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Economics from the Nova School of Business and Economics.

**The Great Recession in Portugal and the Portuguese financial crisis:
A Business Cycle Accounting approach**

Luis Perestrello de Vasconcelos
Arouca

Work project carried out under the supervision of:

Prof. Pedro Miguel Soares Brinca

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Abstract

We apply a Business Cycle Accounting exercise to Portugal, during the Great Recession, and during the Portuguese financial crisis. We conclude that the efficiency wedge, is the most important to explain the movements of output, hours worked, and investment. The investment wedge is the 2nd most important wedge when we consider the full sample. If we consider just the period before Troika, the efficiency and labor wedges are the most important. The efficiency and investment wedges are influenced by mostly the same factors while the labor wedge reflects movements in total employment during this analyzed period.

Keywords: Economics, Business Cycle Accounting, Macroeconomics, Wedges, Capacity Utilization, Troika.

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1. Introduction

Before the 2008 financial crisis, Portugal's economic growth was weak compared to other Eurozone countries. These weak levels of growth were being sustained by external debt. Gross external debt grew from 124% of GDP in 2000 to 201% of GDP in 2008. Households were buying their houses with foreign money. Banks would regularly go to international markets with bond offerings to finance the gap between credits and deposits. Public sector corporations, such as railway and subway companies were financing their capital expenditures with loans from the European Investment Bank and other foreign banks. To sum up, households needed these external flows to keep consuming, corporations to finance new projects or even to cover their losses, and public sector companies to continue their investments. The current account deficit also reached a peak in 2008 of -11,83% of GDP, which was another sign of growing external dependence (Rato 2020). Portugal was vulnerable to a sudden stop in capital inflows.

This paper presents a Business Cycle Accounting exercise (BCA) applied to the Portuguese economy between Jan 2008 and Jan 2016. We will analyze the economic performance of Portugal during the Great Recession as well as during the Portuguese financial crisis, which covers the years of Troika's¹ assistance program. This was one of the harshest periods for the Portuguese economy as real GDP contracted in 2011 (-1,7%), 2012 (-4,1%), and 2013 (-0,9%). The unemployment rate reached 17,1 % in 2013².

BCA builds on the Real Business Cycle modeling of macroeconomic fluctuations introduced by Kydland & Prescott (1982), but to better fit the data, it goes away from modeling perfectly competitive markets by introducing time-varying wedges, that distort the equilibrium decisions of economic agents. Along the same lines as growth accounting, a procedure

¹ Group of 3 institutions that designed and monitored assistance programs in Europe during the peripheral debt crisis. These institutions were the International Monetary Fund ("IMF"), the European Commission and the European Central Bank ("ECB")

² See **Annex 1** for graphs of the statistics mentioned in this section as well as their source.

pioneered by Abramovitz (1956) and Solow (1957), BCA analyses the sources of macroeconomic fluctuations which are a function of endogenous variables and four exogenous residuals (wedges). These four wedges are the efficiency wedge, the labor wedge, the investment wedge, and the government consumption wedge.

BCA has two components: The equivalence result, which is that a class of models, including models with multiple frictions, are equivalent to a prototype model with several wedges, and the focus of the paper, the accounting procedure that determines the wedges and evaluates how much of the observed movements in output, labor, and investment, can be accredited to each wedge or a set of wedges.

The remainder of this paper is structured as follows: First, we summarize the research developments made in BCA, then we present the theoretical framework of the model. Subsequently, we will present the results of the accounting procedure and analyze them. The last sections will recap the main points of discussions and directions for future research.

2. Literature Review

Chari et al. (2002) presented the first Business Cycle Accounting (BCA) exercise applied to the Great Depression, which only included three wedges. The efficiency wedge, the labor wedge, and the investment wedge. Chari et al. (2005) add the government wedge to the BCA exercise. Chari et al. (2007a) consolidated BCA. Christiano and Davis (2006) criticized the BCA approach. The authors argue that some spillovers might be left out since BCA identifies the transmission mechanism, not the sources of the shocks. They also believe the investment wedge is mis specified since BCA is not robust to small changes in the environment. Consequently, a new specification is proposed: The capital wedge.

Chari et al. (2007b) respond to Christiano and Davis (2006) with three points. First, the equilibrium allocations are the same whether we use an investment wedge or a capital wedge.

Second, Chari et al. (2007b) argue their own methodology has more solid foundations. Thirdly, with the VAR decomposition used by Christiano and Davis (2006), the investment wedge absorbs a moderate share of the financial shock, which fortifies the results of the business cycle decomposition of Chari et al. (2007a).

BCA has been applied to several economies, in several historical periods. There have been BCA exercises applied to Portugal by Cavalcanti (2007) and Iskrev (2013) with the latter studying the period from 2008 to 2012. Extensions of BCA have been created over time to capture other dimensions. We have open-economy BCA introduced by He et al. (2009) and Otsu (2010b) where the foreign sector is explicitly introduced and a wedge in foreign debt markets is added. International BCA created by Otsu (2010a) studies business cycle patterns between multiple countries. To do this, government spending and net exports are separated, and international financial market wedges are introduced. Šustek (2011) and Brinca (2013) extend the BCA framework to allow for the interaction between the real and nominal sides of the economy. This is called Monetary BCA. Two variables, inflation, and the short-term nominal interest rate are included in the benchmark economy as well as an asset market wedge and a monetary policy wedge. Brinca et al. (2020) sum up the theoretical background of these extensions of BCA and provide an extensive review of the BCA literature.

3. Methodology

The BCA method proposed by Chari et al. (2007a) has two components: The accounting procedure and the equivalence result.

The accounting procedure can be split into two parts. First, the wedges are measured using the data as well as the equilibrium conditions of the prototype economy. These wedges are labeled the efficiency wedge, the labor wedge, the investment wedge, and the government consumption wedge. They are named after the four equilibrium conditions they distort:

Production, the intratemporal choice between labor and leisure, the intertemporal choice between consumption and savings, and how to satisfy the resource constraint. At face value, the wedges resemble time-varying productivity, labor income taxes, investment taxes, and government consumption, respectively.

Then, the measured wedges are fed back into the prototype model, one at a time and in combinations, to determine how much of the observed movements of output, labor, and investment can be accredited to each wedge separately and in combinations.

While the accounting procedure helps us to identify which wedges are important, the equivalence result helps us to identify which models are important, meaning which models fit the data better. There is a large class of detailed models, including models with various frictions that are equivalent to a prototype model with one or more wedges. To be equivalent implies that the equilibrium allocations in the detailed model and the prototype model are the same. Chari et al. (2007a) and Brinca et al. (2016) illustrate the mapping between detailed economies and prototype economies for multiple wedges.

It is important to note that many models map into the same configuration of wedges so identifying one configuration will not identify one model but rather a whole class of models consistent with that configuration. Moreover, the wedges do not identify the origin of the shocks. They should be seen as a transmission mechanism from those shocks to broader economic activity. For example, many economists believe that the Great Recession in developed economies was caused by shocks to the financial sector but Brinca et al. (2016) show that these shocks manifest themselves as labor wedges in the USA, investment wedges in Spain, Ireland, and Iceland, and efficiency wedges in the rest of the OECD.

3.1 The Benchmark Prototype Economy

Similarly, to Chari et al. (2007a) and Brinca et al. (2016), the benchmark prototype economy used to measure the wedges is a stochastic growth model. The economy experiences one of finitely many events s_t , which index the shocks. We designate $s^t = (s_0, \dots, s_t)$ the history of events up through and including period t and often refer to s^t as the state. The four wedges, which are exogenous, are a function of the random variable s^t . The probability, as of period 0, of any particular history is s^t is $\pi_t(s^t)$. The initial realization s_0 is given. In an economy composed by firms and consumers, agents behave rationally and choose how to allocate resources in each period t based on the state of the economy and the history of events.

In this model, consumers want to maximize expected lifetime utility over per capita consumption c_t and per capita labor l_t ,

$$(1) \sum_{t=0}^{\infty} \sum_{s^t} \beta^t \pi_t(s^t) U(c_t(s^t), l_t(s^t)) N_t,$$

where β is the discount factor, $U(\cdot)$ The utility function and N_t is the population size. The utility function has the following functional form:

$$(2) U(c_t(s^t), l_t(s^t)) = \log[c_t(s^t)] + \psi \log[1 - l_t(s^t)]$$

where ψ is a time allocation parameter. Consumers maximize their utility subject to the following budget constraint:

$$(3) c_t(s^t) + (1 + \tau_{x,t}(s^t)) x_t(s^t) = (1 - \tau_{l,t}(s^t)) w_t(s^t) l_t(s^t) + r_t(s^t) k_t(s^{t-1}) + T_t(s^t)$$

$1/(1 + \tau_{x,t}(s^t))$ is the investment wedge, $x_t(s^t)$ the investment per capita, $(1 - \tau_{l,t}(s^t))$ the labor wedge, $w_t(s^t)$ is the wage rate, $r_t(s^t)$ the rental rate on capital, $k_t(s^{t-1})$ capital stock per capita and $T_t(s^t)$ are per capita lump-sum transfers. Consumers are also subject to the capital accumulation law:

$$(4) (1 + \gamma_N)k_{t+1}(s^t) = (1 - \delta)k_t(s^{t-1}) + x_t(s^t).$$

γ_N is the growth rate of the population and δ is the depreciation rate of capital.

Moving on to the firm side of the economy, their production function is:

$$(5) y_t(s^t) = A_t(s^t)F(k_t(s^{t-1}), (1 + \gamma)^t l_t(s^t)),$$

where $A_t(s^t)$ is the efficiency wedge, $y_t(s^t)$ is per capita output and $F(\cdot)$ is the production function with the following functional form:

$$(6) F(k_t(s^{t-1}), (1 + \gamma)^t l_t(s^t)) = [k_t(s^{t-1})]^a [(1 + \gamma)^t l_t(s^t)]^{1-a},$$

where a is the share of capital and $1 - a$ is the share of labor. Firms want to maximize profits given by:

$$(7) y_t(s^t) - w_t(s^t)l_t(s^t) - r_t(s^t)k_t(s^{t-1}).$$

The equilibrium of the benchmark prototype economy can be determined by four equations:

The production function (5) distorted by the efficiency wedge; the national resource constraint:

$$(8) y_t(s^t) = c_t(s^t) + g_t(s^t) + x_t(s^t),$$

which is distorted by the government wedge $g_t(s^t)$; the function that represents the intratemporal decision between labor and leisure:

$$(9) -\frac{U_{l,t}(s^t)}{U_{c,t}(s^t)} = [1 - \tau_{l,t}(s^t)]A_t(s^t)(1 + \gamma)^t F_{l,t},$$

Which is distorted by the labor wedge $1 - \tau_{l,t}$. $U_{l,t}$ is the first derivative of the utility function with respect to labor, $U_{c,t}$ is the first derivative of the utility function with respect to consumption and $F_{l,t}$ is the first derivative of the production function with respect to labor.

Lastly, we have the function that represents the intertemporal decision between consumption and savings:

$$(10) U_{c,t}(s^t) \left(1 + \tau_{x,t}(s^t)\right) = \beta \sum_{s^{t+1}} \pi_t(s^{t+1}|s^t) [U_{c,t}(s^t) A_{t+1}(s^t) F_{k,t} + (1 - \delta) \left(1 + \tau_{x,t+1}(s^{t+1})\right)],$$

which is distorted by the investment wedge $1/(1 + \tau_{x,t})$. $\pi_t(s^{t+1}|s^t)$ is the conditional probability of s^{t+1} given s^t which can be written as $\pi_t(s^{t+1})/\pi_t(s^t)$. $F_{k,t}$ is the first derivative of the production function with respect to capital. We can obtain **equations (9) and (10)** from the utility and profit maximization decisions of consumers and firms. We can rewrite the equations to solve for each wedge:

$$(11) \quad A_t(s^t) = \frac{y_t(s^t)}{F(k_t(s^{t-1}), (1+\gamma)^t l_t(s^t))},$$

$$(12) \quad g_t(s^t) = y_t(s^t) - c_t(s^t) - x_t(s^t),$$

$$(13) \quad 1 - \tau_{l,t}(s^t) = -\frac{U_{l,t}(s^t)}{U_{c,t}(s^t)} (A_t(s^t)(1+\gamma)^t F_{l,t})^{-1},$$

$$(14) \quad \frac{1}{1 + \tau_{x,t}(s^t)} = \frac{U_{c,t}(s^t)}{\beta \sum_{s^t} \pi_t(s^{t+1}|s^t) [U_{c,t}(s^t) A_{t+1}(s^t) F_{k,t} + (1-\delta)(1 + \tau_{x,t+1}(s^{t+1}))]},$$

To determine the equilibrium of the prototype economy we will need to make some assumptions. We first assume:

$$(15) \quad k_0 = x_0$$

So that we can get a value for capital in period 0. We will determine the values of the parameters of the model in the next chapter. Moving on to the wedges, notice that we can determine (11), (12) and (13) with data on l_t, x_t, g_t and c_t but not (14) since it has an expectation term $\pi_t(s^{t+1}|s^t)$. We will assume just like Chari et al. (2007a) and Brinca et al. (2016) that the expectations follow a first-order Markov process of the type:

$$(16) \quad \pi_t(s_t|s^{t-1}) = \pi_t(s_t|s_{t-1}),$$

This means that the probability of state s_t given the history of all events before the current period s^{t-1} and the probability of s_t given the events of just the previous period s_{t-1} are the same. Consequently, to estimate the expectations in $t+1$ we only need s_t . If we also assume that the mapping from the event s_t to the wedges is one-to-one:

$$(17) \quad s_t = \left[A_t, 1 - \tau_{l,t}, \frac{1}{1 + \tau_{x,t}}, g_t \right],$$

we can specify a vector autoregressive AR (1) process for the event s_t of the form:

$$(18) \quad s_{t+1} = P_0 + P s_t + \varepsilon_{t+1},$$

where P_0 is a vector of constants, P is a 4x4 matrix of coefficients and ε_{t+1} is an i.i.d shock with zero mean and covariance matrix V . This covariance matrix is positive semidefinite by construction which means we have spillover effects between the wedges coming from the matrix P as well as the correlations of the error term in V . To estimate the autoregressive process, we use a standard maximum likelihood procedure along with the log-linear versions of the decision rules which were previously shown as well as data on the variables that we will describe in the next chapter.

4. Description and treatment of the Data

For this BCA exercise, we use quarterly data between 1995:Q1-2016:Q1. The variables used along with their sources are the following: Gross fixed capital formation (investment), GDP (output), private final consumption, government final consumption, exports for goods and services, imports of goods and services, hours worked, total employment and the GDP deflator are taken from *OECD Economic Outlook database*; The annual size of the population from 15-64 years old from the *OECD.Stat database*; consumption durable goods from *OECD National Accounts Statistics database*; and annual tax revenue from goods and services as a % of GDP from the *OECD Data database*.

We multiply hours worked and total employment to calculate total labor. We sum government consumption and net exports to have the government consumption wedge. As Chari et al. (2005) show, with this configuration for the government consumption wedge, we can establish an equivalence result between a small open economy and the close-economy prototype growth model we use. The inclusion of net exports also allows us to understand its impact on output, labor, and investment and study the international transmission of crisis³.

³ See Brinca & Costa-Filho (2021a)

Yearly taxes and the size of the population will be linearly interpolated to obtain quarterly data. We will divide nominal variables by the GDP deflator (the price level), to obtain the real variables.

To make our data more consistent with the theory, multiple adjustments will be made to the variables. Consumption of durable goods will be considered investment, so we need to remove it from total consumption and add it to investment. We assume a depreciation rate, δ_D and a return rate r_D for the stock of durable goods, so we will add back the depreciation and the return rate of durables to consumption and output so that in **equation (8)**, the resource constraint holds.

Taxes from the consumption of goods and services will be subtracted from output. Taxes on goods and services related to durables will be subtracted from investment and the rest will be subtracted from private consumption. Again, these adjustments related to taxes are made so that in **equation (8)**, the resource constraint holds. Finally, we will divide the variables by the size of the population to obtain the variables per capita.

After these computations, we are left with four final variables which will be used to resolve the maximum likelihood procedure and determine the wedges: output per capita; investment per capita; hours worked per capita; government consumption per capita. These variables are logged and, except for hours worked per capita, the rest of the variables are detrended.

When it comes to the model's parameters they are the following:

Table 1 – Parameters of the model

γ	γ_N	β	ψ	δ	α	δ_D	r_D
0,0071	-0,0003	0,9930	2,24	0,0118	0,35	0,0694	0,01

The growth rate of labor-augmenting technological progress, γ is such that the mean detrended output is equal to zero. We use population data to compute γ_N . The values for the time allocation parameter ψ , the depreciation rate δ , and the capital share in the production

function α are taken from Chari et al. (2007a). δ_D , the depreciation rate of durables and r_D , the return rate of durables, is calculated such that the annual δ_D is 25% and the annual r_D is 4%.

5. Results

In table 2, we have the results of the maximum likelihood procedure. Specifically, we show the matrixes of P_0 , P , and the variance covariance matrix and the mean of the states s_t .

Table 2 – Parameters of the stochastic AR (1) process using maximum likelihood

Mean of states s_t :				Vector of constants P_0 :			
0,0208	0,3745	-0,2157	-2,1873	0,1684	0,1740	-0,1156	-0,2796
Matrix of coefficients P:				Variance covariance matrix			
1,2618	-0,0744	0,6298	0,0046	0,0137	0,0085	-0,0065	-0,0093
0,1297	0,6952	0,1633	0,0125	0,0086	0,0086	-0,0028	0,0467
-0,1321	0,1235	0,7323	-0,0066	-0,0028	-0,0028	0,0007	0,0321
-0,1261	-0,2476	-0,0560	0,8341	-0,0093	0,0467	0,0321	0,0547

In this section, we will analyze the results of the accounting procedure and discuss them. All the wedges and economic variables presented in this section are detrended, except the variable hours worked per capita, and indexed to 100. The base period is the 1st quarter of 2008.

To determine the marginal effect of each wedge, and to understand which wedges should be in a model to replicate the movement of macroeconomic aggregates, we will compare the actual movement of economic variables with the simulated movement of economic variables.

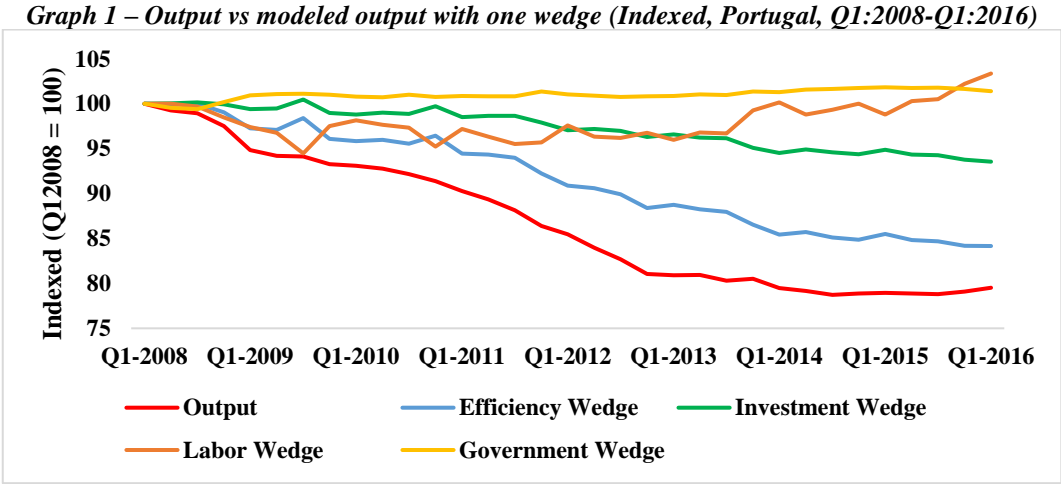
We will have 2 approaches. In the one wedge on economies, only one wedge is allowed to fluctuate, and the other 3 wedges are set to constants. For the one wedge off economies, one wedge is constant while the other 3 are allowed to fluctuate. Let's first look at output and how it compares to the prototype model predictions of output in one wedge on economies⁴.

In **Graph 1**, we can see that actual output is worse than any of the predictions. The efficiency wedge, however, seems to be the strongest predictor of output. The correlation of this wedge

⁴ Tables with all the cross-correlations and relative standard deviations are presented in **Annex 2**

with current output is 0,98, the highest for all the wedges. Out of all the wedges, the standard deviation of the efficiency wedge is the closest to output with a ratio of around 75%. The investment wedge also seems a good predictor of output. The correlation with the current values of output is also very high. However, the relative standard deviation between this wedge and output is around 31%, which is lower than the ratio between the efficiency wedge and output. Both the labor wedge and the government wedge are poor predictors of output. These wedges have a negative correlation with present values of output, with the government wedge having a more negative value of around -0,79. The relative standard deviation of the labor wedge is around 28%. For the government wedge is even lower at around 8%.

It's important to note that the labor wedge is a good predictor of output if we just consider the period before Troika (2008Q1-2011Q1). The labor wedge correlation with output in the current period is around 0,74, the 2nd highest correlation only behind the efficiency wedge. The relative standard deviation for the labor wedge in this sub-sample is the second highest for all the wedges at around 53%.



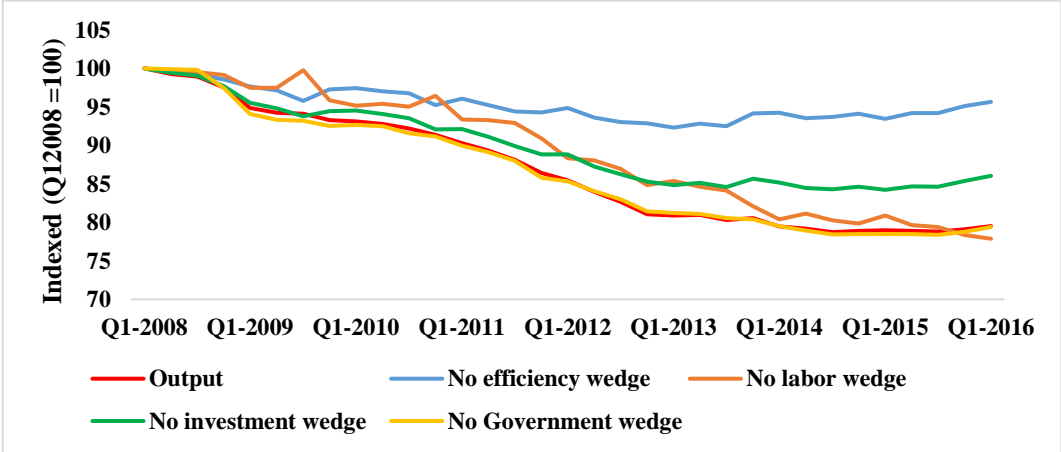
Now analyzing one-wedge off economies, in **Graph 2**, we can see that without the efficiency wedge, output would fall at most 7,7%, unlike the 21,3% fall in actual output. This shows us how important the contribution of the efficiency wedge is to the decline of the actual output.

Without the investment wedge, output would fall at most 15,8% instead of the actual 21,3%, again showing the importance of the investment wedge to the decline of output.

When analyzing the predictions of the prototype economy without the labor wedge, we again must divide the sample. Before the Troika period, actual output falls at most 9,7%. Without the labor wedge, output falls 6,6%. This difference of 3,1 % is the 2nd highest for all the wedges illustrating the contribution of the labor wedge to the decline in output, in this short sample. By the end of the full sample, output without the labor wedge falls 22,1%, which is more than actual output, demonstrating the labor wedge contribution to a slight increase in output in the 4th quarter of 2015 and the 1st quarter of 2016.

Without the government wedge, the prototype economy almost perfectly predicts actual output. Just like the “no labor wedge” case, output without the government wedge falls more than actual output. However, the difference between the actual output and the output without the government wedge is negligible, which shows that this is the least important wedge for output fluctuations.

Graph 2 – Output vs modeled output with all but one wedge (Indexed, Portugal, Q12008-Q12016)



To conclude our analysis of which wedges are more important for output fluctuations we are going to use the \emptyset statistic, presented by Brinca et al. (2016). This statistic captures for example, how closely the output component due to the efficiency wedge tracks the underlying variable output.

$$(19) \quad \emptyset_i^Y = \frac{1}{\frac{\sum_t (y_t - y_{it})^2}{\sum_j (1/\sum_t (y_t - y_{jt})^2)}}$$

Where y_t is the actual variable and y_{it} is the prediction of that variable using wedge i (or all the other wedges except wedge i). The better the variable prediction, the smaller $(y_t - y_{it})$ will be and consequently the closer the \emptyset statistic is to 1, the maximum value. The \emptyset statistic lies between $[0,1]$ and sums to one across the four wedges.

In **Table 3**, we show the \emptyset statistic for output in one wedge on and one wedge off economies. Looking at one wedge on economies for output, we see that the efficiency wedge is responsible for 67,9% of the movements in output. The investment wedge is responsible for 14,1%, the labor wedge 10,1%, and the government wedge 7,5%. These results are consistent with our previous analysis, showing that the movements in output are mostly due to the movements in the efficiency wedge. The one wedge-off \emptyset statistics show us that only the government wedge is negligible to explain output movements, while the other 3 wedges are relevant.

Table 3 – Fi statistics between output and simulated output in Portugal^{5,6}

		\emptyset_e^Y	\emptyset_l^Y	\emptyset_x^Y	\emptyset_g^Y
Full Sample	One wedge on	67,9%	10,1%	14,1%	7,5%
(Q12008-Q12016)	One wedge off	99,8%	97,8%	98,5%	4%
Short Sample	One wedge on	43,1%	34,5%	13,6%	8,8%
(Q12008-Q12011)	One wedge off	97,4%	97,3%	66,1%	39,3%

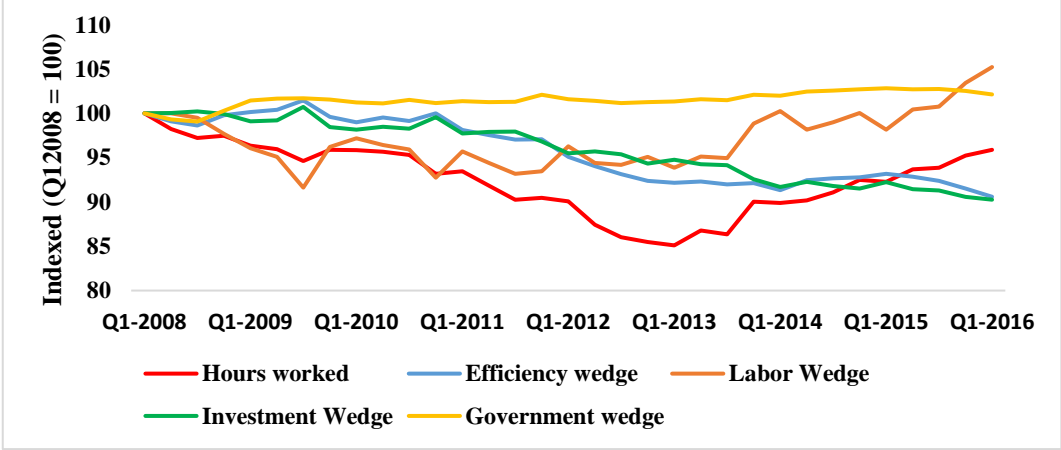
Using the \emptyset statistics for output in the period before Troika we have different results. In one wedge on economies, the efficiency wedge is still responsible for most of the output movements; however, the percentage is now 43,1% instead of 67,9%. The labor wedge's contribution increases massively from 10,1% to 34,5%. These results again confirm how

⁵ The statistics for one wedge off economies are presented as **1- \emptyset instead of \emptyset** , for a better interpretation.

⁶ All statistics are rounded to the second decimal place.

important the labor wedge is for this short sample. The investment wedge contribution decreases slightly to 13,6% while the government wedge contribution increases slightly to 8,8%. The one wedge off statistics in the short sample also confirm the importance of the labor wedge, even though the \emptyset statistic for this wedge is lower than in the full sample case. When it comes to hours worked in the one wedge on economy, the efficiency wedge is still the best predictor. The correlation with current hours worked is 0,64 the highest for all the wedges and the standard deviation relative to hours worked is around 89%, the highest for all the wedges. The investment wedge has the second highest correlation with hours worked at 0,44 with a standard deviation relative to hours worked of around 85%. The labor wedge comes next with a correlation with current hours worked of 0,41 and a standard deviation relative to hours worked of around 79%. The government wedge, just like in the analysis for output, is the worst predictor with a negative correlation of -0,32 and the standard deviation relative to hours worked is also the worst at 22%. Similarly, to output, looking at the short sample, the labor wedge becomes a much better predictor. In this case, the labor wedge is the best predictor of hours worked with a correlation of 0,83, which is much higher than the 2nd best correlation of the investment wedge of around 0,43. The standard deviation is the closest to hours worked with a ratio of around 136%. **Graph 3** shows one wedge on economies compared to actual hours worked.

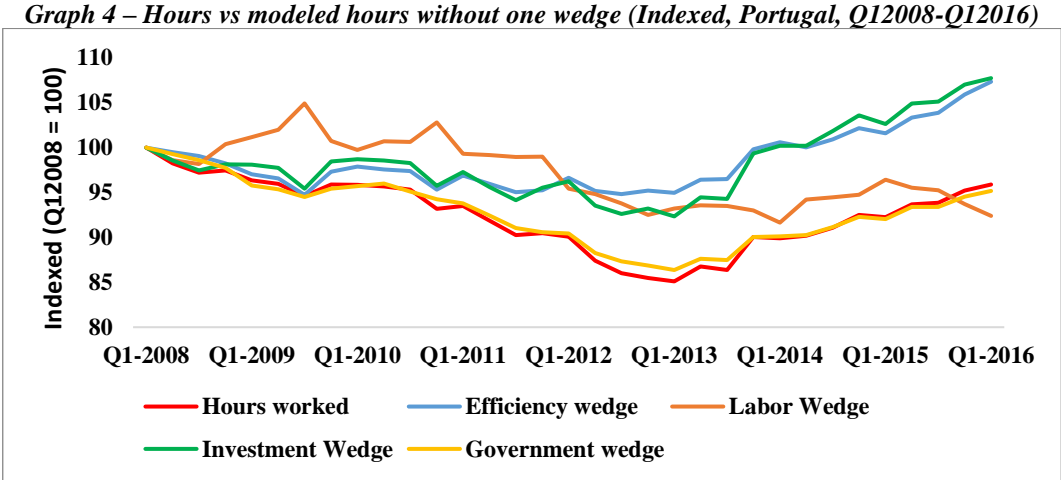
Graph 3 – Hours worked vs modeled hours worked with one wedge (Indexed, Portugal, Q12008-Q12016)



Looking at all but one wedge economies, we can see that the predictions of the model without the efficiency and the investment wedges are much more positive. Without the efficiency wedge, hours worked decrease at most around 5,3% and without the investment wedge, hours worked decrease at most around 7,7%. Actual hours worked decrease at most around 15%. At the end of the sample, without the efficiency wedge, hours worked surpass the base level by 7,3%. Without the investment wedge, at the end of the sample, hours surpass the base level by 7,7%. Actual hours worked at the end of the sample, are still lower than the base level by 5,9%. This shows us how important these 2 wedges are to understand the fluctuations of hours worked.

Without the labor wedge, hours decrease more than actual hours by the end of the sample, showing the importance of the slight increase in the labor wedge during this period. When we just consider the short sample, the labor wedge becomes much more relevant because, without it, hours worked decrease at most by 1,8% instead of the actual decline of 6,8%. Without the government wedge, for the full sample, hours worked predicted are very similar to actual hours worked, with the biggest difference in the values being around 1,6%.

Graph 4 shows the one wedge off economy predictions of hours worked vs actual hours worked.



The \emptyset statistics for hours in one-wedge on and off economies are presented in **Table 4**. For the one-wedge on economy, in the full sample, the efficiency wedge has the highest statistic at around 39%, followed by the investment wedge at around 30%, the labor wedge at 23,1% and the government wedge at 7,7%. For the short sample, the labor wedge has the highest \emptyset statistic at 75,4% with very low values for the remaining wedges. In the one-wedge off all the wedges except the government wedge are important in the full sample and the labor wedge is the most important in the short sample. It's interesting to see that there is no dominant \emptyset statistic for the one-wedge on and off economies in the full sample.

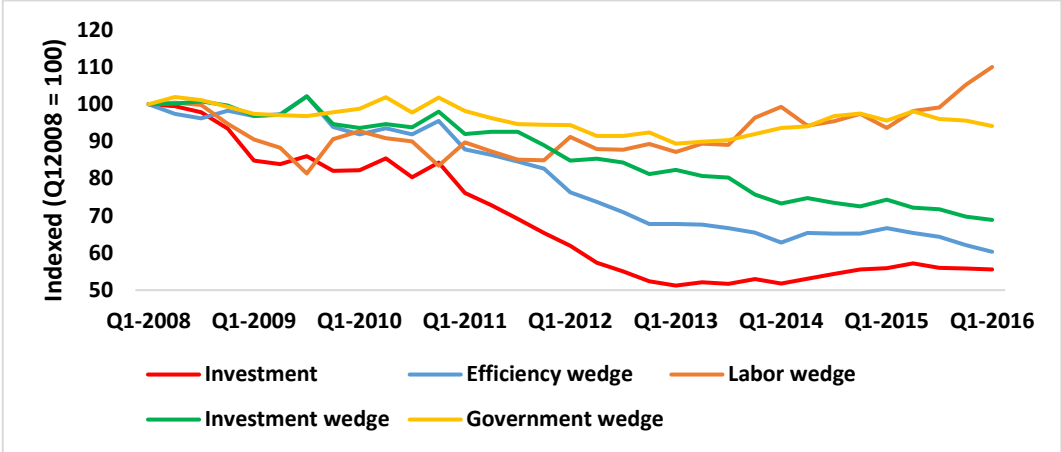
Table 4 – Fi statistics between hours worked and simulated hours worked in Portugal^{5,6}

		\emptyset_e^H	\emptyset_l^H	\emptyset_x^H	\emptyset_g^H
Full Sample (Q12008-Q12016)	One wedge on	38,8%	23,1%	30,4%	7,7%
	One wedge off	99,1%	98,6%	99%	3,4%
Short Sample (Q12008-Q12011)	One wedge on	8,4%	75,4%	11,1%	5,1%
	One wedge off	84,2%	98,9%	91,4%	25,5%

Analogous to output and hours worked, when we look at the one-wedge on economy predictions for investment, the efficiency is again the best predictor, with a correlation with current investment of around 0,95, and a relative standard deviation of 87%, the highest for all the wedges. The investment wedge is the 2nd best predictor with a correlation of 0,90 and a relative standard deviation of around 66%. The government wedge surprisingly is the 3rd best predictor with a very high correlation with current investment of 0,81 but a very low relative standard deviation of around 21%. The labor wedge is the worst predictor of investment with a negative correlation of around 0,08 and a relative standard deviation of around 39%. However, in the short sample, similarly, to output and hours, the labor wedge's prediction power increases tremendously. The correlation with current investment becomes approximately 0,74 and a relative standard deviation of around 76,5%.

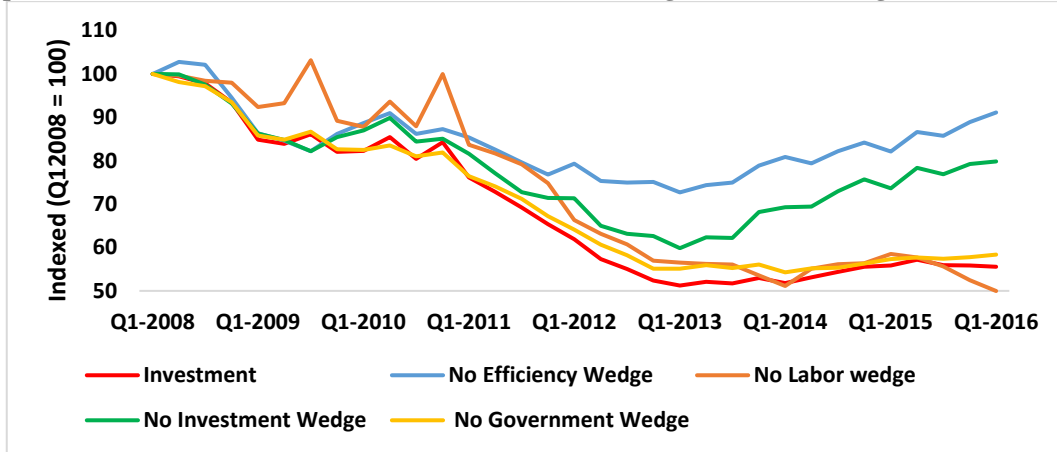
Graph 5 plots actual investment and the one wedge on economy predictions.

Graph 5 – Investment vs modeled investment with one wedge (Indexed, Portugal, Q12008-Q12016)



Concerning one wedge off economies, we see a similar pattern to output and hours. The predictions without the efficiency wedge are much more positive than actual investment. In this prediction, investment at most drops 27,3% compared to the actual maximum decline of 48,8%. Without the investment wedge, the prediction is more positive than actual investment, but the difference is not as large. Without the investment wedge, the maximum decline is 40,2%. Without the labor wedge, investment drops more than actual investment. It seems that the increase in the labor wedge in the final periods of the sample also had a positive impact on investment. If we just consider the short sample, the labor wedge becomes a very relevant contributor to the fluctuations in investment. Without the labor wedge, investment drops by approximately 16,4% instead of the actual 23,9%. Without the government wedge, the investment predictions are slightly different than actual investment with the biggest differences coming in the first 3 quarters of 2013 of around 7%. **Graph 6** plots the one wedge off predictions for investment vs actual investment.

Graph 6 – Investment vs modeled investment without one wedge (Indexed, Portugal, Q12008-Q12016)



The \emptyset statistics related to one wedge on and off economies, for investment, are presented in **Table 5**. In both cases, for the full sample, the efficiency and the investment wedge are more relevant to explain investment fluctuations. For the one wedge on economies, these results are more like the output case. For the one wedge off economies, these results are different from the output and hours worked case. In the short sample, much like in the output and hours worked case the labor wedge is the most responsible for the fluctuations in investment for one wedge on and off economies.

Table 5 – F_i statistics between investment and simulated investment in Portugal^{5,6}

		\emptyset_e^x	\emptyset_t^x	\emptyset_x^x	\emptyset_g^x
Full Sample (Q12008-Q12016)	One wedge on	57,8%	10,2%	22,8%	9,3%
	One wedge off	99%	92%	97,2%	11,8%
Short Sample (Q12008-Q12011)	One wedge on	18,3%	54,9%	15,6%	11,2%
	One wedge off	93,5%	98,7%	86,8%	20,9%

5.1 Discussion

We can conclude that the efficiency wedge is the main responsible for the fluctuations in the variables studied, with the labor wedge being more relevant in the short sample and the investment wedge being more relevant in the full sample. In this section, we will analyze why. Besides data from the *OECD*, we will use data from *the Banco de Portugal*

Publications, BPstat, Statistics Portugal, DGAEP, Eurostat and the European Commission.

The fall in economic activity, caused by the Great Recession was lower in Portugal than in other developed economies. There wasn't an overvaluation of the real estate market as prices moved according to inflation and construction activity remained weak. The Portuguese banking system was conditioned by the international crisis, but there wasn't a fall in the aggregate balance sheets of banks in 2009, in contrast with the euro area.

Real GDP per capita in Portugal decreased 6,7% from the 1st quarter of 2008 to the 4th quarter of 2009. Looking at the supply side of the economy, total labor per capita declined 4,1 %, mostly due to the decline of total employment (3,87%). This decline in labor per capita led to a decline in the labor wedge.

The components that declined the most were real investment per capita (18%) and real exports per capita (16,1%). The reduction in investment was a result of two factors. The ascent in the unemployment rate and the lack of confidence led to a decline in consumer durables expenditure of 13,8% but most importantly there was a deterioration of expectations regarding domestic and external demand which reduced gross fixed capital formation (GFCF) by 12,1%. In fact, according to the Investment Survey made by Statistics Portugal, the decline in sales prospects was the main reason firms limited their investments. Portuguese exports of goods and services declined due to the real GDP contraction of its most important trading partners. The negative expectations and significant fall in international trade led to a steep decline in capacity utilization as the quarterly average went from 81,7% in 2008 to 74,8% in 2009 and naturally, the efficiency wedge decreased.

In 2010, international trade flows accelerated and Portugal's main trading partners had an economic recovery. Consequently, exports per capita increased 14,2 % between the 4th quarter of 2009 and the 4th quarter of 2010. This increase in external demand boosted capacity utilization which in turn increased the efficiency wedge. Investment per capita also increased

by 2,7% as expenditure on durable goods grew 14%, motivated by fiscal changes.

Despite these improvements, output per capita still contracted by 2% this year. The labor wedge continued to decline. Labor per capita decreased by 2,8% as hours worked per worker and total employment both declined by 2,25% and 1,2% respectively. The decline in labor per capita reflects the economic contraction that started in 2008. While investment and productivity increased, labor per capita moved in a similar way to output, which proves the relevance of the labor wedge in this short sample.

Another component that's crucial to talk about is government consumption. To keep the economy from contracting further, in 2009 and 2010, the Portuguese government decided to increase expenditures and embark on record budget deficits. Because of these policies, direct government debt increased in this period. The government started a massive school-building program and continued to construct roads and tunnels (Rato 2020). From 2007 to 2010, the general government deficit went from 2,9 % to 11,4 % of GDP, and public debt in percentage of GDP increased by around 28 percentage points. Unsurprisingly, from the 1st quarter of 2008 to the 2nd quarter of 2010, government consumption per capita increased by 6,3%.

The high deficit and public debt numbers, a high current account deficit and a weak economic growth number increased international investors' concerns about the sustainability of public finances and the intertemporal dynamics of external debt. Private capital flows began to decrease in 2009, with this decline becoming more abrupt in 2010⁷. Fortunately for the Portuguese government, it was possible to partly replace this decline in private lending with the ECB liquidity provision to Portuguese banks, but this measure was not enough. The market conditions where public debt was placed were getting worse and worse. Yields on Portuguese government bonds were 4% at the beginning of 2010 and ended the year close to 7%. From January 2009 to March 2011, Portugal's sovereign bonds went from A+ quality to BBB-, which is almost speculative grade. Market closure, meaning international investors

⁷ The graph of capital flows is from Freitas et al. 2018 and can be seen in **Annex 3**.

were no longer willing to buy new issuances of Portuguese bonds, regardless of their maturities was imminent. Since domestic banks had less and less capacity to absorb the needs of the Portuguese treasury, and the ECB was not willing to finance the Portuguese Government indefinitely, the government had to look for alternative sources of funding: Troika was the available candidate (Rato 2020). On the 7th of May 2011, the economic and financial assistance program was agreed upon between Troika and the Portuguese authorities. The program size was €78 billion and was based on three pillars: balanced fiscal consolidation, frontloaded structural reforms, and financial sector stabilization. Success on these fronts would allow Portugal to return to financial markets within two years.

To correct macroeconomic imbalances and deleverage the public and private sectors of the economy, several measures were taken. Looking at the public sector, the total tax burden went from 30,3% to 33,9% of GDP from 2010 to 2013. The indirect tax revenues as a % of GDP increased by 0,5 percentage points whilst the revenues from direct taxes as a % of GDP increased by 2,9 percentage points, as individual income tax revenue increased 36,1% and corporate tax revenue of the General government increased 14,1%. On the expenditure side, public investment (GFCF) had a tremendous decline of 61%. There were also decreases in the government wage bill of 13,4%, which was also due to a 7,3% reduction in public sector workers. It's important to note that from 2010 to 2012 the government wage bill decreased by 20,2%, because of the suspension of Christmas and holiday bonuses in 2012, a measure that would not be repeated but was quite impactful not only for public sector employees but also pensioners. Given these cuts in expenditure, it is no surprise that government expenditure per capita decreased by 9,2% from the 1st quarter of 2011 to the 4th quarter of 2013.

From 2011 to 2013, the labor market continued to worsen. The rates of job destruction were particularly high for unproductive sectors dependent on internal demand such as construction. In 2012, the gross value added (GVA) in construction declined 15,8% and the number of jobs

declined by 18,9%. Labor per capita declined 3,7%, with total employment decreasing 6,6% and hours per worker increasing 0,3%. This is the point where the labor wedge starts to lose importance. To understand this idea, we need to look at **equation (5)**. Output per capita fell 10,8% during this period, even though labor per capita only declined 3,7%. This means investment $x_t(s^t)$ (the investment wedge) or the efficiency wedge $A_t(s^t)$ had to compensate which was the case. Investment per capita decreased by 30,4%. Expenditure on durable goods fell by 26,2%, as households downgraded their expectations in terms of permanent income⁸ and reassessed their level of indebtedness. GFCF declined 25,2%, thanks to the already mentioned decrease in public GFCF as well as a drop in residential and corporate GFCF. Residential GFCF declined due to the need to lower household indebtedness, high uncertainty about prospects for future income, a worse labor market, and tight conditions for financing⁹. When it comes to corporate GFCF, the decline in domestic demand, the need to deleverage, tight conditions for financing, and the uncertainty about demand prospects led to the postponement of investment decisions and to a 1% fall in the quarterly average of capacity utilization to a level much lower than the 2000-2007 quarterly average. Consequently, the efficiency wedge declined as well.

Despite this depressing scenario, exports per capita saw an impressive 19% increase in these 2 years. This export growth shows an increased effort by Portuguese firms to find new markets in the tradable goods and service sectors. There's also been a gradual reorientation of national inputs towards exporting activities, as the share of firms involved in export activities has been increasing, from 14,5% in 2007 to 17,9% in 2012.

Thanks to the export growth and the sharp decline in investment, Portugal was able to obtain a clear surplus in its current account of 1,6% of GDP. The fiscal consolidation process led to a decline in the government deficit, from – 11,4% in 2010 to – 5,1% in 2013. Also in 2013,

⁸ The decline in disposable income, due to unemployment, lower wages and tax increases was perceived to be permanent.

⁹ Due to the deterioration in economic activity, banks became more sensitive to credit risk. See **Annex 3**

Portugal was able to return to the financial markets. In terms of debt, non-financial corporations' debt slightly increased, and household debt slightly decreased. Public debt went from 100,2% of GDP to 131,4% of GDP, because of financing needs during the program, unexpected additions to public debt, a deeper-than-anticipated downturn, and a weaker recovery.

Let's now analyze the last period of our sample. From the 1st quarter of 2014 to the 1st quarter of 2016, the Portuguese economy stagnated after years of decline. The real GDP growth was 0,05 %. The labor market saw considerable improvements, with total employment increasing by 3,8% and hours worked per worker increasing by 1,3%. Labor per capita increased by 6,7% which led to an increase in the labor wedge. Real Investment per capita had an increase of 7,3% in 2014 but from 2015 to 2016 it decreased by 0,5%. The improvements in the labor market, a moderate recovery of disposable income, together with a rise in consumer confidence and permanent income expectations led to an increase of 31% in consumer durable expenditure for the whole period. GFCF grew by 8,2% in 2014, with most of the growth coming from business GFCF, from sectors such as transport material as well as machinery and equipment. GFCF also stalled from 2015 to 2016 with a growth of 0,7%. The reason for this slowdown is a consequence of the fall in oil prices impacting Angola's economy. Angola went from the 9th most important destination for Portuguese exports in 2005 to the 4th in the 2011-2014 period. In 2015, exports to Angola fell remarkably, with a downfall of 34% in the export of goods and 14% in the export of services. This decline in exports, in a context of increased uncertainty, led to the postponement of investment decisions as well as to a lack of pressure to increase capacity utilization, which stagnated the efficiency wedge. Quarterly average capacity utilization increased by 3,6% when compared to the 2011-2013 average, which is smaller than the increases for labor and investment per capita. Moreover, this average capacity utilization is still below the 2008 average. Government expenditure per

capita had an insignificant decrease of 0,2% in this last period of the sample, as the numbers of public workers declined but their salaries increased. Exports per capita grew 4,4%, a number impacted by the decline of exports to Angola. Imports per capita grew 2,1% and the current account managed to obtain surpluses in 2014 and 2015.

6. Conclusions and Further Research

The objective of this paper is to help researchers find out what frictions should they try to model to better examine the economic shocks of Portugal during the Great Recession and the Portuguese financial crisis.

Using a prototype economy, like the one in Chari et al. (2007a) we estimated wedges that distort production decisions, the labor leisure choice, the intertemporal choice between consumption and savings, and the resource constraint. We find that the efficiency wedge is the most important to explain the movements in output, hours worked and investment. The investment wedge is also important for the full sample and the labor wedge is much more important in the period before Troika.

When modeling the Portuguese economy from Jan 2008 to Jan 2016 researchers should consider the following mechanisms: The movements of the efficiency wedge are correlated with the movements in capacity utilization. Before Troika, negative expectations regarding future demand and the abrupt decline in international trade led to a fall in capacity utilization. In the years of the adjustment program, besides the negative expectations, the need to deleverage and to reduce public expenditure, tight financing conditions, and the fall of domestic demand were additional factors that conditioned capacity utilization. After the adjustment program, the decrease in exports to Angola contributed to a slowdown in productivity. The investment wedge is affected by mostly the same factors that affect the efficiency wedge and the labor wedge is related to the movements in employment in the studied period.

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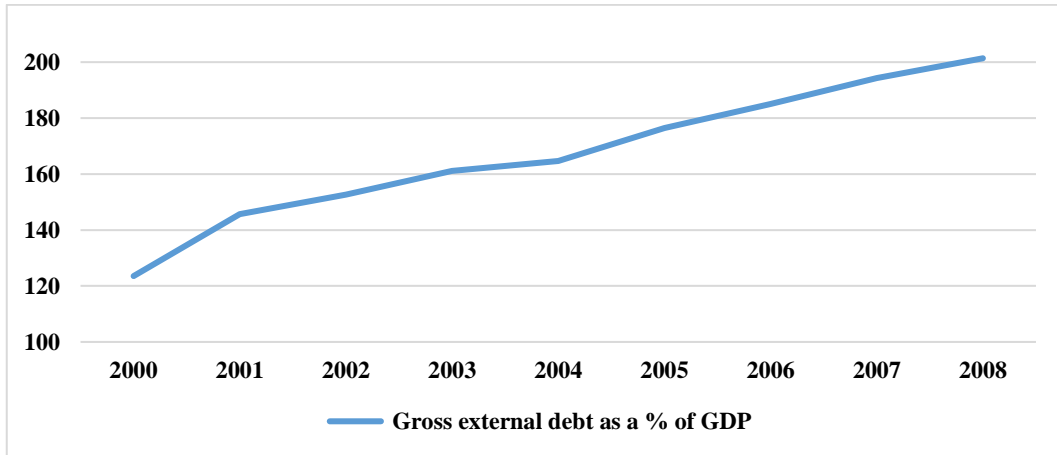
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8. Annex

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Annex 3 – Statistics for 5.1 Discussion	42

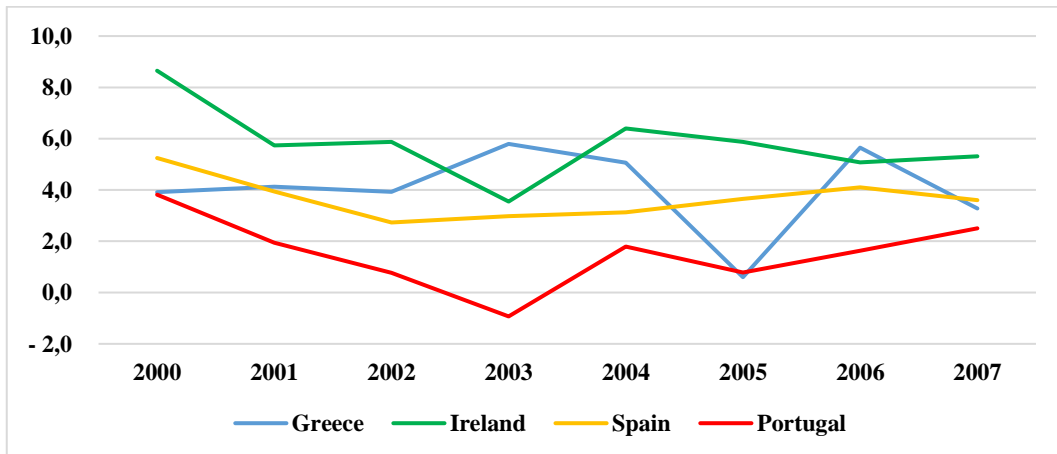
Annex 1

Graph 7 – Gross External Debt as a % of GDP (Portugal, 2000-2008)



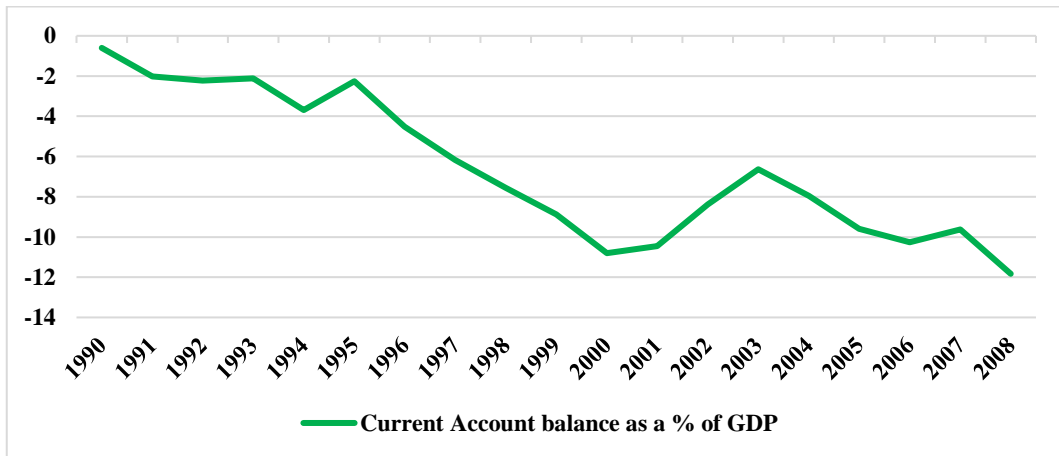
Source: BPstat

Graph 8 – Real GDP growth of Greece, Ireland, Spain, and Portugal (2000-2007)



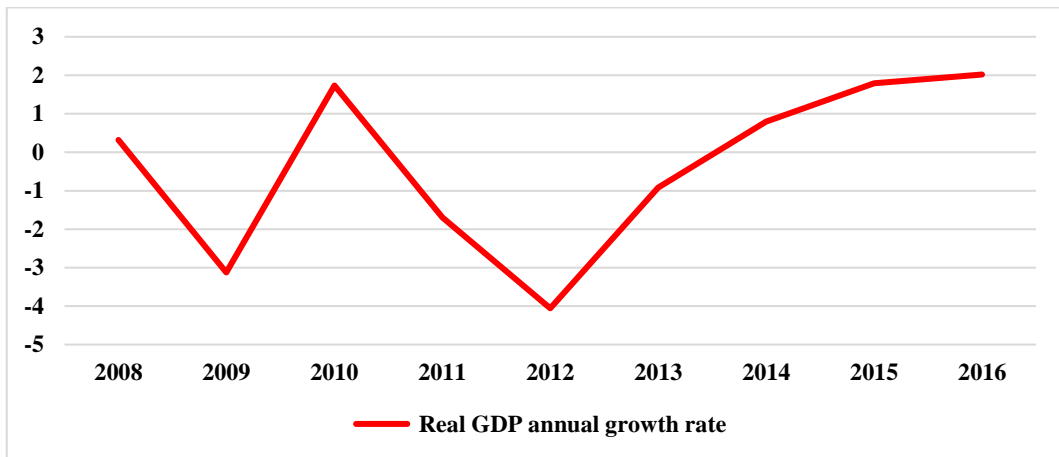
Source: OECD iLibrary

Graph 9- Current Account balance as a % of GDP (Portugal, 1990-2008)



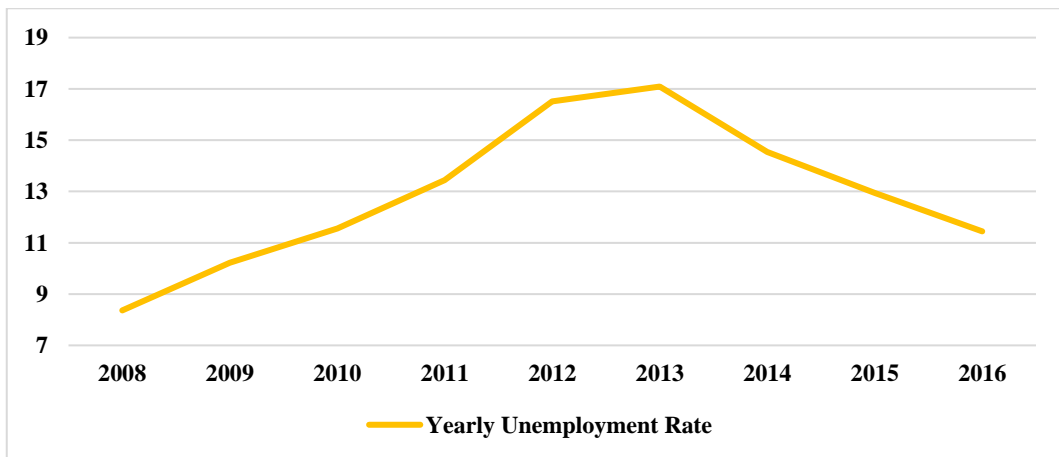
Source: BPstat

Graph 10 – Real GDP annual rate of change (Portugal, 2008-2016)



Source: OECD iLibrary

Graph 11- Yearly Unemployment rate (Portugal, 2008-2016)



Source: OECD iLibrary

Annex 2

Table 6 – Cross correlations between the output models and output and between the output models themselves (Portugal, 2008Q1-2016Q1)

Summary statistics						
Cross correlations between output models and output at lag k =						
Components	σ_{wi}/σ_y	-2	-1	0	1	2
Efficiency	0,7533	0,7962	0,8920	0,9838	0,9316	0,8685
Labor	0,2816	-0,0340	-0,1269	-0,2462	-0,3473	-0,4521
Investment	0,3062	0,7373	0,8409	0,9448	0,9145	0,8728
Government	0,0769	-0,6235	-0,7180	-0,7871	-0,7146	-0,5838

Cross Correlations						
Cross-Correlation of Output Models of Component X with Output Models of Component Y at Lag k =						
Components (X, Y)	-2	-1	0	1	2	
Efficiency, Labor	-0,5160	-0,4514	-0,4111	-0,2385	-0,1218	
Efficiency, Investment	0,8547	0,9202	0,9879	0,8847	0,7903	
Efficiency, Government	-0,5766	-0,7021	-0,7936	-0,7438	-0,6624	
Labor, Investment	-0,1902	-0,3305	-0,5461	-0,5276	-0,5543	
Labor, Government	0,1133	0,0807	0,1677	0,2987	0,4121	
Investment, Government	-0,5491	-0,6587	-0,7593	-0,7324	-0,6726	

Table 7 - Cross correlations between the hours worked models and hours worked and between the hours worked models themselves (Portugal, 2008Q1-2016Q1)

Summary statistics						
Cross correlations between hours worked models and hours worked at lag k =						
Components	σ_{wi}/σ_h	-2	-1	0	1	2

Efficiency	0,8887	0,4318	0,5442	0,6405	0,7010	0,7598
Labor	0,7862	0,3795	0,3691	0,4193	0,2082	0,0066
Investment	0,8476	0,2569	0,3544	0,4410	0,5393	0,6135
Government	0,2209	-0,1622	-0,2280	-0,3201	-0,3695	-0,3408

Cross Correlations

Cross-Correlation of Hours Worked Models of Component X with Hours worked Models of Component Y at Lag k =					
Components (X, Y)	-2	-1	0	1	2
Efficiency, Labor	-0,4666	-0,4113	-0,4112	-0,2296	-0,0650
Efficiency, Investment	0,8205	0,8681	0,9407	0,8502	0,7689
Efficiency, Government	-0,4822	-0,5270	-0,5714	-0,5705	-0,5716
Labor, Investment	-0,1872	-0,3277	-0,5440	-0,5264	-0,5537
Labor, Government	0,1136	0,0822	0,1701	0,3019	0,4150
Investment, Government	-0,5504	-0,6597	-0,7601	-0,7328	-0,6727

Table 8 - Cross correlations between the investment models and investment and between the investment models themselves (Portugal, 2008Q1-2016Q1)

Summary statistics

Cross correlations between investment models and investment at lag k =						
Components	σ_{wi}/σ_i	-2	-1	0	1	2
Efficiency	0,8732	0,7518	0,8520	0,9545	0,9125	0,8812
Labor	0,3876	0,1085	0,0372	-0,0785	-0,1775	-0,3218
Investment	0,6568	0,6691	0,7840	0,9013	0,8741	0,8510
Government	0,2111	0,6912	0,7407	0,8099	0,7249	0,6042

Cross Correlations

Cross-Correlation of Investment Models of Component X with Investment Models of Component Y at Lag k =	
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Components (X, Y)	-2	-1	0	1	2
Efficiency, Labor	-0,4496	- 0,3802	- 0,3547	-0,1690	- 0,0271
Efficiency, Investment	0,8485	0,9032	0,9733	0,8755	0,7899
Efficiency, Government	0,4987	0,6107	0,6870	0,6646	0,6830
Labor, Investment	-0,1154	-0,2463	-0,4622	-0,4633	-0,5066
Labor, Government	0,2632	0,2266	0,1801	0,0903	-0,1101
Investment, Government	0,3523	0,4683	0,5523	0,5537	0,5943

Graph 12 – Detrended output and wedges indexed (Portugal, 2008Q1-2016Q1)

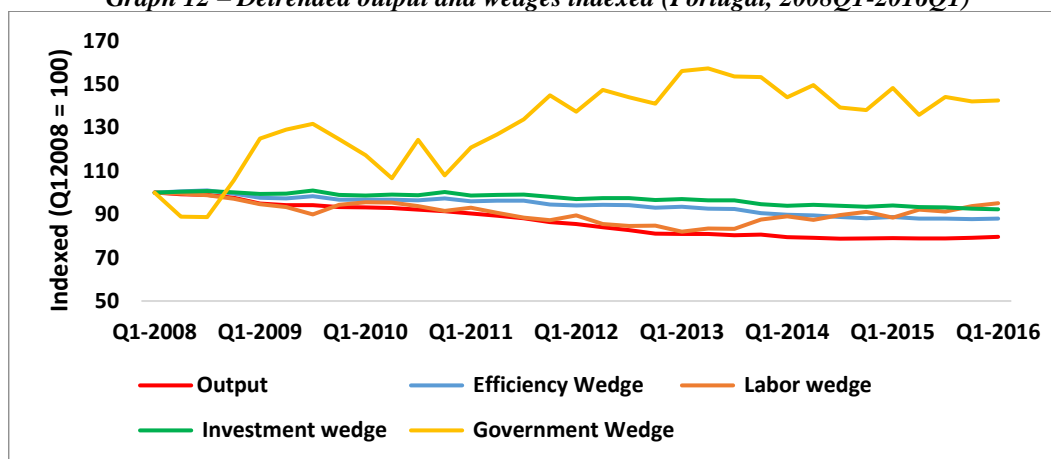


Table 9 – Cross-correlation between output and the wedges and between the wedges themselves (Portugal, 2008Q1-2016Q1)

Output						
Cross correlations between wedges and output at lag k =						
Components	σ_{wi}/σ_y	-2	-1	0	1	2
Efficiency	0,5670	0,7418	0,841	0,9474	0,9042	0,8423
Labor	0,6542	0,7199	0,7210	0,7034	0,5865	0,4607
Investment	0,3689	0,6835	0,7941	0,9052	0,8867	0,8508
Government	2,5605	-0,7581	-0,8202	-0,8703	-0,7856	-0,6463

Cross Correlations

Cross-Correlation of Output Models of Component X with Output Models of Component Y at Lag k =					
Components (X, Y)	-2	-1	0	1	2
Efficiency, Labor	0,2491	0,3610	0,4593	0,5506	0,5905
Efficiency, Investment	0,8284	0,9091	0,9826	0,8687	0,7664
Efficiency, Government	-0,4952	-0,6454	-0,7575	-0,7433	-0,7097
Labor, Investment	0,5779	0,4941	0,3501	0,2892	0,1918
Labor, Government	0,1133	0,0807	0,1677	0,2987	0,4121
Investment, Government	-0,6957	-0,7955	-0,8517	-0,6951	-0,5355

Table 10- Cross correlations between the wedges and the other variables and between the wedges themselves (2008Q1-2016Q1)

Hours Worked						
Cross correlations between wedges and hours worked at lag k =						
Components	σ_{wi}/σ_h	-2	-1	0	1	2
Efficiency	1,0368	0,2234	0,3154	0,4152	0,4999	0,5551
Labor	1,1962	0,7149	0,8228	0,9681	0,8639	0,7530
Investment	0,6745	0,1646	0,2535	0,3282	0,4482	0,5353
Government	4,6819	-0,5424	-0,6555	-0,7672	-0,7761	-0,7106

Investment						
Cross correlations between wedges and investment at lag k =						
Components	σ_{wi}/σ_I	-2	-1	0	1	2
Efficiency	0,2504	0,6486	0,7678	0,8800	0,8481	0,8072
Labor	0,2899	0,7635	0,7937	0,7984	0,6966	0,5653
Investment	0,1629	0,5859	0,7070	0,8334	0,8198	0,8085
Government	1,1309	-0,4373	-0,5708	-0,6865	-0,6998	-0,7124

Government consumption

Cross correlations between wedges and government consumption at lag k =

Components	σ_{wi}/σ_G	-2	-1	0	1	2
Efficiency	0,2241	-0,4952	-0,6454	-0,7575	-0,7433	-0,7097
Labor	0,2555	-0,6957	-0,7955	-0,8517	-0,6951	-0,5355
Investment	0,1441	-0,4373	-0,5708	-0,6865	-0,6998	-0,7124

Table 11 - Cross correlations between the output models and output and between the output models themselves (Portugal, 2008Q1-2011Q1)

Summary statistics

Cross correlations between output models and output at lag k =

Components	σ_{wi}/σ_y	-2	-1	0	1	2
Efficiency	0,5950	0,4936	0,6619	0,9519	0,7292	0,5046
Labor	0,5254	0,3705	0,6766	0,7359	0,5299	0,2642
Investment	0,1942	0,3865	0,4040	0,7078	0,5582	0,4180
Government	0,1856	-0,4856	-0,6815	-0,8291	-0,6535	-0,3277

Cross Correlations

Cross-Correlation of Output Models of Component X with Output Models of Component Y at Lag k =

Components (X, Y)	-2	-1	0	1	2
Efficiency, Labor	0,2894	0,4908	0,5142	0,6785	0,4176
Efficiency, Investment	0,3589	0,4539	0,8889	0,3568	0,3354
Efficiency, Government	-0,2871	-0,5608	-0,7804	-0,6389	-0,4854
Labor, Investment	0,4031	0,5389	0,0726	0,3262	0,2690
Labor, Government	-0,3135	-0,7130	-0,7939	-0,6164	-0,2560

Investment, Government	-0,1815	-0,2992	-0,5263	-0,4277	-0,4009
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Table 12 - Cross correlations between the hours worked models and hours worked and between the hours worked models themselves (Portugal, 2008Q1-2011Q1)

Summary statistics						
Cross correlations between hours worked models and hours worked at lag k =						
Components	σ_{wi}/σ_h	-2	-1	0	1	2
Efficiency	0,4611	0,0032	-0,1042	0,0098	0,0673	0,0398
Labor	1,3590	0,2240	0,5362	0,8313	0,4777	0,2162
Investment	0,5080	0,3704	0,3312	0,4275	0,5638	0,4164
Government	0,4875	-0,3799	-0,5342	-0,6772	-0,6314	-0,3812

Cross Correlations					
Cross-Correlation of Hours Worked Models of Component X with Hours worked Models of Component Y at Lag k =					
Components (X, Y)	-2	-1	0	1	2
Efficiency, Labor	-0,0087	-0,1878	-0,5399	-0,0534	0,0965
Efficiency, Investment	-0,0302	-0,1488	0,5495	-0,0810	0,1100
Efficiency, Government	0,0189	0,3423	0,3671	0,2696	-0,1524
Labor, Investment	0,4034	0,5390	0,0768	0,3266	0,2691
Labor, Government	-0,3155	-0,7157	-0,7966	-0,6171	-0,2556
Investment, Government	-0,1815	-0,2991	-0,5261	-0,4271	-0,4007

Table 13 - Cross correlations between the investment models and investment and between the investment models themselves (Portugal, 2008Q1-2011Q1)

Summary statistics	
Cross correlations between investment models and investment at lag k =	

Components	σ_{wi}/σ_i	-2	-1	0	1	2
Efficiency	0,4891	0,2261	0,2011	0,6483	0,2907	0,4023
Labor	0,7647	0,3612	0,7399	0,7378	0,6290	0,3224
Investment	0,4170	0,2698	0,3147	0,7849	0,4667	0,4637
Government	0,2496	0,3352	0,2023	0,5408	0,2205	-0,0036

Cross Correlations

Cross-Correlation of Investment Models of Component X with Investment Models of Component Y at Lag k =

Components (X, Y)	-2	-1	0	1	2
Efficiency, Labor	0,2090	0,2152	0,0447	0,4011	0,3388
Efficiency, Investment	0,2244	0,2164	0,9149	0,2073	0,2899
Efficiency, Government	-0,0847	-0,2360	-0,0090	-0,3271	0,2986
Labor, Investment	0,4170	0,5699	0,1985	0,3620	0,2760
Labor, Government	0,0176	0,4969	0,4585	0,4913	0,1019
Investment, Government	-0,1694	-0,1504	0,2197	-0,0725	0,3836

Graph 13 - Detrended output and wedges indexed (Portugal, 2008Q1-2011Q1)

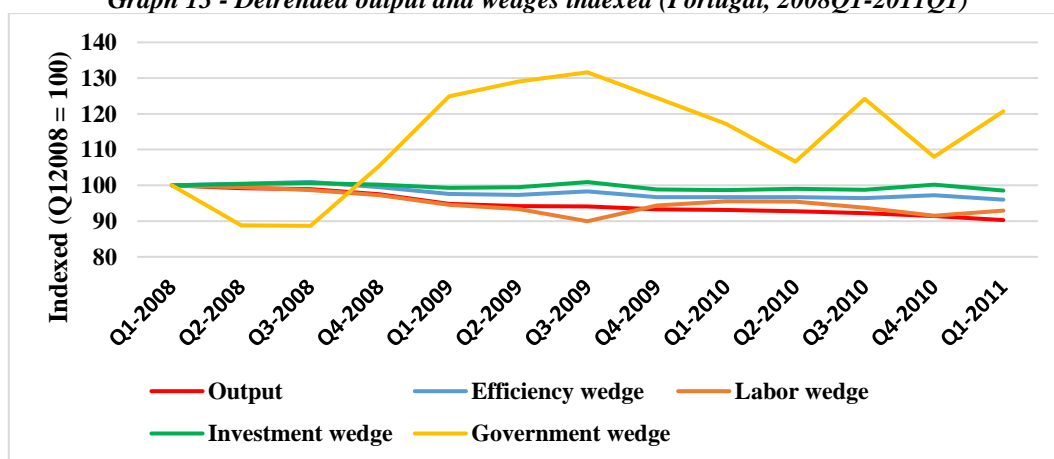


Table 14 – Cross-correlation between output and the wedges and between the wedges themselves (Portugal, 2008Q1-2011Q1)

Output						
Cross correlations between wedges and output at lag k =						
Components	σ_{wi}/σ_y	-2	-1	0	1	2
Efficiency	0,5289	0,5094	0,6991	0,9468	0,7481	0,4876
Labor	0,9543	0,4234	0,6919	0,8269	0,5836	0,3042
Investment	0,2571	0,3677	0,3471	0,6199	0,5141	0,3643
Government	4,605	-0,4390	-0,5373	-0,6800	-0,5082	-0,1694

Cross Correlations						
Cross-Correlation of Output Models of Component X with Output Models of Component Y at Lag k =						
Components (X, Y)		-2	-1	0	1	2
Efficiency, Labor		0,3334	0,5748	0,7112	0,7222	0,4804
Efficiency, Investment		0,2877	0,4387	0,7950	0,3275	0,2718
Efficiency, Government		-0,1191	-0,4782	-0,7511	-0,5843	-0,4650
Labor, Investment		0,4531	0,4912	0,1664	0,2862	0,2840
Labor, Government		-0,2472	-0,6605	-0,8001	-0,6071	-0,2643
Investment, Government		-0,0314	-0,1130	-0,4505	-0,2599	-0,4163

Table 15 - Cross correlations between the wedges and the other variables and between the wedges themselves (Portugal, 2008Q1-2011Q1)

Hours Worked						
Cross correlations between wedges and hours worked at lag k =						
Components	σ_{wi}/σ_h	-2	-1	0	1	2
Efficiency	0,9012	0,4341	0,5578	0,7433	0,7083	0,4795

Labor	1,6271	0,2548	0,5569	0,8901	0,5472	0,2511
Investment	0,4384	0,3710	0,2815	0,2912	0,5293	0,4104
Government	7,8508	-0,2990	-0,4253	-0,5581	-0,5437	-0,2587

Investment

Cross correlations between wedges and investment at lag k =

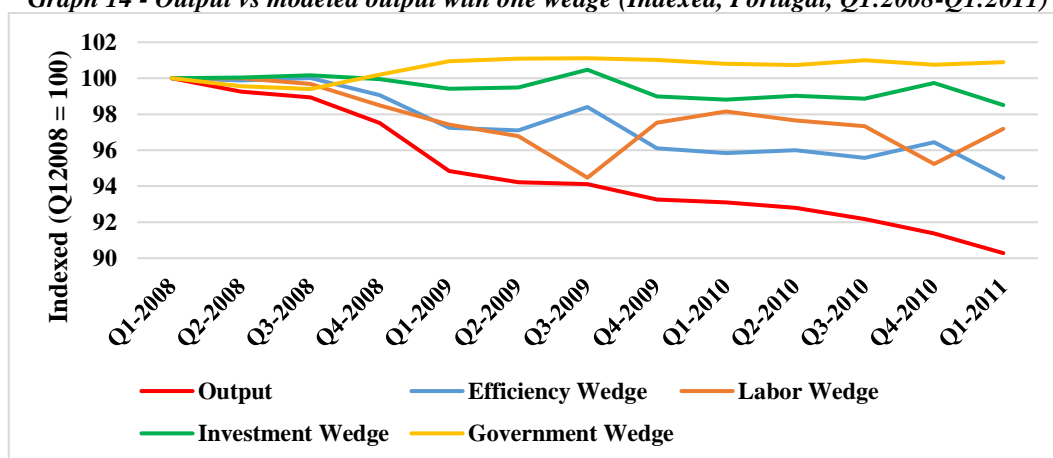
Components	σ_{wi}/σ_I	-2	-1	0	1	2
Efficiency	0,2168	0,3772	0,6239	0,9643	0,7085	0,5269
Labor	0,3912	0,3948	0,7067	0,8006	0,6080	0,3435
Investment	0,1054	0,2371	0,2253	0,7121	0,4172	0,4172
Government	1,8874	-0,4054	-0,5183	-0,8050	-0,5387	-0,2494

Government consumption

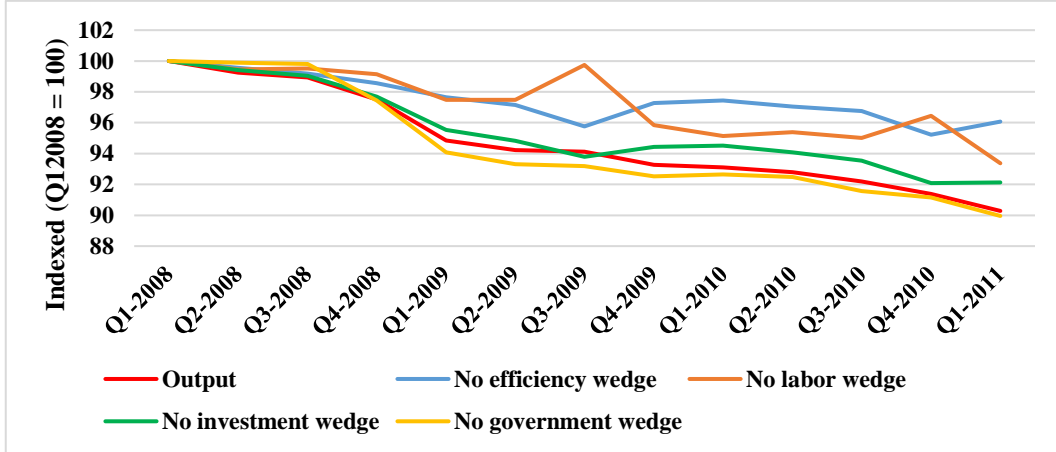
Cross correlations between wedges and government consumption at lag k =

Components	σ_{wi}/σ_G	-2	-1	0	1	2
Efficiency	0,1149	-0,1191	-0,4782	-0,7511	-0,5843	-0,4650
Labor	0,2073	-0,2472	-0,6605	-0,8001	-0,6071	-0,2643
Investment	0,0558	-0,0314	-0,1130	-0,4505	-0,2599	-0,4163

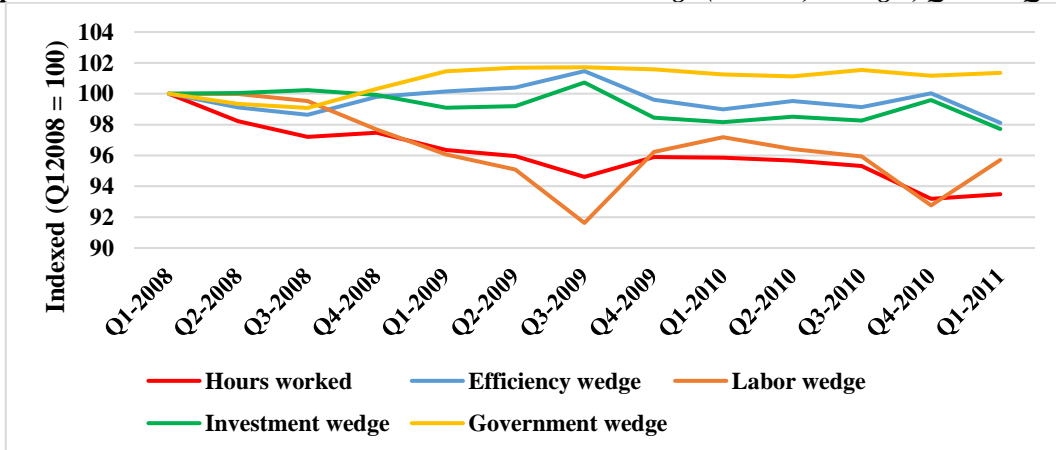
Graph 14 - Output vs modeled output with one wedge (Indexed, Portugal, Q1:2008-Q1:2011)



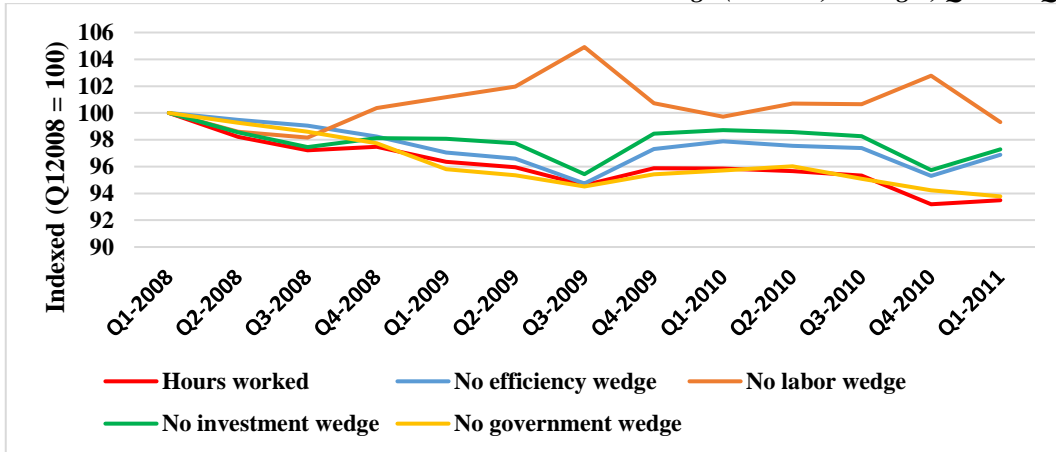
Graph 15 – Output vs modeled output with all but one wedge (Indexed, Portugal, Q12008-Q12011)



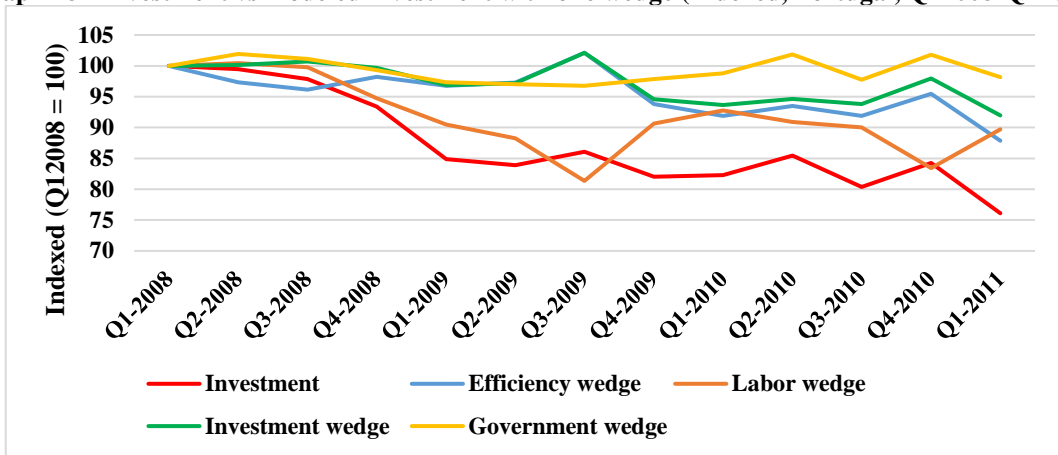
Graph 16 - Hours worked vs modeled hours worked with one wedge (Indexed, Portugal, Q12008-Q12011)



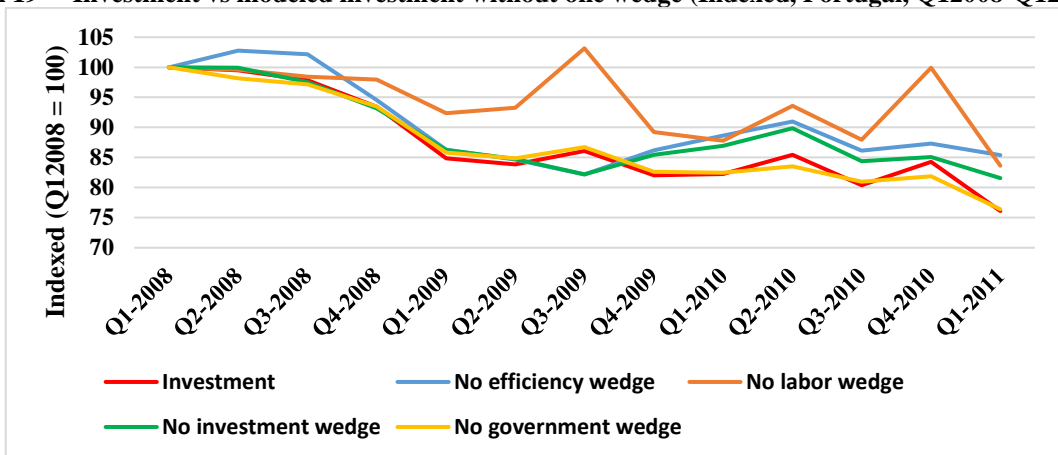
Graph 17 - Hours worked vs modeled hours worked without one wedge (Indexed, Portugal, Q12008-Q12011)



Graph 18 - Investment vs modeled investment with one wedge (Indexed, Portugal, Q12008-Q12011)

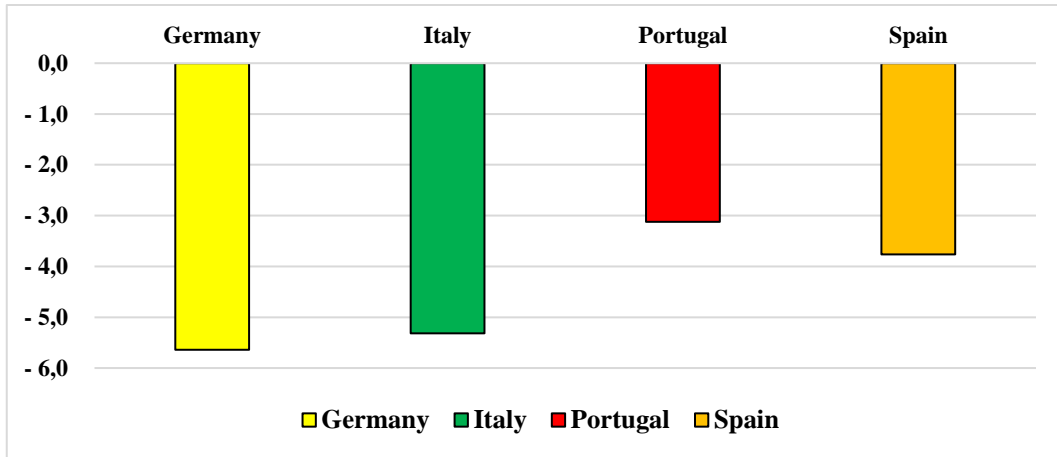


Graph 19 - Investment vs modeled investment without one wedge (Indexed, Portugal, Q12008-Q12011)

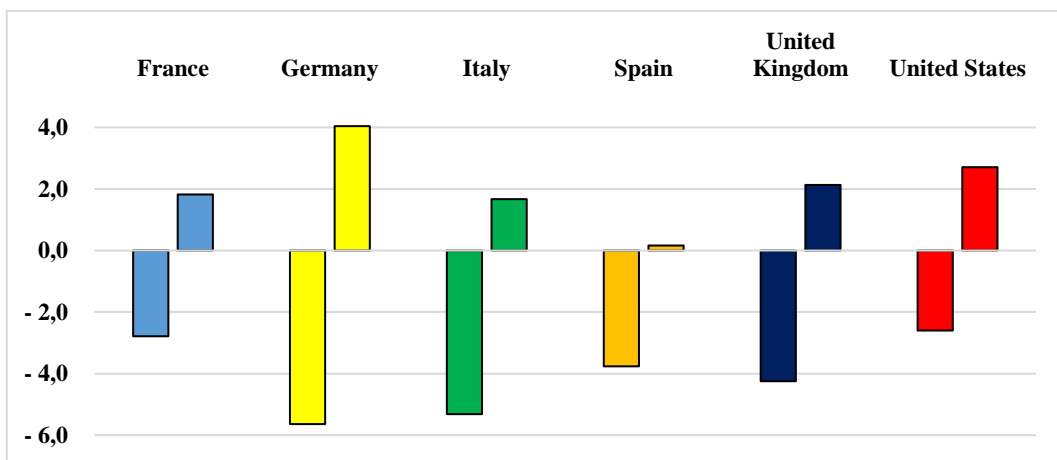


Annex 3

Graph 20 – Real GDP growth of Portugal compared to other countries in the Euro Area (2009)

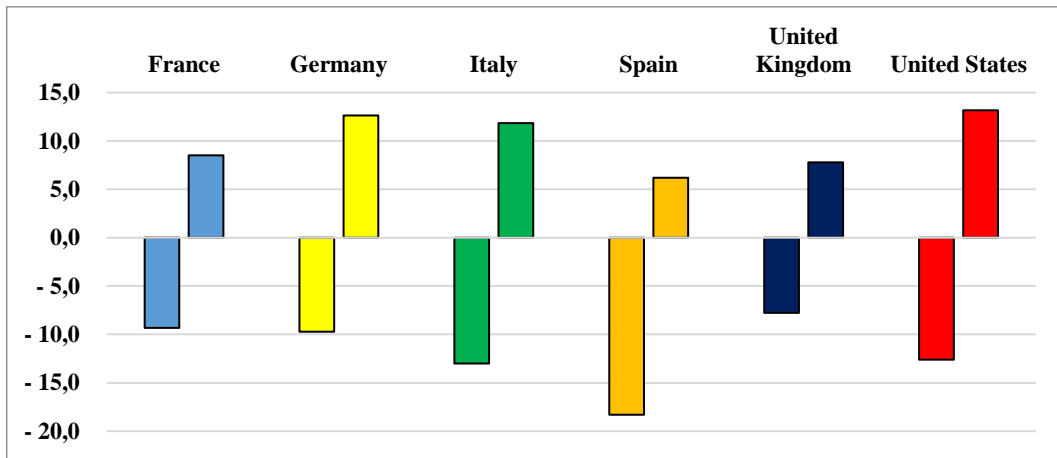


Graph 21 – Portugal's main trading partners' real GDP growth rate (2009 and 2010)¹⁰

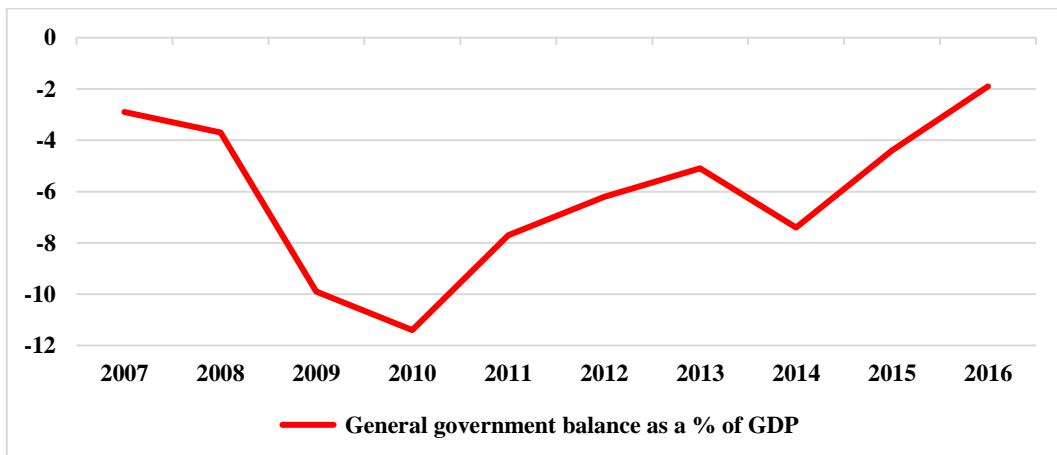


¹⁰ The negative numbers are from 2009 and the positive numbers are from 2010.

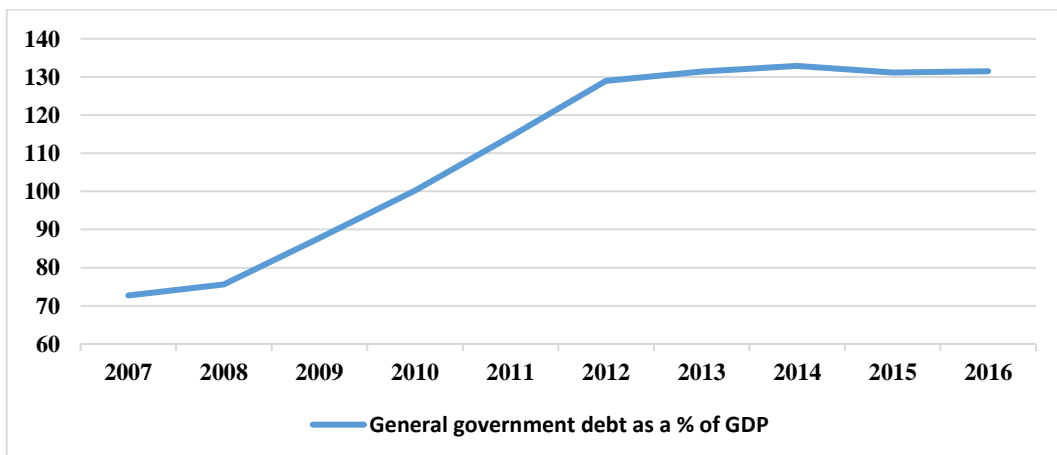
Graph 22 – Portugal’s main trade partners real imports growth rate (2009 and 2010)¹⁰



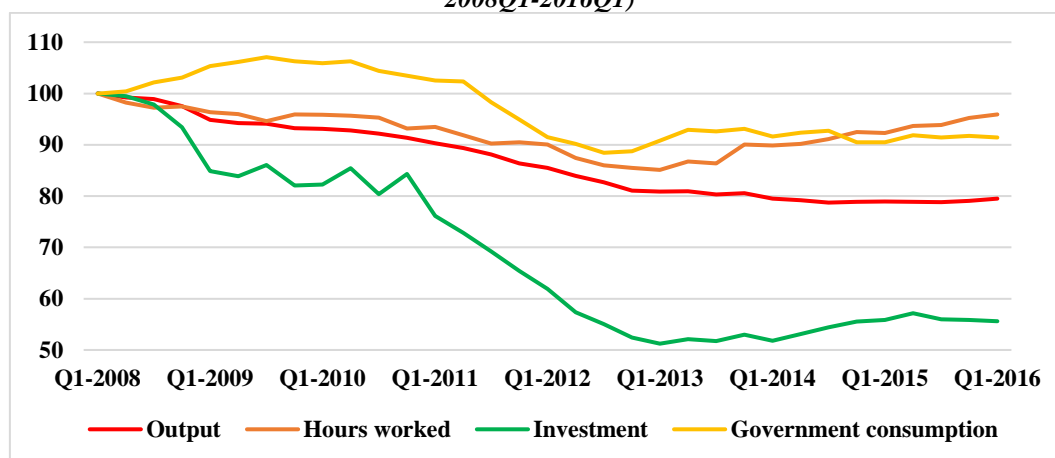
Graph 23 – General government balance as a % of GDP (Portugal, 2007-2015)



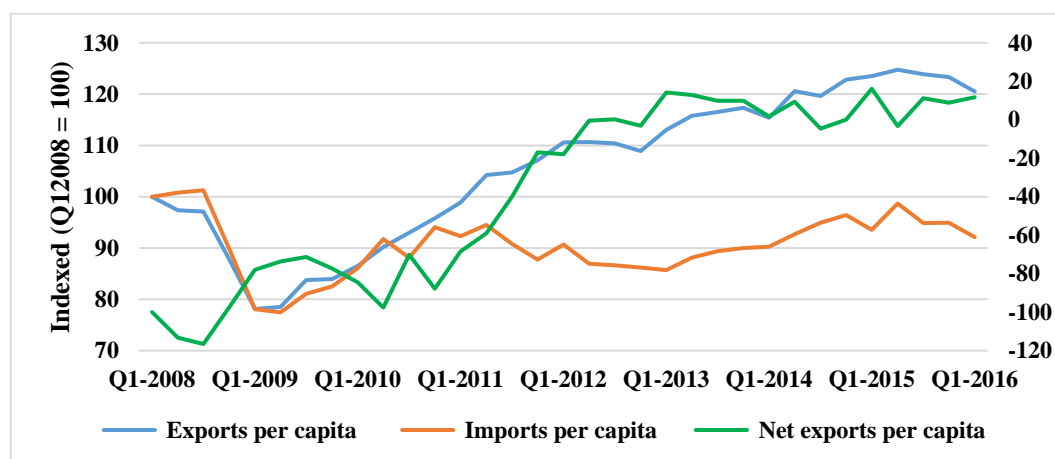
Graph 24 – General government consolidated debt as a % of GDP (Portugal, 2007-2016)



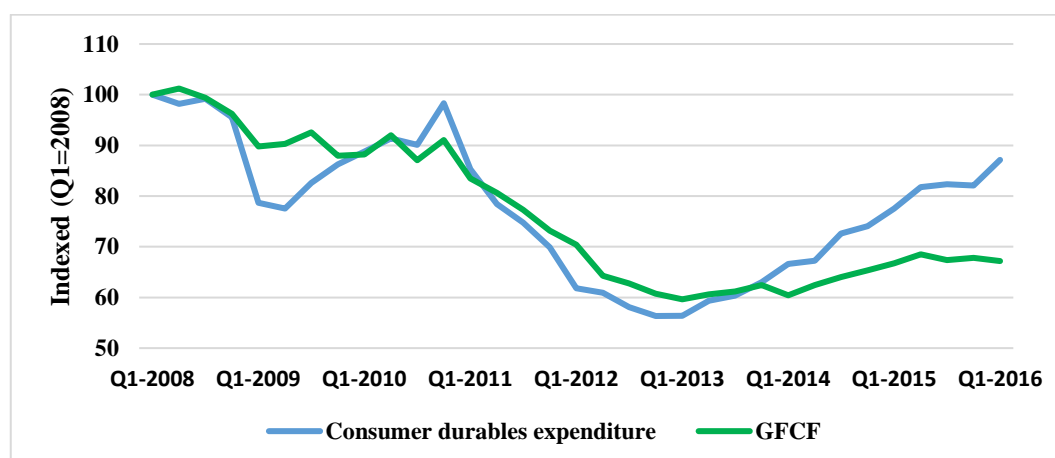
Graph 25 – Output, Hours Worked, Investment and Government Consumption per capita (Indexed, Portugal, 2008Q1-2016Q1)



Graph 26 – Exports, Imports, and Net exports per capita (Indexed, Portugal, 2008Q1-2016Q1¹¹)

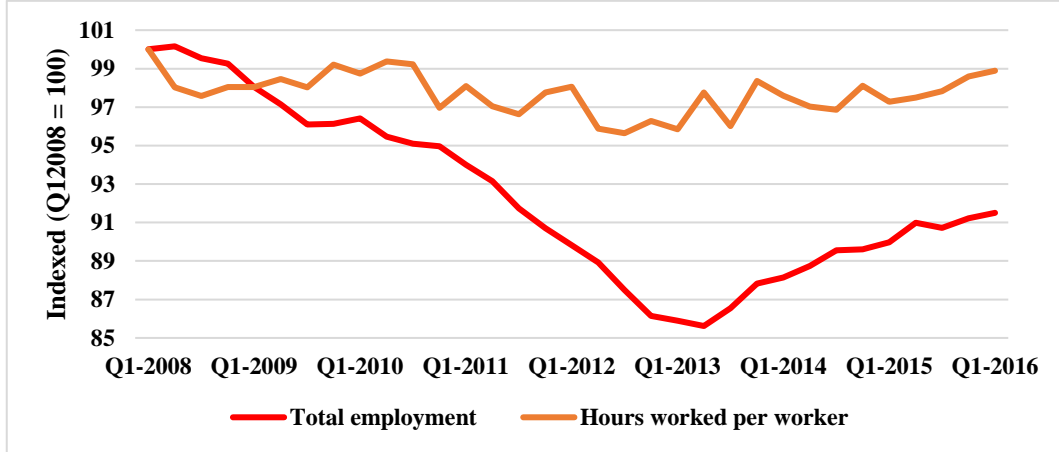


Graph 27 – Durable goods expenditure and gross fixed capital formation (Portugal, Q12008-Q12016)

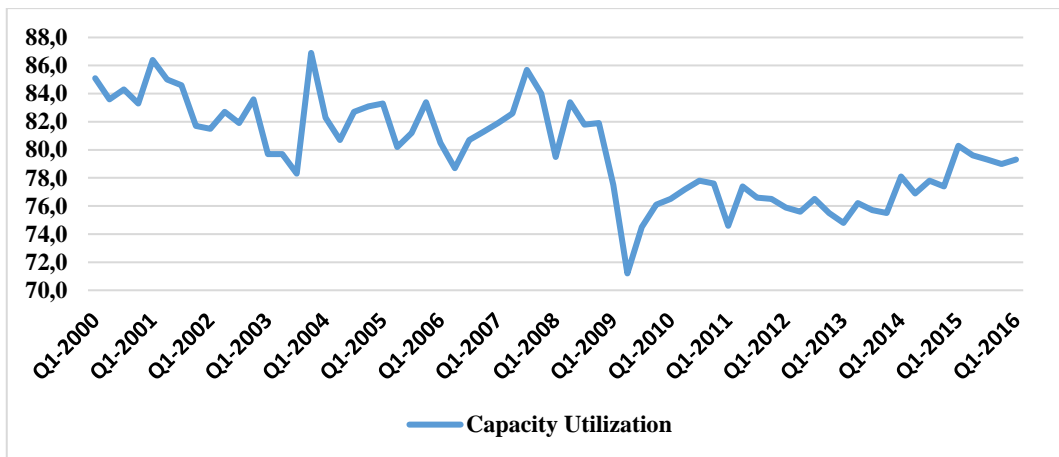


¹¹ Net exports are indexed such that Q12008 = -100. When the indexed values are negative, imports exceed exports and when the indexed value is positive, exports exceed imports.

Graph 28 – Total employment and hours worked per worker (Indexed, Portugal, Q12008-Q12016)

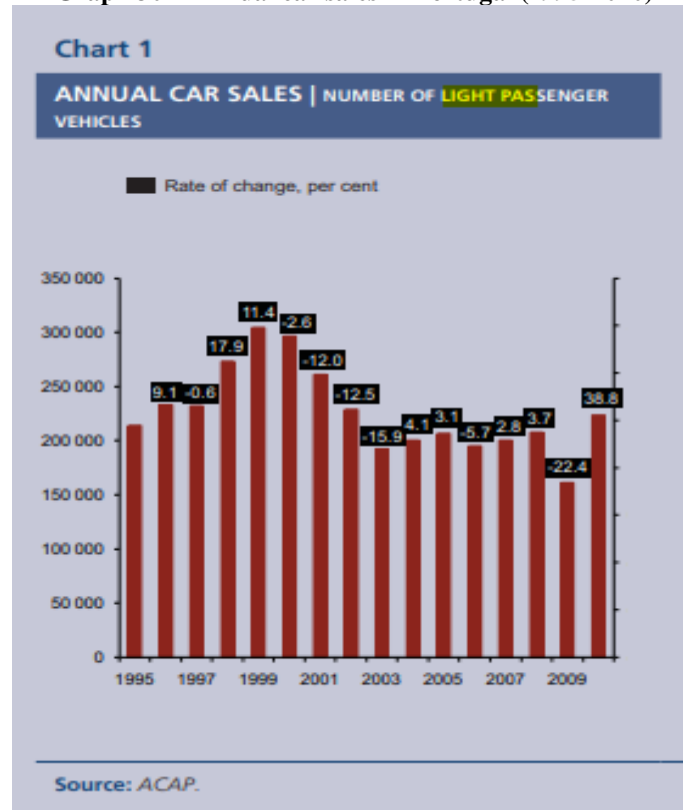


Graph 29 – Capacity utilization rate in the manufacturing industry (Portugal, Q12000-Q12016)



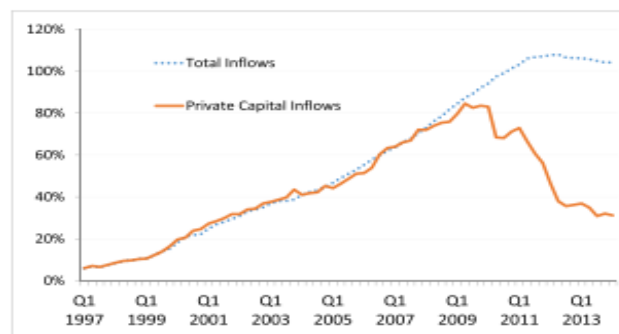
Source: European Commission

Graph 30 – Annual car sales in Portugal (1995-2010)



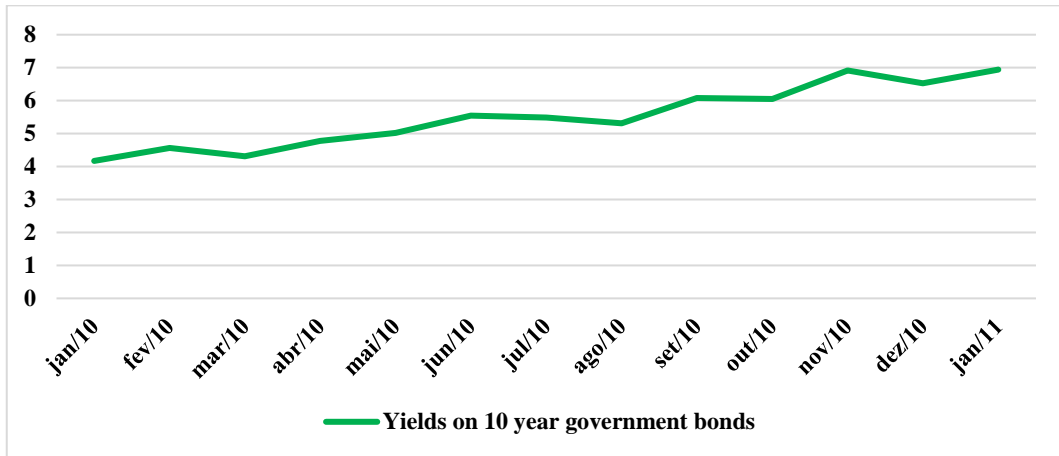
Graph 31 – Total and Private Capital flows to Portugal

Figure 1: Cumulative Total and Private Capital Inflows - Portugal (percentage of 2007 GDP).
 Notes: The figure shows the cumulative values of 'private capital flows' (solid line) and of total capital flows (dashed line) for Portugal, as a percentage of 2007 GDP at current market prices. Total capital flows correspond to the Financial Account Balance. The proxy for private capital inflows corresponds to the Financial Account Balance minus the period changes in TARGET2 balances and IMF/EU programme disbursements.

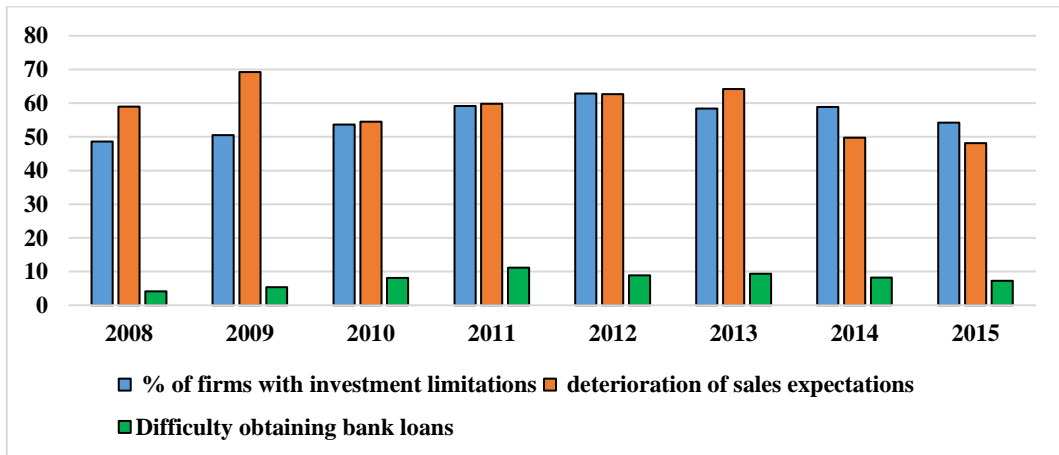


Source: Authors' calculations based on data from the Eurostat (Financial Account), 'Euro crisis monitor' (end-of-quarter Target 2 balances), and the IMF/European Commission (disbursements in the scope of official assistance to programme countries). [Colour figure can be viewed at wileyonlinelibrary.com]

Graph 32– Yields on 10-year government bonds (Portugal, Jan 2010- Jan 2011)



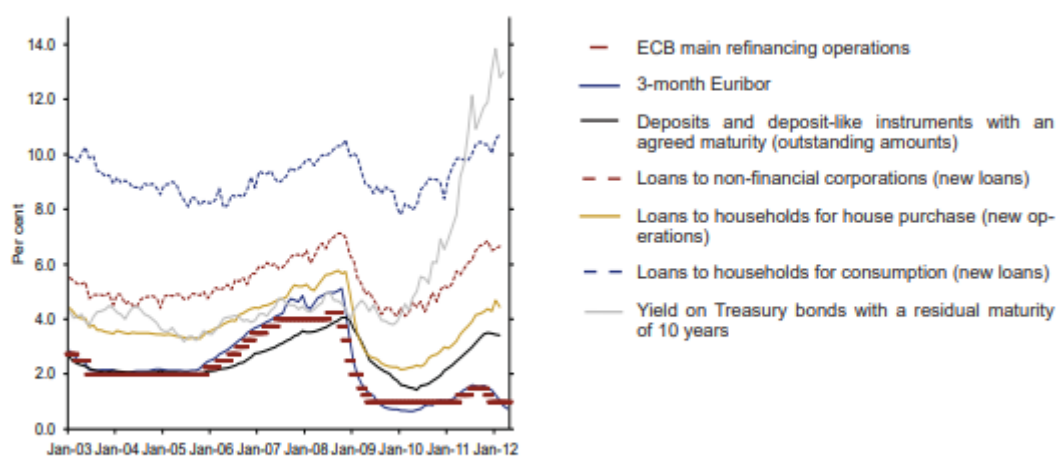
Graph 33 - Statistics Portugal Investment Survey results (Portugal, 2008-2016)



Graph 34 – Interest rates

Chart 2.2.1

INTEREST RATES

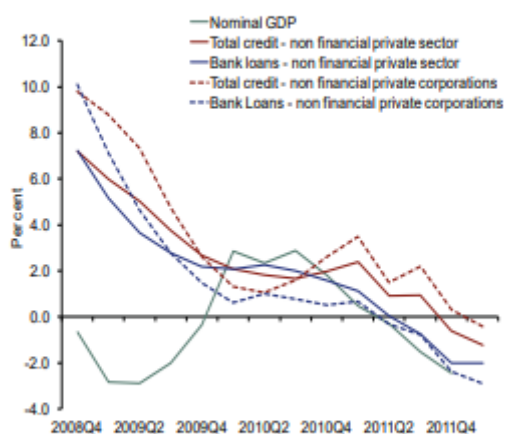


Sources: Bloomberg, ECB and Banco de Portugal.

Graph 35 – Credit to non-financial private sector and nominal GDP (Portugal, 2008Q4-February 2012)

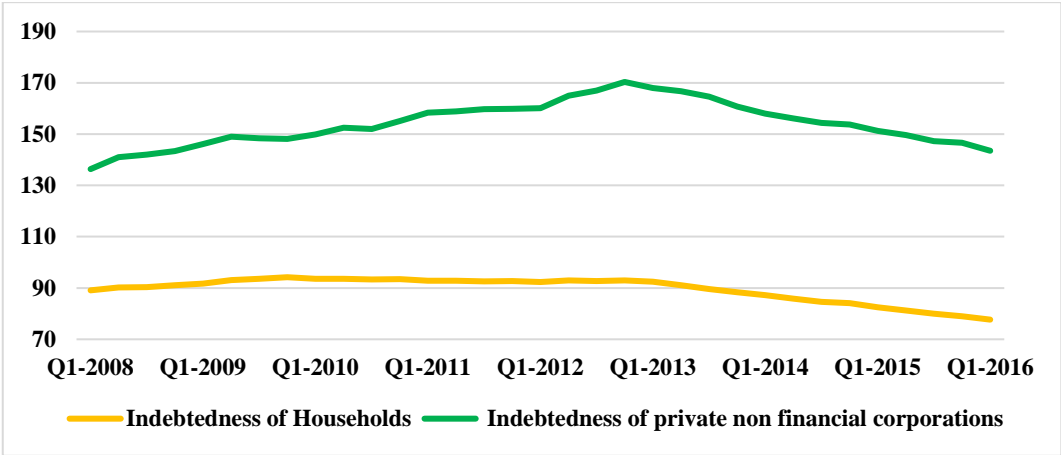
Chart 2.2.2

CREDIT TO NON-FINANCIAL PRIVATE SECTOR AND NOMINAL GDP | YEAR-ON-YEAR RATE OF CHANGE

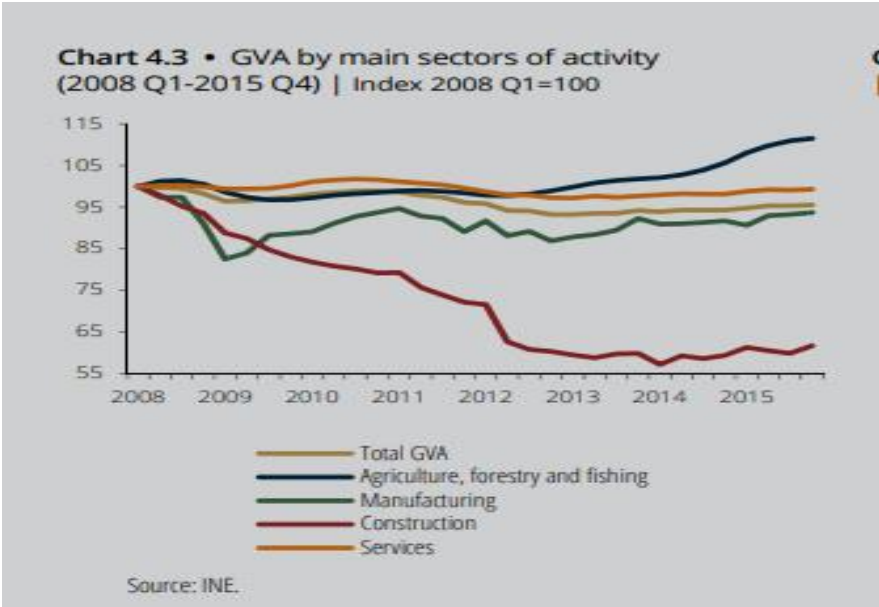


Source: INE and Banco de Portugal.
Note: Last observation: February 2012.

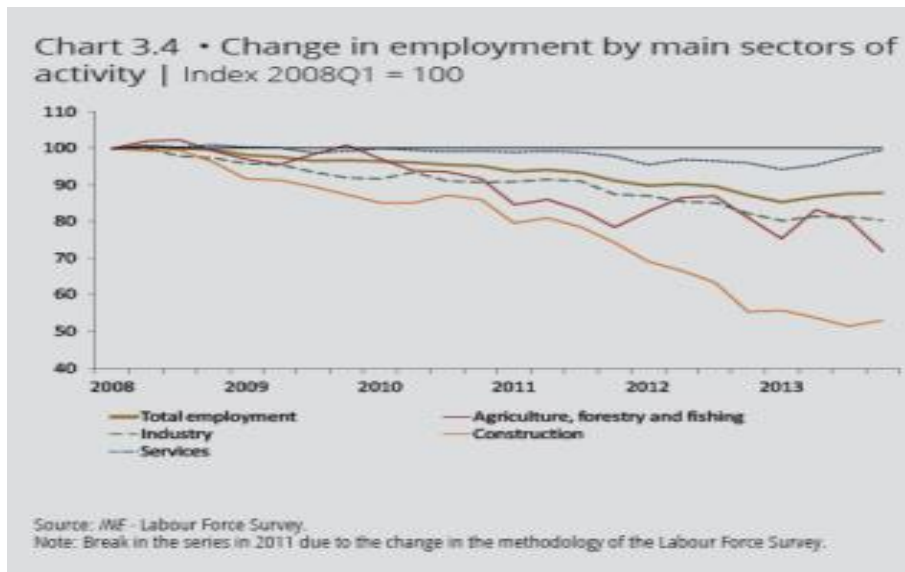
Graph 36 – Indebtedness of Households and Non-financial corporations as a % of GDP Portugal, Q12008-Q12016)



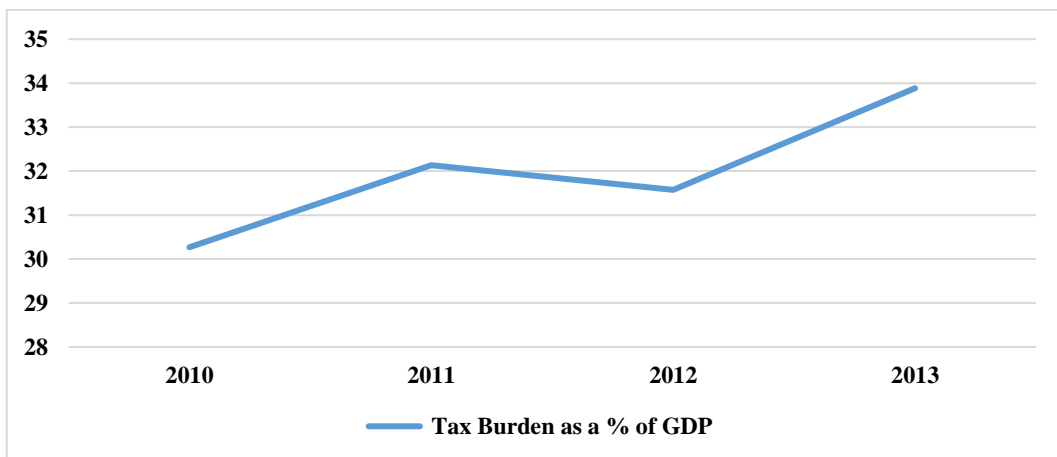
Graph 37 – Gross value added by main sectors of activity (Indexed, Portugal, 2008-2015)



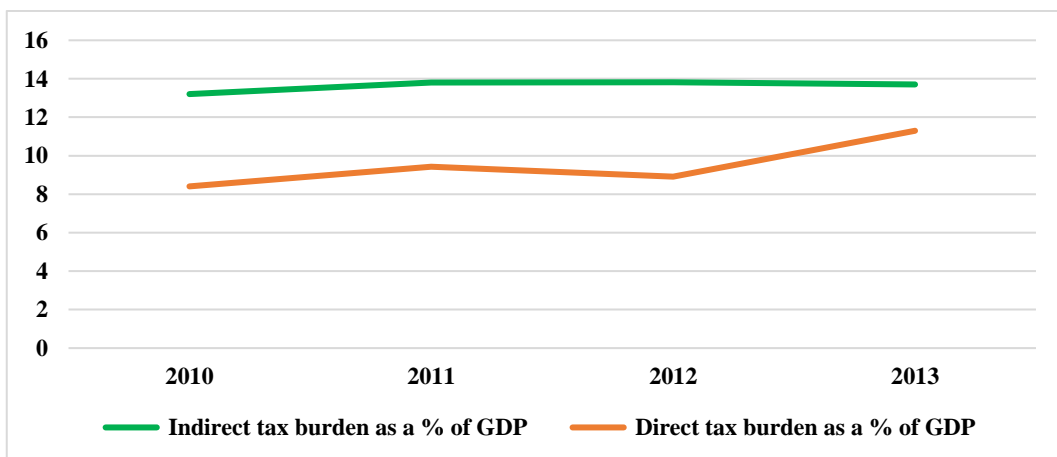
Graph 38 – Employment by main sectors of activity (Indexed, Portugal)



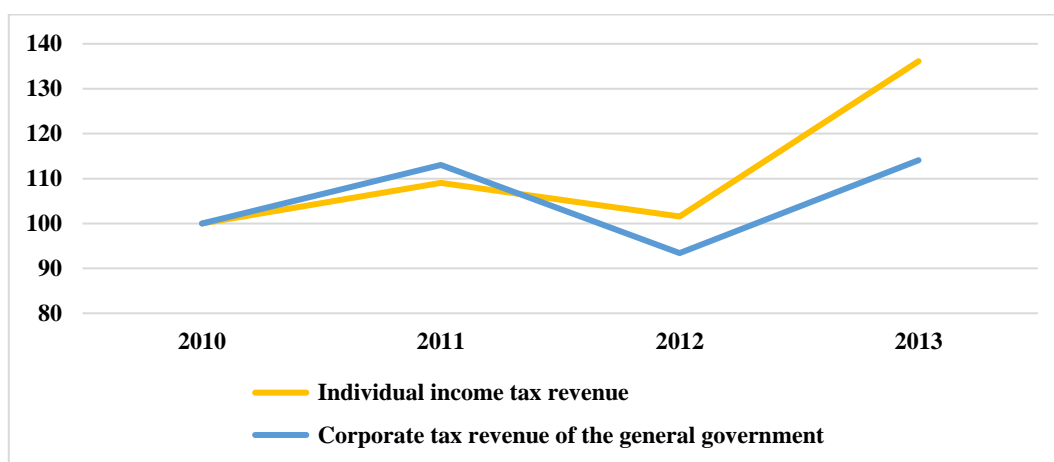
Graph 39 – Tax burden as a % of GDP (Portugal, 2010-2013)



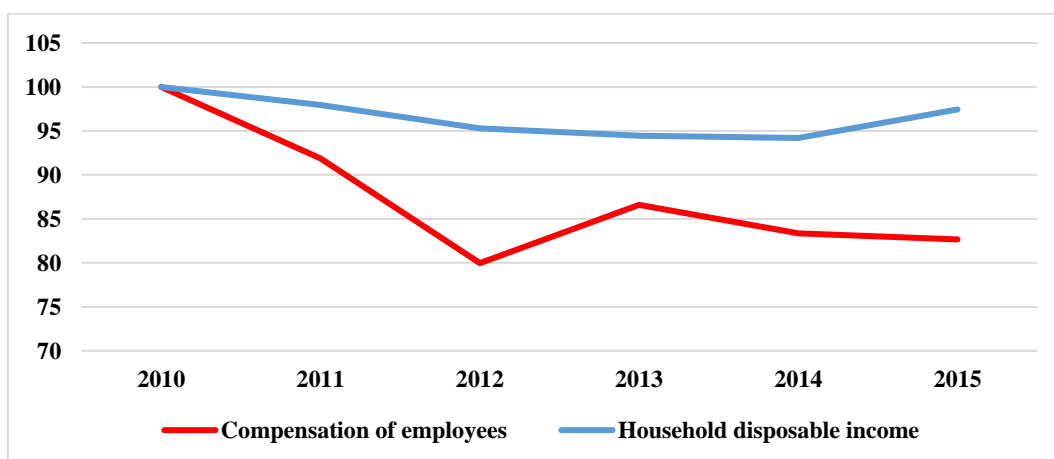
Graph 40 – Indirect and direct tax burden as a % of GDP (Indexed, Portugal, 2010-2013)



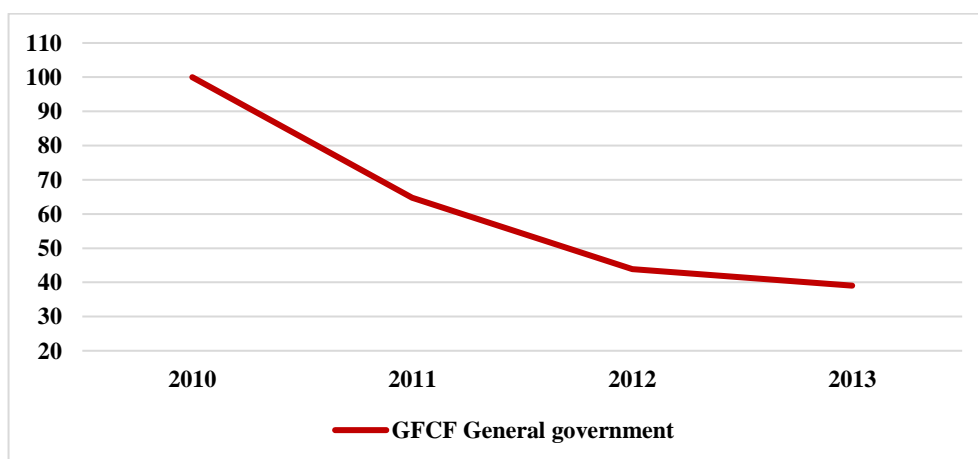
Graph 41 – Individual income and corporate tax revenue (Indexed, Portugal, 2010-2013)



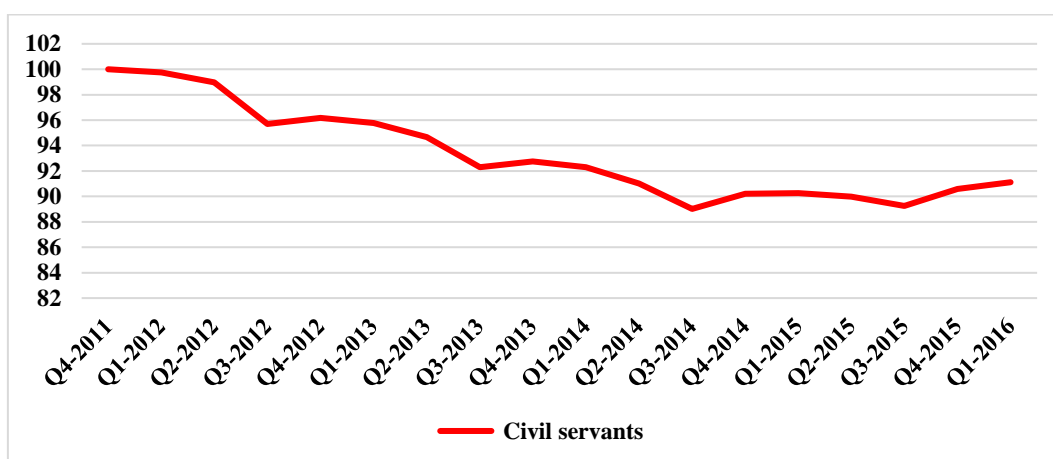
Graph 42 – Compensation of employees in the general government and Household disposable income (Indexed, Portugal, 2010-2015)



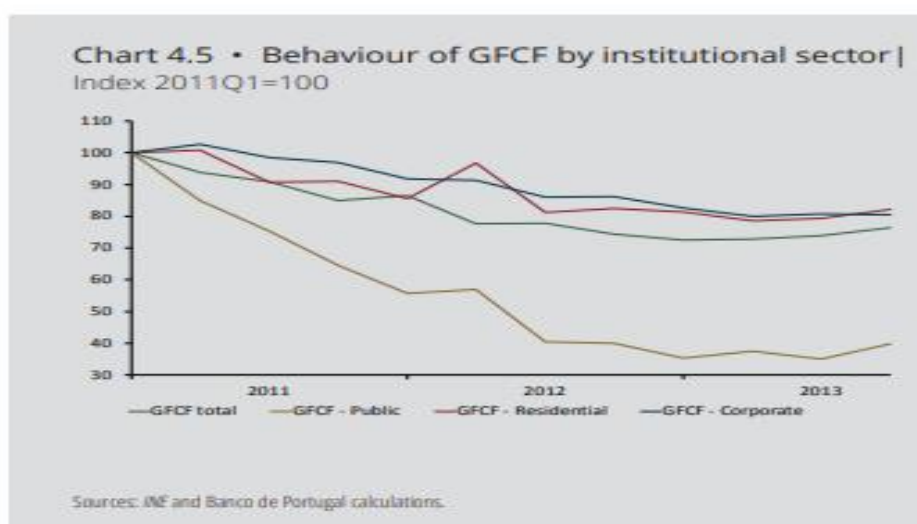
Graph 43 – Gross fixed capital formation of the General Government (Indexed, Portugal, 2010-2013)



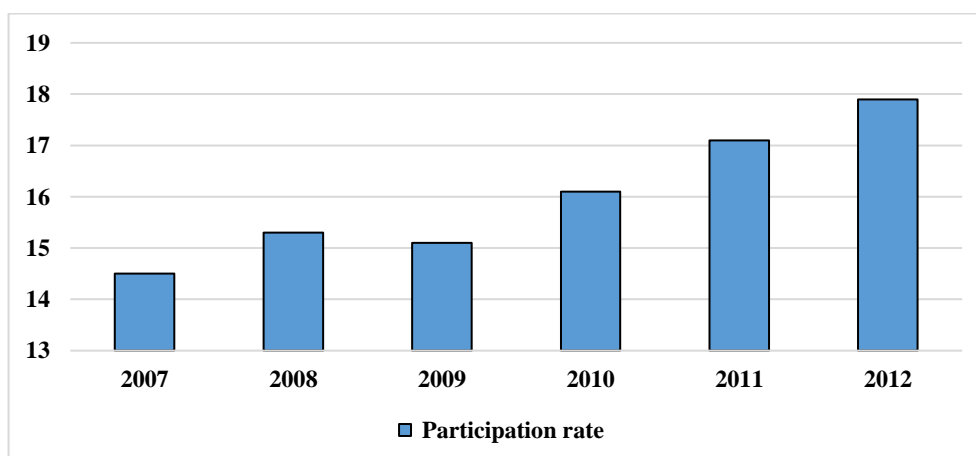
Graph 44 – Number of civil servants (Indexed, Portugal, Q42011-Q12016)



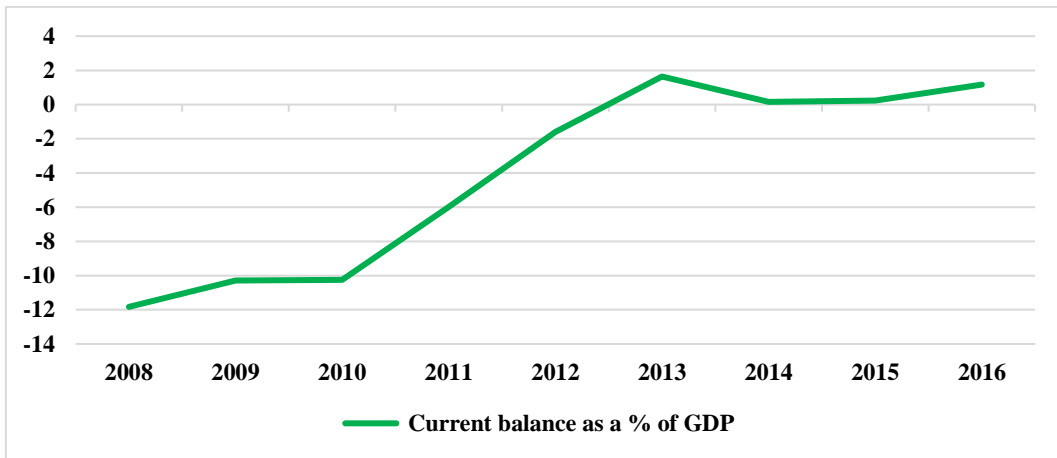
Graph 45 – GFCF by institutional sector (Indexed, Portugal, 2011-2013)



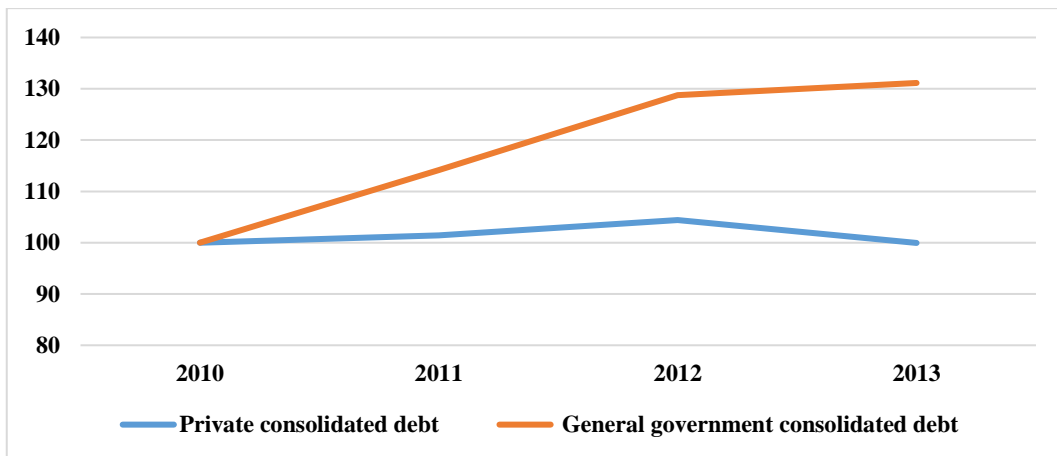
Graph 46 – Export market participation rate (Portugal, 2007-2015)



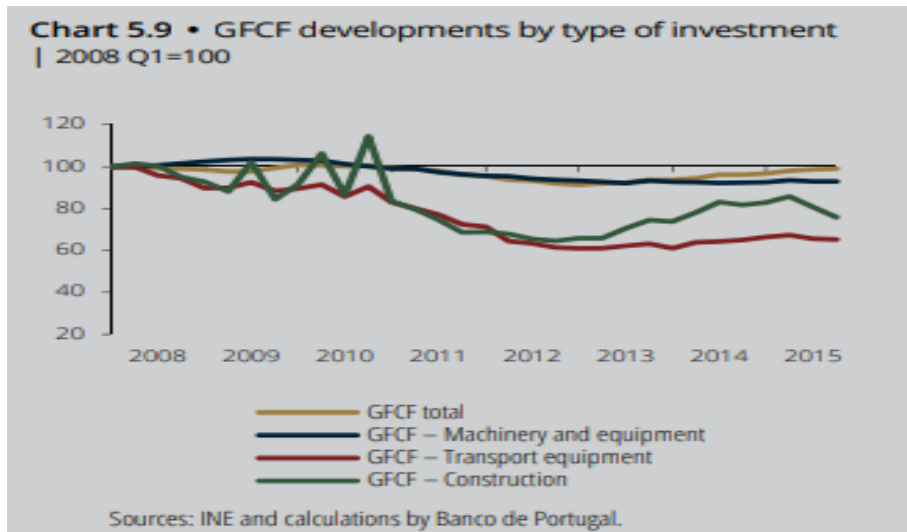
Graph 47 – Current Account balance as a % of GDP (Portugal, 2008-2016)



Graph 48 – Private and General government debt as a % of GDP (Indexed, Portugal, 2010 -2013)



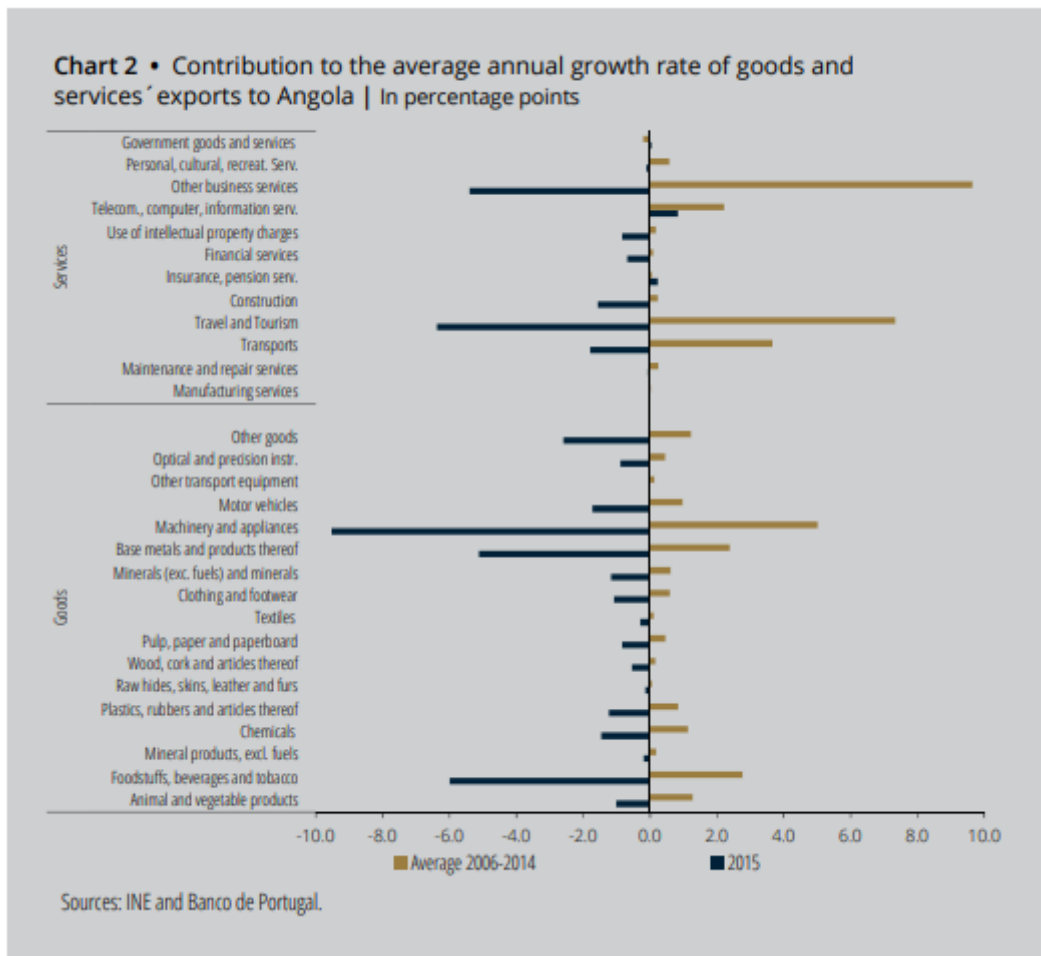
Graph 49 – GFCF by type of investment



Graph 50 – Angola GDP and oil prices (2008-2015)



Graph 51 – Breakdown of exports of goods and services to Angola (Portugal,2006-2015)



Graph 52 – Nominal exports of goods and service by country of destination (Portugal, 2012-2015)

