	2.76%
2018	1.12%	1.92%	3.07%

This concludes the long term analysis and the presentation of the results. The real business cycle model, as simple as it may be, can provide a useful insight about an economy and its business cycle. The results found regarding the Greek economy will be discussed in the next section.

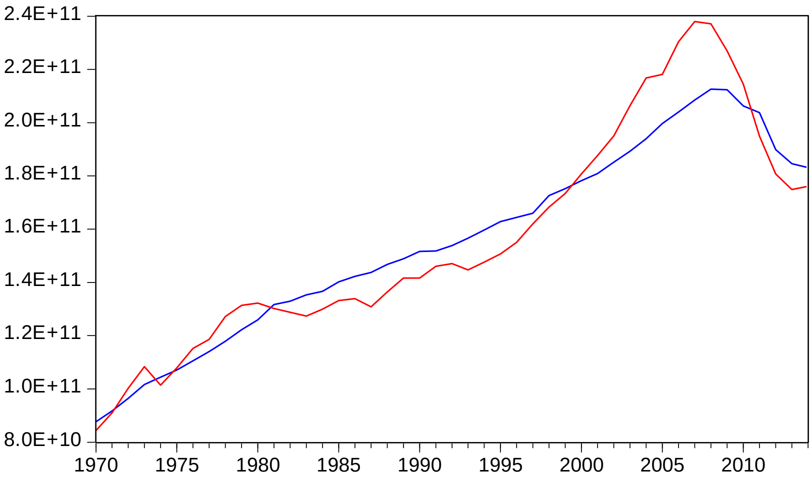
[7] IMF's and OECD's values for 2015 are actual values. IMF's forecasts are those of October 2016, and OECD's forecasts for GDP, capital stock and hours worked are those of November 2016.

It must be pointed out that, according to Kydland and Prescott, the business cycle component of such a model can be used to simulate a positive or negative shock to the economy, but the fact that in literature there is not a unanimous opinion about what moves business cycles and that is hard to calculate to what extend (and direction) a change in fiscal policy will affect the business cycle model and to what extend it will affect hours worked in an economy and thus realistically allocating the change in GDP between those variables, render the attempt of running such a scenario in a reduced form model extremely difficult.

Result Discussion

A. The Greek Business Cycle in a Glance

Figure 27: Actual output against output net of shocks



Red: Actual Output
Blue: Output net of shocks.

In figure 28 the actual output is plotted against the output net of productivity shocks from the annual data. This way, four major business cycle movements are easily distinguished. From 1970 to 1981 a positive productivity shock is evident (with a small "rebound in 1974) which turns negative up to 1999. From there up to 2008 the productivity shock is positive again, only to start declining in 2008 and turn negative again in 2011.

The period between 1975 and 1993 with the restoration of democracy in Greece, private investment was crowded out, and more populist and redistributive macroeconomic policies were implemented (Oltheten, Pinteris and Sougiannis, 2003). These macroeconomic imbalances led to high inflation, high debt and high budget deficits. In Figure 26 it is evident that even though those policies worked as a positive shock to the economy initially, after the second oil shock in 1979 those imbalances had a negative effect on production. These negative shocks stopped deteriorating after the implementation of the convergence criteria of the Eurozone which somewhat corrected those macroeconomic imbalances.

Additionally, in the second positive period of the business cycle component it was the access to cheap financing that had a positive impact in production (Vamvakidis and Zanforlin, 2002).

From 2008 onwards, the financial crisis effects can be assumed to have been driving the business cycle component.

B. Conclusions

For the purpose of this analysis a reduced formed model, in the logic of Kydland and Prescott was estimated. The model produced a business cycle similar to the cyclical components obtained from other methods such as the HP filter and the Baxter-King filter. Furthermore, from the model the persistence factor of the production shock was estimated and it was found to be increasing when it was recursively estimated. In the end when the model was estimated using data from a prolonged period (1970-2009) it could forecast developments in Greek GDP with a small deviation from the actual values, even if the forecasting sample represented a period that could possibly be described as a “tail event” period. Finally, Figure 28 shows that the estimated business cycle is consistent with the economic history of the country.

There are some key “takeaways” from this analysis regarding both econometric and economic aspects:

Econometrically speaking, from the analysis is shown that a reduced form model, with no underlying structural equations and little judgment involved, can adequately forecast and capture economic developments from a real business cycle perspective, provided that the model is estimated over a prolonged period of “healthy” data that do not include tail events.

Another issue that has risen from the model is the stability of labor and capital coefficients. When recursively estimated in both quarterly and annual samples, the coefficients seem to be volatile. Additionally, little changes in the sample period may result to very different values for the estimated coefficients. Even though this is not a desirable property for the model, intuitively it makes sense, given that, over time, many aspects of the production as a process change, such as technology, preferences, needs or even policies as to what products and services’ production the country is going to support.

Economically speaking, there are two major points that the model has revealed. The first one has to do with the output net of shocks (which seems to approximate the potential output as generated by the HP filter, as seen in figure 23). From the model, it has been revealed that from 2008 onwards the output net of shocks is decreasing, showing that the economic performance of the country has declined not only because of negative shocks but because of a permanent decrease of the country’s productive capabilities, showing that the recession has done “structural” damage on the economy, which should be rebuilt.

The second economic takeaway has to do with the persistence factor. The analysis showed that the persistence factor has been ever rising through decades reaching a value of 0.876. A high persistence factor worked as a both a blessing and a curse for the Greek economy; the positive shocks stop at 2008 but the economy starts to produce below the output net of shocks from 2011 onwards. This shows that the carryover of the positive shocks “kept” the economy above potential and would have smoothened the fall of GDP if decisive actions (which in our model would have been consistent with new positive shocks) had been taken. On the other hand, in the final observations where economy is below the output net of shocks (hence, the shocks are negative), any attempt to implement actions that lead back to growth is undermined by the carryover of negative shocks from previous periods, which leads to the conclusion that returning to robust growth is going to be a slow process, which needs decisive and continuous actions (translated into consecutive positive shocks into our model).

Surprisingly, even though there is extensive research on business cycles and total factor productivity, there is little to none research on the contribution of their persistence factor, what affects its value and how it affects the economy.

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