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Contents

LIST OF FIGURES AND TABLES

Abbreviations utilized

AFE: Advanced Front-End

CD: Cobb- Douglas

CES: Constant Elasticity Substitution

DEA: Data Envelopment Analysis

EFTA: European Free Trade Association

EU: European Union

EMU: European Monetary Union

FDI: Foreign Direct Investment

GATT: General Agreement on Tariffs and Trade

GDP: Gross Domestic Product

GFCF: Gross Fixed Capital Formation

HP filter: Hodrick and Prescott filter

IV: Instruments Variables

LS: Least Square

OECD: Organization for Economic Co- Operation and Development

OLS: Ordinary Least Squares

PI: Perpetual Inventory

TFP: Total Factor Productivity

VAR: Vector Auto-Regressive

R&D: Research and Development

Introduction

The relevance of the theme "The contribution of Total Factor Productivity (TFP) for the Portuguese economic growth between 1960 and 2008" happens essentially because of the social-economic moment currently faced by Portugal (characterized by deep macroeconomic imbalances, which were caused not only by cyclical phenomena, but also by both inadequate structural policies and Portuguese economy particularities). These policies and idiosyncrasies had impact in the variables that drive economic growth. In turn, their performances determined the evolution of Portuguese economic growth in the last decades.

While discussing how the explanatory variables of economic growth have been evolving and how they must evolve in order to Portugal present a relevant and sustainable growth, we realized that in the last two decades the inputs accumulation has increased whereas the TFP has lost importance as a stimulator of the Portuguese economic growth. Although we believe that these inputs accumulation is not a necessary but no sufficient condition for the economic growth that Portugal needs.

Thereby, we understand the relevance of TFP for the Portuguese economic growth is important to define new policies that should be implemented to promote a sustainable economic growth based on an efficient combination of input factors and not limited to the accumulation of those factors.

In the last 48 years, Portugal experienced both economic growth and improvement of people´s welfare and life condition. Aware of this phenomena, we decided to study the main forces of economic growth, more precisely, our aim was to understand if this growth was either a result of increase inputs factors accumulation, as many authors affirm, if it was rather based on an increase in the efficient combination of inputs (i.e., if the TFP was the main force of the observed growth). Thus, we decide to analyze the supply side of the economy as driver of the Portuguese economic growth in the long-run.

It must be noticed that, despite the absence of a linear strategy to guarantee economic growth in the long run, it is of the utmost importance to deepen our understanding of the mechanisms that influence economic growth, in order to design efficient and effective economic policies to boost Portuguese economic growth.

Taking into consideration the above mentioned, the work body structure is divided into three chapters: *Literature Review, Methodology, Empirical Analysis and Results.*

In the *Literature Review* chapter we analyze the main drivers of economic growth: - Human Capital, Stock of Capital and the TFP. There will be a subchapter for each production factor, in which it is included a discussion about its concept, the best way to calculate it and finally, its relationship with the economic growth (not only for the Portuguese case but also for other geographies). In the TFP sub-chapter, there is also an analysis on the relationship between the TFP and economic growth in Portugal for the period between 1960 and 2005[1].

The *Methodology* is also divided in to three sub-chapters, that are, *Data Description, Variable Definition and Analytical Framework.* Here we discuss the database selected, the economic variables chosen and explain which are the reasons that justify the selection of a Cobb-Douglas production function for growth accounting.

Furthermore, it is also discussed the introduction of the Mincer formulation in order to estimate, in an accurate way, the human capital. In the *Empirical Analysis and Results* chapter we present the results of the model estimation.

[1] Due to the lack of recent bibliography, the analysis does not cover the period between 2005 and 2008.

Finally, in the conclusion chapter, there is a discussion about the results obtained by us and other authors and it is also given some perspectives about future research.

Literature Review

The main drivers of economic growth

Human Capital

Human Capital[2] and its contribution to the economic growth is a theme that has been widely discussed by economists for many years. Because of that, in this point our analysis we will only focus on post-Second World War authors.

According with economic theory, the Human Capital represents all the intrinsic abilities of the worker; however, this definition is simultaneously vague and complex (Teixeira, 1999) . There are many approaches to measure this input factor. One of them is the measure of productivity through the number of hours worked by an individual worker, however this is not the best approach to measure it because the worker can be more productive and have more impact on the GDP without changing the number of hours worked (Chinloy, 1980). It can be also measured by the active population indicator of the country[3], however this also does not characterize the human capital precisely because it is not possible count the workers that work without getting any wage, thus biasing its influence on economic growth. (Amaral, Estêvão, & Serra, 2008)

[2] Until to decade 50, the studies like (Solow, 1957) claims that the main differences of economic growth between countries was due to the exogenous technical progress and the stock of capital. Furthermore, it with the advances in research of economic growth they felt necessity to adding the human capital variable.

[3] Population with age superior than 15 years and that they are available to working on the production of goods and services of such economy.

Another indicator is the literacy rate, but it is also incomplete and biased because it just takes into account the basic education and it not other degree as the university education, so it´s a fallible measurement. (Teixeira, 1999)

It is generally accepted that, the best indicator to measure the impact of human capital in economic growth are the years of schooling of an individual (Schultz, 1961), (Becker, 1962) and (Mincer, 1981). Despite the fact that not all knowledge[4] is a result of school education, it is proven that the education level of an individual has a positive impact in economic growth (Teixeira, 1999).

In the mid of 1980's, a growing interest under the new models of endogenous[5] growth, which arose due to the limitations of the traditional Solow[6] model, is the human capital accumulation became an essential to the economic growth of the countries. (Teixeira, 1999)

One of the most important and innovators studies about the relationship between human capital and economic growth was (Lucas, 1988). The main goal of this study was to find the ideal model to characterize the sustainable economic growth, it having as a sample the American economy in the period 1909-1957. Initially, Lucas used the traditional neoclassical model to replicate the work papers of Robert Solow and Edward Denison, but suddenly concluded that the referred model was not an accurate measure of the economic growth[7]. Secondly, Lucas adapted the traditional model including the

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[4] The knowledge is also known for: - Learning by Doing or On-the-job-training.

[5] (Lucas, 1988) and (Romer, 1986) were the main drivers of the renewed neoclassical theory of economic growth with the inclusion of human capital as the essential variable for the economic growth. In these new models of endogenous growth, the endogenous technological progress is the main driver of economic growth, i.e., it is a *"…actividade inovadora, gerada no interior da economia, é ela própria influenciada pela dotação da economia em capital humano já que os avanços tecnológicos são, regra geral, fruto do esforço de indivíduos que detêm qualificações especiais…"* (Teixeira, 1999)

[6] *No modelo de Solow o único motor de crescimento, o progresso tecnológico, é exógeno, ou seja, algo que 'caiu do céu', que não é determinado ou explicado no interior do sistema económico."* (Teixeira, 1999)

[7] The author claim that the model is not good because"… *its apparent inability to account for observed diversity across countries and its strong and evidently counterfactual prediction that international trade should induce rapid movement toward equality in capital-labor ratios and factor prices".* (Lucas, 1988)

human capital variable[8] (measured by education level), in order to measure the effects of human capital accumulation in production and then, create a more complex and realist model. Thus, Lucas concluded that human capital accumulation was the main driver of economic growth, because in some countries with high human capital average level, with the investment and high propensity to learn[9] between people will lead to increase in productivity gains in firms and society, that will positively impact the economic growth in countries.

More recently, (Krueger & Lindahl, 2001) estimated the influence of human capital (measured as education level) in the economic growth through Lucas model and with aggregate statistical data. The authors introduced Mincer´s formulation in CD production function aggregate of Lucas model, in order to obtain a new and more consistent estimation of the impact of human capital in economic growth.

(Bassanini & Scarpetta, 2001) also used the same Mincerian approach in CD production function, however their study included the OECD countries for the time period 1971-1988 and their database was the *pooled* average and group estimator from (Barro & Lee, 1996). The authors concluded that exist a relationship between human capital and economic growth since that, and according with Mincer[10] approach, a positive change in the education average level of certain country is the main reason for the increase in income (Krueger & Lindahl, 2001)

However, (Pritchett, 2001) through the estimation of a standard production function, for the period 1960 to 1985 concluded that there was no statistical evidence of a relationship between human capital and economic growth. These results occurred

[8] Note also that (Mankiw, Romer, & Weil, 1992), (Fuente & Ciccone , 2002) and (Sianesi & Reenen, 2003) claims that they gave a great contribution for the affirmation of human capital as an important driver in the economic growth.

[9] On-the-job or learning-by-doing.

[10] (Mincer, 1974) developed a wage stochastic function with the aim to explain the relationship between the education and professional experience with the income.

because of measurement problems on the education variable, which arose from the fact that, and according with the author, the average of educational years is an inconsistent variable since the school enrollment variable is a flow and not a stock, which made hard to measure/quantify. Despite that, (Bils & Klenow, 2000) concluded that the problem was not the measure of the years education average level but omission from the model of relevant factors that impact economic growth and also due to *reverse causality*. When an increase in future economic growth leads to an increase in population education level, but the opposite is not verified.

(Benhabib & Spiegel, 1992) used the same methodology and had reached to the same conclusions that (Barro & Sala-i-Martin, 1995) and (Pritchett, 2001) some years ago. In these studies, it was realized that the human capital[11] contribution for the economic growth was not statistical significantly, even if it was used the Mincer formulation. However, the authors concluded that just exist a positive effect in economic growth for countries of low income.

In respect to Portuguese case, (Teixeira & Fortuna, 2003) studied the effects of human capital in the Portuguese economic growth, during the period 1960 to 2001, the authors built their own data and the through a VAR estimation its cointegration, (Teixeira & Fortuna, 2003) analyzed the relationship between the dependent variable; the TFP; and the explanatory variables; the human capital, internal innovation capacity and accumulation expenses in R&D. The authors concluded that human capital had a positive impact in Portuguese economic growth and was the main driver of productivity growth in Portuguese economy during the period 1960-2008.

(Pereira, 2003) and (Pina & St. Aubyn, 2005) concluded that, there was not a positive relationship between human capital and economic growth, in Portugal during

[11] Kyriacou´s database of the education level for the period between 1965 and 1985.

the period 1960 - 2001 the low standard of Portuguese education system[12], thus an increase on the average years education do not imply gains of labor productivity.

Using the same methodology approach but with a different database from (St. Aubyn & Pereira, 2007) study estimated the CD production function using a set of econometric tests[13], wherein the variable human capital; created by (Pereira, 2005); corresponded to a decomposition of average years of education level for the Portuguese population with age between 15 and 64 years old and three education levels[14] for the period between 1960 and 2001. The authors concluded that both primary and secondary education were statistical significantly but not the tertiary education. St. Aubyn and Pereira justified that by arguing that only countries with big technologic sectors with a relevant dimension can absorb the individuals with a tertiary education level and thus, obtain a positive effect in economic growth.

From the previous explanation, it can be stated that there is no consensus between the economists about this theme. While some of them advocate that there is a positive relationship between human capital and economic growth, others argue the opposite. In our opinion, and taking into account all the authors here mentioned, it is hard to detect a direct relationship between human capital and economic growth; and this happens mainly due to problems of the referred variable contribution of human capital to economic growth was measured by TFP growth. However, it cannot be said that neither the increment nor the improvement of population education level, in a certain country, do not promote gains of labor productivity[15] and, therefore, economic growth.

[12] Also (Hanushek, 2013) claim that, if education system does not improve, the developed countries will have difficulties to achieve a sustainable economic growth, in the long-run.

[13] VAR approach, Granger Causality test and Cointegration test.

[14] Appendix 1 – The analysis of gross education rate by level of degree, in Portugal.

[15] To know more about this theme, see (Centeno, Novo, & Alves, 2010)

Stock of capital

As in the case of human capital, over the time many schools of economic thought have presented different concept definition for the stock of capital and, thus, different perspective for its measure.

Generally, the stock of capital is defined, as the value of durable goods that constitute the GBCF[16], at a given moment. (Amaral & Freitas, 1994)

The mainstream economic literature, identify three ways to measure the capital input in the estimation of TFP growth. Nevertheless, all of them face technical and conceptual problems[17].

Since that capital input is a stock; i.e., depreciate through time; the existence of depreciation costs does not allow the computation the economic depreciation rate when measuring the productivity. Therefore, there are indirect methods to measure the capital factor, such as the calculation of the stock of gross capital, which is measured using the "perpetual inventory" (PI) method.

(Hulten C. , 1990) asserts that the PI[18] method defines the quantity of capital factor equal to the capital stock. In the PI method, the capital stock is computed as a weighted sum of the past investments by the relative efficiency of the capital goods[19], and since the capital factor is a durable good it will be productivity for at least two periods. Thus, the equation to compute the capital stock using the PI method is:

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[16] The characteristics that belong to the GBCF are: - Tangible, sustainable, reproducible. (Amaral & Freitas, 1994)

[17] (Silva, Crescimento Económico e Mudança Estrutural em Portugal: Os últimos Trinta Anos, 2012) claim that the stock of capital is not an good indicator to measure the capital factor because the estimation of the accounting growth model all the variables are flows and not stocks, so the capital factor is treated as a flow and not as a stock that depreciate. Another two reasons are: - the stock of capital can have into account the efficiency of capital and the fact that capital assets being measure by the market price, it created a undervaluation and overvaluation of contribution at the capital assets in the production.

[18] (Amaral & Freitas, 1994) asserts that PI method is the most utilized by the OECD countries in the estimation of the stock of capital.

[19] $\emptyset_0 = 1$ means that the relative efficiency of the new good is equal to the unit.

$$K_t = \emptyset_0 I_t + \emptyset_1 I_t + \cdots + \emptyset_T I_{t-T}$$

Where:

K_t is the quantity of capital stock in the period t;

I_t is the investment in the period t;

$\emptyset_\varphi$ is the distribution of relative efficiencies with $\varphi = 0, 1, 2, \ldots, T$.

Notice that, since the relative efficiency depend on capital good age and not in the moment when it was acquired, furthermore can be compute as a constant variable, linearly decreasing variable or as a geometrically decreasing variable[20].

It´s worth mentioned that the cited method to compute capital stock presents, on one hand, there is the implicit loss of efficiency in the first year of life due to the method used to calculate relative efficiencies (Hulten C. , 1990). This limitation would be minimized with a model more complete, in which the endogeneity of relative efficiencies were recognized. On the other hand, and as stated by (Amaral & Freitas, 1994) the limitations are also a result of the shortage of information regarding the useful life of capital goods.

To measure the capital stock, we can also use the net capital stock[21] method, were the capital stock is presented as the current market value of capital goods. (Silva & Lains, 2013) claim that, *"The net stock is usually calculated from the gross stock by deducting accumulated consumption of fixed capital.* " However, the fact that capital

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[20] Constant relative eficiency over time and after it is zero: $\emptyset_\varphi = \begin{cases} 1 & \varphi = 0,1,\ldots,T-1 \\ 0 & \varphi = T, T+1, \ldots \end{cases}$

Relative Efficiency linearly decreases at over time: $\emptyset_\varphi = \begin{cases} 1 - \frac{\varphi}{T} & \varphi = 0,1,\ldots,T-1 \\ o & \varphi = T, T+1 \end{cases}$

Relative efficiency geometrically decreases at a rate δ : $\emptyset_\varphi = (1-\delta)^\varphi$

[21] To know more about this theme, see (Amaral & Freitas, 1994);

goods with some utilization years do not have their own market, due to the inexistence of a second hand market where to sell once again those capital goods constitutes a limitation to this approach. (Amaral, Estêvão, & Serra, 2008)

Finally, it is also worth mentioned the capital service approach[22], which according with (Silva & Lains, 2013), it connotes the capital as a production function input and the capital stock converted in efficiency units is proportional to the capital services.

(Biatour, Bryon, & Kegels, 2007) says that capital service is the most appropriate way to estimate of growth accounting because "*The other variables in the growth accounting model are all flows. The use of net or gross stocks is therefore not consistent; gross or net stocks do not reflect the productive efficiency of capital assets declining with the age; in calculating capital stocks, each asset in the stocks is weighted by its market value, independently of its service life"*.

According to (Silva & Lains, 2013) the calculus of capital service is initially given by:

$$S_t^i = \sum_{\tau=1}^{T^i} \left(\frac{I_{t-\tau}^i}{q_{t-\tau,0}^i} \right) h_\tau^i F_\tau^i$$

Where:

S_t^i is the weighted sum of all previous investment;

$(I_{t-\tau}^i)$ deflated by the new prices of capital goods;

$(q_{t-\tau,0}^i)$, consider the "age-efficiency function";

(h_τ^i) and the probability of withdraw the capital goods of the market;

(F_τ^i). T^i is the duration of capital good in years.

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[22] According with OECD, the capital service approach is the most appropriate approach for estimate the productivity of capital goods in the production function. The calculus of capital service is followed by United States Bureau of Labor Statistics (BLS).

Nevertheless, all the stocks must be to obtain the global capital services and therefore to interlink the stocks of all goods by type in order to obtain the capital services index volume for all type of activities[23].

In relation to the study of contribution of capital to the GDP growth, the empirical studies developed by some economists, such that, (Young, 1994) and (Krugman, 1994) claims that regarding the "*economic miracle of the Asian Tigers*[24]" analyzed the economic miracle of "*Asian Tigers*" were crucial to the economic theory, since they concluded that high economic growth was due to capital stock and human capital accumulation fast growth and not to TFP.

In the Portuguese case, (Amador & Coimbra, 2007) e (Pina & St. Aubyn, 2005) the studies that the increase of capital stock; which was essentially due to EU structural funding; had a positive impact in GDP growth. Although, that increase of capital stock did not lead to productivity gains for Portuguese economy. (Amador & Coimbra, 2007)

In sum, it is possible to conclude that stock capital accumulation has a direct impact in GDP growth. However, an inadequate utilization of capital stock can have, in the long-run, negative effects in GDP growth. And it can also be concluded that there is no consensus regarding the most accurate way to estimate the contribution of capital stock to GDP growth; nevertheless, PI and capital service are the most used approaches

Total Factor Productivity

The purpose of this chapter is to present the neoclassical concept and ways of measuring the TFP, as well as its contribution. In the end, it will be developed an

[23] Normally, that index is made by superlative numbers and Törnqvist indexes.
[24] The Asian Tigers are: - Hong Kong, Singapore, South Korea and Taiwan.

analysis of the discussion had and the studies performed regarding the impact of TFP to Portuguese economic growth in the period 1960-2008.

The concept of TFP, also known as non-incorporated technique progress[25], represents the proportion of the GDP which derive from factors[26] that are not explicitly included in the production function, i.e., any changes in the GDP growth are explained by the efficiency gains of the productive inputs – Human capital and stock of capital (Coelli, Rao, Battese, & O´Donnel, 1998) More precisely, the TFP is a weighted average of the production factors partial productivity on a certain sector or economy.

(Abramovitz, 1994) claim that due to impossibility to directly measure these intrinsic factors of TFP, the TFP is as "measure of our ignorance".

Despite many factors impact TFP (Griliches, 1987) show us that TFP growth is mainly associate to technologic progress, since that, the growth will lead to a change in the production possibility frontier.

Nevertheless, (Hulten C. , 2001) affirm that TFP should not be only compared with technologic progress, as it's usual.

Regarding the methods of measuring TFP[27], and given the existence of a large set of index[28] and methods[29] to measure it, we will focus only on most highlighted in the literature.

According with some authors, such as (Diewert W. E., 1976), (Coelli, Rao, Battese, & O´Donnel, 1998) and (Lipsey & Carlaw, 2004), the Fisher quantity index,

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[25] The difference between the non-incorporated technique progress and incorporated technique progress is that, in the first case, there is a relationship between the human capital and stock of capital together and not of isolated way.

[26] The main factors are, for example, the technological progress (technological innovation), organizational progress (improvement of management on business sector), and knowledge progress (investment in the education sector). (Amaral, Estêvão, & Serra, 2008)

[27] There are two approaches for to measure the TFP. The first one is the primal approach used by Solow, and shows us that the TFP is measure in terms of changes on the product and not in relation to the changes of production factors The second one, the dual approach, it show us that the TFP is measured by the omitted contributions of the prices of factors. (Aiyar & Dalgaard, 2005)

[28] Appendix 2 – Theory of Indexes Numbers.

[29] The divisia method used by Solow, Kendrick and Jorgenson was important for measure the TFP, but now is not used due to the fact that indexes numbers require the using of discrete data instead of continuous data. (Coelli, Rao, Battese, & O´Donnel, 1998)

the Törnqvist and Malmquist indexes are the most indicated to measure the TFP. However, the Solow residual (*Growth accounting method*), is also a relevant methodology used while measuring the TFP. (Lipsey & Carlaw, 2004) and (Coelli, Rao, Battese, & O´Donnel, 1998)

According with (Diewert W. E., 1976) and (Lovell & Grifell-Tatjé, 1995) claims that Fisher and Törnqvist quantity indexes are the most utilized method to measure TFP since they are superlatives quantity indexes[30]. In other words, for a quadratic form, in the ideal case of Fisher, and using a translogarithmic form, and in for the case of the Törnqvist[31] quantity index, the referred indexes are consistent and accurate in the aggregation of the production function. In addition, (Diewert W. E., 1976) claim that Fisher[32] quantity index is the only index which satisfies all the twenty properties[33] of the indexes numbers.

However, (Coelli, Rao, Battese, & O´Donnel, 1998) defended that the Törnqvist index should be preferred to the Fisher one, since the later should be only used when facing property of self-duality or when the data presented null values.

(Lovell & Grifell-Tatjé, 1995) asserts that the Malmquist[34] quantity index is a good methodology to measure the TFP since there is no need to maximize the profit function or to minimize the cost function, because by one hand, the prices of both inputs and products and, by the other, because facilitates the decomposition of TFP growth (by changing the productive efficiency and by technological progress variations). The

[30] (Färe, Grosskopf, Norris, & Zhang, 1994) claims that "superlatives" means that, by one hand, that are "exact" because it can be calculated an productivity index non-parametric in the same way that translogarithmic form, and by another hand, it because the "flexible" lead to an approximation of second order by the random functional form of the continuous time in the production function.

[31] (Caves, Christensen, & Swanson, 1981) asserts that Törnqvist quantity index is a superlative index broader and exact for the geometric average than Malmquist indexes of factors. And it is presented as a geometric average of the values of shares in the quantity ratio.

[32] The Fisher quantity index is a geometric average of the indexes of quantity of Laspeyres and Paasche.

[33] See (Diewert W. , 1992)

[34] Appendix 3 – Decomposition of Malmquist Index Quantity

Malmquist index is calculated as the distance functions[35] to the frontier function and there are two approaches to compute those distance functions, the DEA[36] and AFE[37]. (Coelli, Rao, Battese, & O´Donnel, 1998) asserts that the former approach differs from the latter, since it uses deterministic nonparametric methods[38] to estimate the distance function. However, the fact that the DEA approach can only be applied while using panel data, it also presents some limitations. (Lovell & Grifell-Tatjé, 1995)

In fact, (Denny & Fuss, 1983) argued that both Törnqvist and Fisher quantity indexes can also suffer from some bias due to the flexible function, since the approximation may be different from the second order quadratic approximation that creates the data.

Finally, (Coelli, Rao, Battese, & O´Donnel, 1998) asserts that if distance functions are represented by translogarithmic function, the geometric average of the Malmquist index is identical to the Törnqvist quantity. On the other hand, if the distance functions are substituted by quadratic functions, occurs the same as in the case of translogarithmic functions and it is gotten a Fisher ideal index.

Another relevant methodology used to measure the TFP is the *Growth Accounting method*. Created by (Solow, 1957) and deeply developed by other authors, this method measures the contribution of both production inputs and TFP to the GDP growth, using a CD production function. When it is decomposed[39] the CD production function and is put in order to A_t, it is obtained the measure of the TFP growth rate, also known as *Solow residual*. To (Amaral, Estêvão, & Serra, Economia do Crescimento,

[35] The distance functions are the boundaries of technological possibilities of any company and are described as an set Y and the possible combinations of factors and products (x,y).
[36] This method has been the most utilized at working papers as (Coelli, Rao, Battese, & O´Donnel, 1998), (Lovell & Grifell-Tatjé, 1995) e (Färe, Grosskopf, Norris, & Zhang, 1994).
[37] This method was also studied by (Aigner, Lovell, & Schimidt, 1977) e (Meeusen & Broeck, 1977).
[38] The approach non-parametric is utilized for measure the productive efficiency and the productivity changes of the production function through the linear programming methods. (Coelli, Rao, Battese, & O´Donnel, 1998)
[39] See Appendix 4 – Decomposition of CD production function.

2008) this is the simplest method to measure the TFP, since it is only needed data regarding capital, human capital and GDP. It is worth mentioned assuming that this method assumes the existence constant returns to scale and perfect competition in the production inputs market, and this can be seen as a limitation.

(Silva, 2012) claim that due to lack of statistical data regarding to stock of capital, the measurement of the productivity for all the countries that has focused on the human capital productivity, and not on the TFP. With the new database for the stock of capital, the using of TFP as indicator of productivity, is today, more frequent.

In fact, the hypothesis of perfect competition in both labor and stock capital market can arise some limitations it taking to necessary constraints in the calculus method. However, this is a typical limitation of neoclassical models since they usually consider the existence of perfect competition in the production inputs markets.

Another limitation of the *Growth accounting method* is the fact it is not seen as a good indicator to analyze the main forces of the economic growth, in the short-run. (Teixeira, 1999)

Despite the referred limitations regarding the Solow residual the most accurate method (in comparison to Fisher and Törnqvist) since not always there is the necessary information to compute the indexes (Coelli, Rao, Battese, & O´Donnel, 1998).

The main drivers of economic growth have been to analyzed since the classical economists, nevertheless it was from the 50´s of the 20^{Th} century that appear more relevant research about this theme, and with special focus on the contribution of TFP to the economic growth.

The study named - "*The contribution to the Theory of Economic Growth*" developed by Robert Solow in 1956, which originated the modern economic growth theory, is one of the most important studies[40] regarding total factor productivity. The traditional Solow model shows that the exogenous technical progress is the main drive of the GDP growth of a country, because, and according with study, an increase of exogenous technical progress leads to an increase of inputs productivity, due to the positive effects of production inputs accumulation. Nevertheless, the exogenous technical progress is seen as something that “falls from the sky”, i.e., it is not explained by the economic internal factors, such as, the innovation. (Teixeira, 1999) This led to the creation of endogenous growth model, like by (Romer, 1986) and (Lucas, 1988). This type of models are characterized by the fact that human capital and endogenous technical progress are the main drivers of the economic growth since the innovation generated within the economic system leads to productivity gains and consequently economic growth.

Hall and Jones, in the study (Hall & jones, 1998) in which they analyzed a set of countries, concluded that the high level economic growth in their sample was not only due to human capital and stock of capital, but also and mainly due to the high level of TFP.

By the authors stated above it can be concluded that, the TFP growth rate has a relevant in the economic growth. However (Young, 1994), (Krugman, 1994) and (Kim & Lau, 1994) in their studies, regarding the Asian Miracle, realized that is not always the case. In fact, they concluded that fast economic growth of these countries was due to production factors accumulation and productive resources mobilization and not by TFP. More precisely, (Krugman, 1994) concluded that the fast economic growth was due to expansionists policies regarding employment and stock of capital and also sue to an education level increase.

[40] See (Kendrick, 1961), (Griliches & Jorgenson, 1967) e (Denison, 1962).

Briefly, it is concluded that the most accurate method to measure the TFP is the Solow residual. And TFP is crucial for economic growth in the long-run since of growth impacts a wide range of indicators, such as countries competitiveness and workers wage.

In this section it will be analyzed the contribution of TFP[41] for the Portuguese economic growth[42] during the period 1960-2008. We decided to divide these 40 years into five different periods, 1960-1973, 1974-1985, 1985-1993, 1994-1998 and 1999-2005.

Between 1960 and 1973, the Portuguese economy presented high economic growth rates thanks to relevant accumulation of stock of capital[43] and also to TFP improvements (for which contributed the significant efficiency gains achieved by human capital efficiency[44]) (Afonso, 1999). The literature justifies this growth rates by Portuguese membership in GATT (1959) and EFTA (1961), which contributed to a opening of the Portuguese economy and to decreasing of agriculture sector share due to an increasing of manufacturing industry and services sectors shares. Thus, this phenomenon drove by technological, led to productivity gains. (Amador & Coimbra, 2007)

Between 1974 and 1985, (Amador & Coimbra, 2007) asserts that TFP had negative effect on the Portuguese GDP growth mainly because of two events that were: - the oil shocks in 1973 and 1979 and the Portuguese revolution in 1974. Both events impacted the Portuguese growth path. More accurately, (Amador & Coimbra, 2007) argued that the decrease of TFP was due to, by the one side, the loss of capital

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[41] See Appendix 5 – Evolution of TFP in Portugal (1960-2008).

[42] See Appendix 6 – Evolution of economic growth in Portugal (1960-2008)

[43] See Appendix 7 – Despite of increase of the stock of capital contribution on the GDP growth, the investments on this input did not reflected at a stock of capital efficient and productivity earnings.

[44] (Afonso, 1999) asserts it occurred productivity earnings of labor factor owing to "*TFP_{UE}, a taxa de crescimento das exportações reais por trabalhador, a taxa de crescimento das importações reais de máquinas e material de transporte por trabalhador e, finalmente, a "variável doméstica" investimento real por trabalhador".*

efficiency because of social, politics and economic phenomena's, which it provoked an reduction of the investment level by the firms, that the leading to an diminishing of capital imports; nevertheless, the author claim also that public investment in this period reflects the losses of productivity on the Portuguese economy. By the other side, the author says that negative growth rates of the real investment per worker, the real imports of machines per worker and the transport of commodities per worker leading to diminishing of the human factor efficiency, and also (Afonso, 1999) cited Silva Lopes show that " (…) *a maior lentidão de crescimento dos anos de 1974-1985 teve muito a ver com as gravíssimas dificuldades provocadas pela (…) queda da emigração para os países europeus, com o menor dinamismo da procura internacional para bens e serviços portugueses."*

Regarding the human capital, it´s also important emphasize that growing accumulation of this input happened due to the return for Portugal by the Portuguese returnees and the women's entered in the labor market.

Between 1986 and 1993, (Afonso, 1999) also argued that Portuguese economy restart its convergence process towards EU countries, presented similar GDP growth rates as over the period 1960-1973. During this five-year period the stock of capital accumulation and the TFP were the main drivers of the economic growth, which is explained by (Amador & Coimbra, 2007) and (Afonso, 1999) claims that the event that increased the GDP growth was the joining of Portugal to the EU. This contributed to increase the level of openness of the Portuguese economy the European countries and introduced a range of structural reforms in the financial sector. (Afonso, 1999) also referred that TFP had positively contributed to the Portuguese GDP growth, thanks to the efficiency gains in labor factor, more namely, with the increase of imports growth rates of real capital per worker and transport of commodities per worker. (Amador & Coimbra, 2007) argue the stock of capital accumulation cause a high FDI, strongly associate to European structural funds granted to Portugal; however, this accumulation didn´t result to efficiency gains[45] to the Portuguese economy.

For the period between 1994 and 1998, (Amador & Coimbra, 2007) claims that, although the positive contribution of stock of capital and human capital on the economic growth, the GDP growth rate decreased because of TFP performance. Such phenomenon is partially explained by the, manufacturing industry stagnate, agriculture sector breakdown and by the growing of the services and constructions sectors[46]. (Amador & Coimbra, 2007)

Finally, for the period between 1999 and 2005, we observe a worsening of the economic scenario created in the previous decade. (Amador & Coimbra, 2007) claims that stock of capital accumulation was the factor that most contributed for the GDP growth[47], however the TFP had a negative contribute – in this period, we saw a decreasing of GDP growth rate. With the creation of the EMU, in 1999, we attended a decreasing of the interest rate, it created a significant increase on the household and company investment. Though, this investment was not channeled for the intensive stock of capital neither for production of transactional goods that can increase the productivity, but just for buying houses[48] and other actives with low financial return. In respect of Portuguese human capital (Amador & Coimbra, 2007) argue that, based on a study about Portugal from the author Oliver Blanchard, he show us that negative impact of human capital efficiency was due to reduced flexibility of the labor market.

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[45] (Afonso, 1999) asserts that the capital efficiency had not an positive impact on the GDP growth due to the public investment of low return for the GDP growth and the disinvestment of companies in capital of goods at the period between 1991-1993 (lack of foreign capital more efficient), despite of at the period between 1986-90 had happened an import increased of capital goods by companies.

[46] (Silva, 2012) says that, the policies followed by Portugal were toward to the services, it led to the productivity paradox. This is, it being the Portuguese economy composed in the majority by services, so an increase of technological progress won´t leads to an increase of productivity.

[47] (Lopes, 1996) claim that the GDP growth was also influenced by domestic demand.

[48] See appendix 7 – Evolution of housing credit for the period between 1994 and 2007.

We conclude that between 1960 and 2005 the stock of capital[49] was the factor that most contribute to Portuguese GDP growth. Relatively to contribution of human capital we observed that, even with the continuous strong investment in education[50] and the number of graduates' individuals[51], it do not had influence on the GDP growth. However, we argue that education investment is fundamental key for the Portuguese economic growth, in the long-run.

We observed also that, in the 60´s and 70´s, the TFP had a significant impact on the Portuguese GDP growth. In following years, with exception for the period between 1986 and 1993, the Portuguese TFP diverged compared with the most developed countries, this is, in the last decades we have attended a quantitative increased of production factors but not qualitative, i.e., we see that an increase of stock of capital and human capital accumulation were the main forces of the economic growth, however it do not means that exists productivity gains for the Portuguese economy[52], but an decrease of real convergence.

Methodology

Data description

In this chapter is presented the econometric model, it was built for time series and it is utilized for estimate the contribution of TFP on the Portuguese economic growth over the period between 1960 and 2008, through of *growth accounting method*.

[49] See appendix 8 – Evolution of the stock of capital.
[50] See appendix 10 – Graph with the number of graduate's individuals per thousand inhabitants (1991-2008).
[51] See appendix 9 – Evolution of education investment in %GDP.
[52] (Lopes, 1996) claim that "*"A falta de dinâmica da produtividade é o calcanhar de Aquiles da economia portuguesa."*

We choose to limit the sample for the period between 1960 and 2008 not because of the difficulties to find the database for a long-run period, but because of the inclusion of the post-crisis period on the model that could cause biased results owing to negative effect of the Great Recession over the Portuguese economic growth.

The majority of the variables that constitutes the model were withdrawal from AMECO database, with the exception of human capital whose database was withdrawal from Barro and Lee (2010) database. The time indicator of all variables is annual.

Variable definition

All the variables are logarithmic[53], once that we are measuring the effects of full utilization of each input on the GDP growth.

Given the CD production function, the dependent variable is $D(LY_t)$ and it is represented by potential GDP growth rate[54] on the Portuguese economy, at constant prices of 2005.

The explanatory variables of the model are, the $D(LA_t)$ that represents the contribution of TFP[55] and will show the variation of the productivity gains of labor and capital over the Portuguese economic growth. The variable $D(LL_t)$ from the initial model it is assumed as a contribution of labor factor, however with utilization of Mincer formulation in the variable labor factor, we obtained the variable D(L_t), which means that the exponential of years of schooling for individuals aged over 25 years and that it represents the contribution of human capital. The $D(LK_t)$ represents the contribution of

[53] To obtain the changes of production factors over the potential GDP growth rate is necessary logarithmic them and take the first order.
[54] It is a component of structural nature. Characterize it as, the maximum GDP that such economy is able to produce given all the available resources.
[55] The TFP is measured, according with AMECO, by the CD production function.

stock of capital and it is measured by the AMECO methodology and the ε_t is the error. The L means that variable is logarithmic.

In the case that there may be problems of endogeneity, we will estimate the model by the two steps method. In this regard, we selected two IV are the investment contribution, it is represented by *D(LINV)*, and the contribution of the export weight on the GDP, represented by *D(LExp_PIB)*.

Analytical framework

To estimate the contribution of the Portuguese economic growth there are, according with the calculus of potential GDP, two important methodologies: statistical methods[56] and structural methods. On our model, we will use the structural method because it allows, through of macroeconomics variables, obtain results of the potential GDP closer to the economic reality. However, this method is dependent of the statistical methods for the calculus of their tendency. (Almeida & Félix, 2006)

Within of structural method, according with (Almeida & Félix, 2006), the utilization by the production function approach[57] is most suitable, i.e., this method it presents as the most appropriate for the estimation of potential GDP growth rate regarding to the inputs growth, in the long run.

However, it does not exist a universal production function, so we will discuss just the models of economic growth most utilized for the estimation of the *growth accounting model*, that are: - the CES[58] production function and the CD production function, that it is a particular case of the CES production function.

[56] See (Almeida & Félix, 2006).
[57] (Almeida & Félix, 2006) says that this approach is the most adequate for measured the contribution of available quantity and productivity of each productive factor on the GDP.
[58] See appendix 11 – Decomposition of CES production function.

Despite of many differences[59] between the CES production function and the CD production function, the main difference is the fact that CES production function have an elasticity of substitution between factors that can be constant but not necessarily unitary however, the CD production function should have an constant elasticity of substitution and unitary. The elasticity of substitution unitary entails the existence of many assumptions underlying to the CD production function, such as, the market of perfect competition, return constant to scale[60] and factor price elasticity equal to one, which aims to simplify the estimation of the explanatory variables. So that, we can claim that CD production function[61] is the most adequate over the *growth accounting method*[62] because allows show us an existence of substitutability between human capital and stock of capital factors, in the long run.

The initial equation for to estimate the contribution of TFP on the Portuguese economic growth, between 1960 and 2008, will be the CD production function, logarithmic and taken at the first order:

$$D(LY_t) = \beta_0 + \beta_1 D(LA_t) + \beta_2 D(LK_t) + \beta_3 D(LL_t) + \varepsilon_t \qquad (1)$$

However, the most suitable way to estimate[63] the years of schooling for individual on the $D(LL_t)$, is given by Mincer Formulation[64] (Krueger & Lindahl, 2001)

[59] To know more about the differences between CD and CES production function, see (Almeida & Félix, 2006).
[60] If we had return increased to scale we will have problems of econometric evidence. In the case of return decrease to scale exists some problems by explain, which factors fall down. (Lipsey & Carlaw, 2004)
[61] (Almeida & Félix, 2006) asserts that the contribution of TFP is equal even if we had utilized the CES or CD production function over the potential GDP growth.
[62] Appendix 12 – Formulation of growth Accounting Method.

[63] Notice that, to apply this approach we have to admit that all the individuals are identical because the ability and the innate abilities of each individual are able to explain the income differences. (Mincer, 1981)

and (Bassanini & Scarpetta, 2001). With the aim to show, economically, that the increase of an additional year of schooling can explain the wages differences of the individuals and, as a result, the GDP changes. (Mincer, 1974)

We introduce an exponential function over the variable $D(LL_t)$. So, we intend to estimate the income increase percentage of an individual for each additional year of schooling average and the influence of this income variation in the GDP growth. The same author also says that there are decreasing incomes for each additional year of schooling, this is, have reached the limit[65] of degrees of schooling such increase in additional year of schooling will lead to a continuous decreasing of income over the time.

The two main limitations of this approach are the difficulties to estimate the effects of human abilities and the measurement way of the years of schooling average, that underestimate the influence of schooling in the wages. (Bassanini & Scarpetta, 2001)

The Mincer Formulation, (Krueger & Lindahl, 2001) e (Pina & St. Aubyn, 2005), is given by:

$$H_t = \exp\big(D(LL_t)\big) \tag{2}$$

$$H_t = D(L_t) \tag{3}$$

Where:

H_t : Human Capital

$D(LL_t)$: Contribution of the labor factor

$D(L_t)$: Contribution of the Human Capital

[64] See (Mincer, 1981) and (Mincer, 1974).

[65] Until to reaching the boundary, if the individual increase the investment in education after the basic training, it will have a big influence on the actual and future incomes. (Mincer, 1981)

L : Logarithmic

With the introduction of Mincer Formulation on the CD production function, our final model will be:

$$D(LY_t) = \beta_0 + \beta_1 D(LA_t) + \beta_2 D(LK_t) + \beta_3 D(L_t) + \varepsilon_t \qquad (4)$$

Where, $D(LY_t)$ represents the potential GDP growth rate, $D(LA_t)$ is the contribution of total factor productivity, $D(LK_t)$ represents the contribution of stock of capital factor, $D(L_t)$ represents the contribution of human capital and ε_t is the error.

Therefore, the utilization of CD production function presents some limitations that we would like emphasize. (Almeida & Félix, 2006) claims that in the CD production function is not possible identify in isolation the existence of technical progress at each input of production.

The same author also says that, in spite of the production function presents some constrains, it limits his flexibility for other types of complex estimations.

Meanwhile, it arose a problem on the database used to characterize the variable A_t, given that the methodology used by AMECO for calculate this variable is the same that was used for built the final regression of this thesis, so created it bias problems on the final model owing to undervaluation of the variable A_t.

Despite of existence of this issue on the database, we will analyze the impact of variable A_t on the GDP growth just as a mere statistical quantification[66], i.e., we will just analyze the statistical significance of TFP on the GDP growth, following to table 4.

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[66] Despite of the econometric tests done by us, we feel necessity to try a new estimation approach, with the aim to analyze the same question in the different way. See Appendix 17 – Table 5.

Presented the model and using the OLS method, we expect that results of econometric estimations show us that TFP evolution was the main driver of the Portuguese economic growth between 1960 and 2008. Moreover, we also expect that inputs, stock of capital and human capital, they will converge towards to the presented previously literature.

Empirical Analysis and Results

The analyzes of TFP contribution on the Portuguese Economic growth

It´s important emphasize that we are in the presence of a model with large sample, so there is an increase consistence over the results presents in the model estimation.

We estimate the equation (4) by the LS and we observe (Appendix 13 – Table 1) that the estimations are in line with the econometrics assumptions to reach it. However, we suspect that an explanatory variable of the model is endogenous. Thus, we will test, through of the Hausman test, the endogeneity of the regressors. (Appendix 14 – Table 2)

We estimated the model by the LS (Appendix 14 – Table 2) with the inclusion of the supposed endogenous variable $D(LK_t)$ and the exogenous variables, pre-determined, with the aim to obtain the residuals. Indeed, we suspect that there is a correlation between the regressor $D(LK_t)$ and the error. So, we introduce two instrumental variables[67] in the model, such as *D(LINV)* and *D(LExp_PIB)*, they are within of the error term and they are not directly observed, but affects the $D(LY_t)$.

[67] The instrumental variables give us more consistency for the estimators when we will have endogenous variables in the model.

In respect of the table 3, we observed that $D(LK_t)$ is an endogenous[68] variable because when we obtain the residuals we can see that the hypothesis of RES nullity is rejected, so there is an omitted variable *D(LINV)* associate to the residual that is significant statistically and it is correlated with the $D(LK_t)$, and also influence the $D(LY_t)$ (Appendix 15 – Table 3)

Note that we won´t do the Sargan[69] test because we just have one instrumental variable valid on the model.

Given that the model[70] has endogenous variables, we claim that the estimators of the LS in the linear regression model are biased, inconsistent and inefficiency, and consequently, and the analysis will be inferential. However, we will have to estimate the parameters of the model through of LS in two steps method. (Appendix 16 – Table 4)

After we had utilized the LS in two steps method, the output in the table 4 shows us that it would be rather more suitable for presents the results and the final conclusions.

It´s also important emphasize that the adjusted R^2 was 0, 8091, i.e., 80, 91% of the dependent variable can be explained by the regressors in the model.

Presented the results, we concluded that for the period between 1960 and 2008, the TFP had a positive impact on the explanation of the Portuguese economic growth. Regarding to the stock of capital we observed that, an increase by 1% on the variation of stock of capital led to, in average, an increase by 1.153% on the Portuguese GDP growth rate, *ceteris paribus*. The human capital was not statistically significant. (Appendix 16 – Table 4)

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[68] Violate MLR.4 (MLR.4 means that all the factors inside of ε_t shouldn´t have correlated with the explanatory variables).

[69] The Sargan test is utilized when we have a number of instrumental variables equal or superior to the number of endogenous explanatory variables. Also known by over-identifying test, it estimates the correlation between the instrumental variables and the error.

[70] The Table 1 loses credibility and it has an output biased.

Then, we did the Durbin-Watson test for a sample of 45 observations and 3 explanatory variables with a significantly level of 1%, with the aim to give more consistency to the econometric test. Having these assumptions, the our critical values are $d_l = 1{,}24$ e $d_u = 1{,}49$. (Appendix 16 – Table 4)

We concluded that hypothesis H_0 is rejected, so there is statistical evidence that such errors are positively autocorrelated[71]. Furthermore, we analyze the histogram of the errors correlation (Appendix 18 – Table 6) and we concluded that do not exist statistical evidence on the presence of negative autocorrelation of the errors. We finalize that, as the errors are positively autocorrelated the statistical inference is not valid, i.e., the F and t tests are not valid because our model is not dynamically complete, so it needs lags into the regression.

To solve this problem of positive autocorrelation, we are going to use the previous approach but with changes in the covariance matrix, through of West and Newey estimator test. These changes on the estimation will provide more consistence's to the statistical inference. (Appendix 19 – Table 7)

Before we estimate the existence of the heteroscedasticity it is adequate refer that there are three ways to do it. Two of these three tests, WHITE and Breusch-Pagan-Godfrey tests, they won´t are utilized because of the increased numbers of freedom degrees of Chi-Square, higher number of regressors and also due to a finite sample, so the potency of these tests will be lower. One way to solve this issue will be utilized the WHITE test simplified.

Testing the existence of the heteroscedasticity, through the WHITE test simplified (Appendix 20 – Table 8) we observed that does not reject the null hypothesis, i.e., there is a statistical evidence of homoscedasticity in the model. The presence of

[71] The existence of the positive autocorrelation shows that there is a relationship between the explanatory variables and the error term, over time.

homoscedasticity it shows us that there is a constant variance of the errors in such variables for all the observations. So, the standard errors of estimators, which are estimated by the LS method, are valid and the statistical inference is also valid.

In respect of VAR estimation we pretend to catch the linear interdependences between the variable $log(Y_t)$ and the variable $log(A_t)$, i.e., based on each variable we will like to analyze his own evolution and interconnection, through of past lags of these variables. We can concluded that, the variable $log(Y_t)$ is just influenced by the $log(Y_{t-1})$, and the $log(A_t)$ is also just influenced by the $log(A_{t-1})$. This result[72] shows us that, cyclical policies do not have positive effects on the Portuguese GDP growth. So, just structural policies, like changes in A_t, it will have a significant impact on the Portuguese GDP growth. (Appendix 21- Table 9)

On the unit root test we are going to verify the stationary of the variables A_t and Y_t over time. We did the augmented *Dickey-Fuller*[73] unit root test for those two variables with a lag[74] and we concluded that for both cases the null hypotheses is not rejected, so the variables are not stationary but are integrated at the same order. Also, it verifies that $Y_t \sim I(1)$ and $A_t \sim I(1)$ are variables that exhibit a behavior persistent highly[75], i.e., the current values will be important to determine his value in the future. (Appendix 22 and 23 – Tables 10 and 11)

The non-stationary of all the variables are subject a stochastic tendency, this means that, in the case of temporary shock[76] over the variable Y_t will lead certainly a

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[72] In the table 10 we observe that variable $\log(A_{t-1})$ not have impact on the variable $log(Y_t)$.

[73] The ADF test has a number of lags and the first differences of the variable with the aim to avoid problems of errors autocorrelation.

[74] Given the small number of lags it can exist some problems of on-rejection over the null hypothesis, i.e., in the estimation of the unit roots the probability of do not reject the null hypothesis is higher, it biased the results.

[75] The variables have a big “memory”.

[76] (Mendes & Murteira, 2001) claim that, if GDP has a stochastic tendency, it will be apply economic policies, as protectionist policies and incentives for domestic policy with the aim to influence the economy path, given that, small economic changes can be followed by permanents changes on the economic growth.

permanent effects in the future values of Y_t. The same occurs in the variable A_t, which such temporary shock[77] will have a permanent effect in the productivity of the Portuguese economy.

According with previous test, we found out that variables are not stationary and are $I(1)$, however even that these variables are integers at the same order, we pretend confirm if the variables are cointegrated, i.e., if there is such relationship between those variables, in the long-run. For obtain the cointegrated test, first we will estimate a regression of LS just with two variables (Appendix 24 – Table 12). After that, we will estimate the unit root of the residuals of the previous regression. Presented all the estimations, we concluded that a null hypothesis of unit root is rejected, so the process is $I(0)$, i.e., there is a stable and constant relationship between the variable Y_t and A_t, in the long-run. (Appendix 25 – Table 13)

Like the cointegration does not reflect causality, we will estimate the *Granger*-causality between two variables. Observing the table 14 (Appendix 26) we verify that, for the significant test of 10%, there is an cause-effect relationship between $log(A_t)$ and $log(Y_t)$, i.e., the passed values of $log(A_t)$, it can help to forecast the best way and more consistent way to submits the values of $log(Y_t)$, but the opposite it is not possible.

Despite of econometric tests already done, we feel need to show a new approach, with aim to reach the same results but using a different method for analyze the relationship between A_t and Y_t and to give a numerical impact of the TFP on the Portuguese GDP growth. The path followed was a univariate filter[78], also known by HP

[77] In the case of TFP has a tendency an positive shock as for example, exchange depreciation or wage diminishing, it can has permanent effects on the productivity of such economy. (Mendes & Murteira, 2001)

[78] There are many filters as Hodrick and Prescott filter (HP), Baxter and King (BK) and Christiano and Fitzgerald (CF).

filter[79], it has as aim to withdraw the tendency of residuals of these two variables and estimate if exist or not relationship between potential TFP and the potential GDP growth at the long of the series.

From this formula we will try to estimate if exist or not such relationship between the potential TFP and the potential GDP growth, that is:

$$HPTREND\ L(Y_t) = \beta_0 + \beta_1 HPTREND\ L(A_t)$$

Based on the table 5, we can verify that exist a relationship between the TFP growth and the potential GDP for the period between 1960 and 2008. The variable $HPTREND\ L(A_t)$, that represents the TFP growth, it explains approximately 71% of Portuguese economic growth, for the period between 1960 and 2008. More precisely, an increase of 1% in the TFP growth will have an increase of 1.7% in the GDP growth, *ceteris paribus*. (Appendix 17 – Table 5)

With the aim to answer the main question of this thesis, we can affirm that the TFP had a significant contribution on the Portuguese economic growth for the period between 1960 and 2008. Following the HP filter approach we can conclude that TFP explain approximately 71% of the Portuguese economic growth for the period between 1960 and 2008; for the same period of time, the accumulation of capital stock was one of the main drivers for the economic growth in Portugal, i.e., the stock of capital explain approximately 15% of the Portuguese GDP growth; the human capital didn´t have any effect on the GDP growth. Additionally, we observed that it exist an cause-effect relationship between $log(A_t)$ and $lo\,g(Y_t)$ and with temporary shocks on the variables Y_t and A_t, it will have permanent effects on the future values of variables Y_t and A_t.

[79] Some authors claims that HP filter has been criticized by introduce spurious cycles on the time series.

Conclusion

We are on the crucial moment where the policymakers discuss the structural reforms for the Portuguese economy and we are in the stage of greater changes that should be taken for the medium/long run and that can have a significant impact on the Portuguese economic performance, so it was important analyze “The contribution of TFP for the Portuguese economic growth between 1960 and 2008”.

Indeed, this theme brings for the Portuguese academy – which it should be an important issue for analyzes and understanding the economic phenomenon’s in Portugal -, an important thematic as a study of TFP and its contribution for the Portuguese economic growth (between 1960 and 2008).

The thesis presented a new temporal analysis more long and consistent of the TFP on the Portuguese economic. In our study, we can concluded that the TFP had a positive impact over the GDP growth for the period between 1960 and 2008, given the statistical significance of 5% and 10%; the stock of capital has a positive impact over the Portuguese economic growth, furthermore this has been the main driver for the economic growth, more recently; Although the human capital had not any impact for the GDP growth we think that the continuous investment at the human capital should be done because it will be a positive effect on the GDP growth, but those effects just can be seeing on the GDP growth from indirect way.

The result presented about the TFP support the ideas of many authors that TFP had a positive impact over the GDP growth.

We have some limitations, but the main limitation was due to database of TFP (the principal variable of our thesis). The values these variable were obtain through the same equation that we used for estimate the final regression, which could biased the estimation and the interpretation of the final model.

For future research we would like to do the comparison between Portuguese TFP and the TFP at others countries of the European South (Spain, Italy and Greece) with the aim to understand the main drivers of the productivity of each country and also understand, through of the sensibilities analysis, which impact had the historical events, for example the joining of Portugal into the Eurozone, that determined the Portuguese economy.

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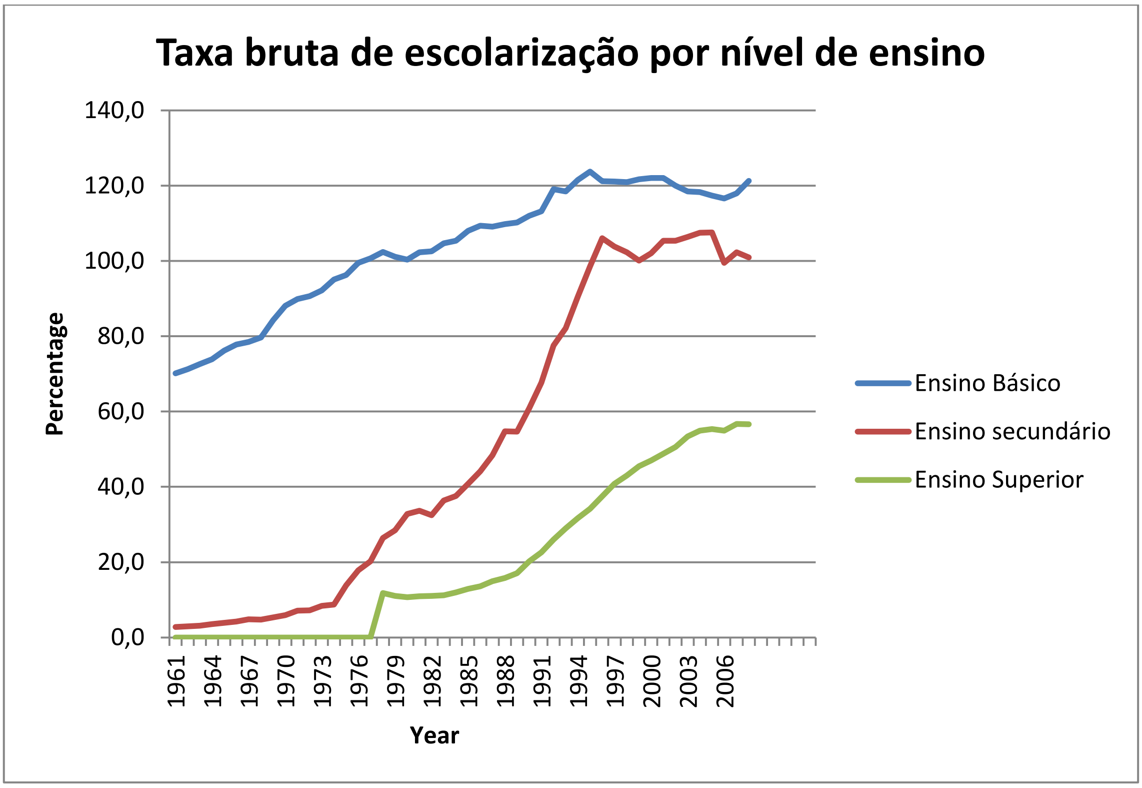
Appendix

Appendix 1 - The analysis of gross education rate by level of degree, in Portugal



Source: AMECO

Appendix 2 – Theory of indexes numbers

Teoria dos números índices	Price index	QÍndice de Quantidades
Törnqvist	$P_T(p^1,p^2,x^1,x^2) \equiv \prod_{i=1}^{N}\left(\frac{p_1^2}{p_1^1}\right)^{s_i}$ $s_i = \frac{1}{2}\frac{p_i^1\,x_i^1}{p^1\,x^1} + \frac{1}{2}\frac{p_i^2\,p_i^2}{p^2\,p^2} \quad i = 1,\dots,N$	$Q_T(p^1,p^2,x^1,x^2) \equiv \prod_{i=1}^{N}\left(\frac{x_1^2}{x_1^1}\right)^{s_i}$ $s_i = \frac{1}{2}\frac{p_i^1\,x_i^1}{p^1\,x^1} + \frac{1}{2}\frac{p_i^2\,p_i^2}{p^2\,p^2} \quad i = 1,\dots,N$
Vartia	$\ln P_V\,(p^1,p^2,x^1,x^2)$ $\equiv \sum_{i=1}^{N}\left(\frac{L(p_i^2x_i^2,p_i^1x_i^1)}{L(p^2x^2,\ p^1x^1)}\right)\ln\frac{p_i^2}{p_i^1}$	$\ln Q_V\,(p^1,p^2,x^1,x^2) \equiv$ $\sum_{i=1}^{N}\left(\frac{L(p_i^2x_i^2,p_i^1x_i^1)}{L(p^2x^2,p^1x^1)}\right)\ln\frac{x_i^2}{x_i^1} = \ln P_V\,(p^1,p^2,x^1,x^2)$
Laaspeyres	$P_L(p^1,p^2,x^1,x^2) \equiv \frac{p^2\,x^1}{p^1\,x^1}$	$Q_L(p^1,p^2,x^1,x^2) \equiv \frac{x^2p^1}{x^1p^1}$
Paasche	$P_P\,(p^1,p^2,x^1,x^2) \equiv \frac{p^2\,x^2}{p^1\,x^2}$	$Q_P(p^1,p^2,x^1,x^2) \equiv \frac{x^2p^2}{x^1p^2}$
Ideal de Fisher	$P_F(p^1,p^2,x^1,x^2) \equiv (P_l\,P_p)^{\frac{1}{2}}$	$Q_F = \frac{p^2x^2}{p^1x^1} \times \frac{1}{P_F(p^1,p^2,x^1,x^2)} = \frac{p^2x^2}{p^1x^1}$ $\times \frac{1}{\frac{p^2x^1}{p^1x^1}\frac{p^2x^2}{p^1x^2}} \equiv \left(\frac{p^1x^2\,p^2x^2}{p^1x^1\,p^2x^1}\right)^{\frac{1}{2}} \equiv (Q_L\,Q_P)^{\frac{1}{2}}$

Source: (Diewert W. E., 1976) and (Coelli, Rao, Battese, & O´Donnel, 1998);

Appendix 3 – Decomposition of Malmquist Index Quantity

Índice Malmquist de quantidades dos fatores, em relação ao período 1 é representado como:

$$Q_{MI}^{1}(x^{2},x^{1}) \equiv \frac{D_{I}^{1}\,(y^{1},x^{2})}{D_{I}^{1}\,(y^{1},x^{1})} = \max_{\partial}\left\{\partial : F^{1}(y^{1},\frac{x^{2}}{\partial}) \geq y_{1}^{1}\right\},$$

em que $y^{1} = (y_{1}^{1}, y_{2}^{1}, \dots, y_{N}^{1}) = (y_{1}^{1}, y^{1})$ é a função de produção que representa a tecnologia no período 1.

Índice Malmquist de quantidades dos produtos, em relação ao período 1 é representado como:

$$Q_{MO}^{1}(y^{2},y^{1}) \equiv \frac{D_{O}^{1}\,(y^{2},x^{1})}{D_{O}^{1}\,(y^{1},x^{1})} = \min_{\partial}\left\{\partial : g^{1}\left(\frac{y^{2}}{\partial},x^{2}\right) \leq x_{1}^{1}\right\},$$

em que $x^{1} = g^{1}\,(y,x)$, onde g^{1} representa a função de necessidades de fatores.

Índice de produtividade de Malmquist baseado nos produtos, para um período é representado por:

$$M_{O}^{1}(x^{2},x^{1},y^{2},y^{1}) \equiv \frac{D_{O}^{1}\,(y^{2},x^{2})}{D_{O}^{1}\,(y^{1},x^{1})} = \min_{\partial}\left\{\partial : g^{1}\left(\frac{y^{2}}{\partial},x^{2}\right) \leq x_{1}^{2}\right\}$$

Índice de produtividade de Malmquist baseado nos fatores, para um período é representado por:

$$M_{I}^{1}(x^{2},x^{1},y^{2},y^{1}) \equiv \frac{D_{I}^{1}\,(y^{1},x^{1})}{D_{I}^{1}\,(y^{1},x^{1})} = \min_{\partial}\{\partial : F^{1}(y^{2},\partial x^{2}) \geq y_{1}^{2}\}$$

Appendix 4 – Decomposition of Cobb-Douglas Production Function

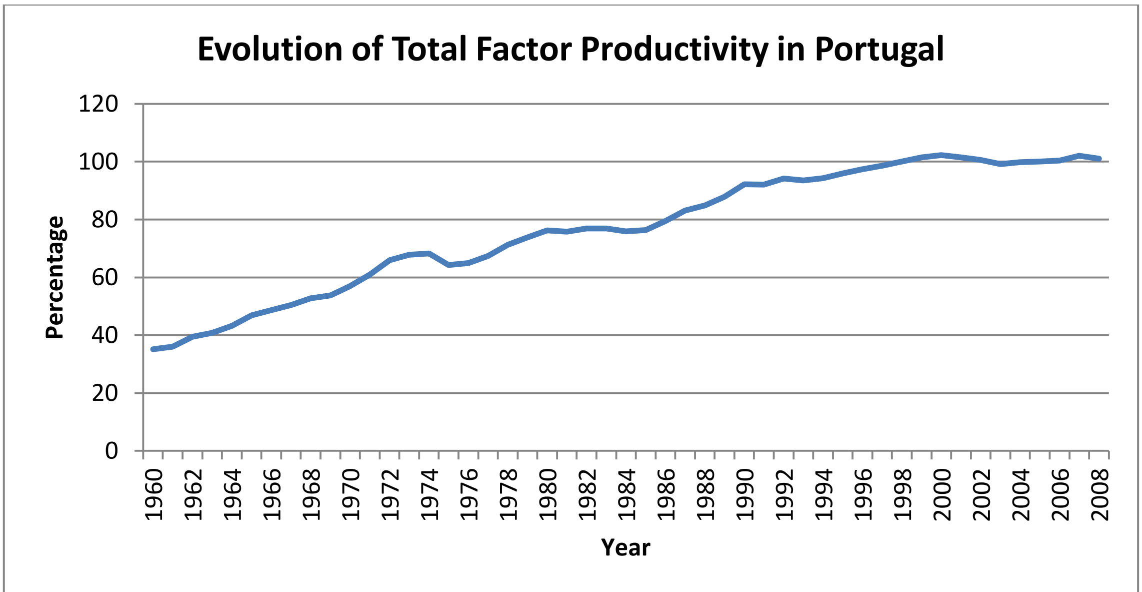
A *decomposição de Solow* obtida através de uma função de produção Cobb- Douglas ($Y = AK^{\alpha}L^{1-\alpha}$), com rendimentos constantes à escala e progresso técnico neutro, é dado por:

$$\frac{dY}{dt} = \frac{dA}{dt} + (1-\alpha) \times \frac{dK}{dt} + \alpha \times \frac{dL}{dt} \Leftrightarrow \dot{Y} = \dot{A} + (1-\alpha)\dot{K} + \alpha\dot{L} \Leftrightarrow$$

$\Leftrightarrow \dot{A} = \dot{Y} - \alpha\dot{K} - \alpha\dot{L}$, logo a PTF, também chamado *resíduo de Solow*, é :

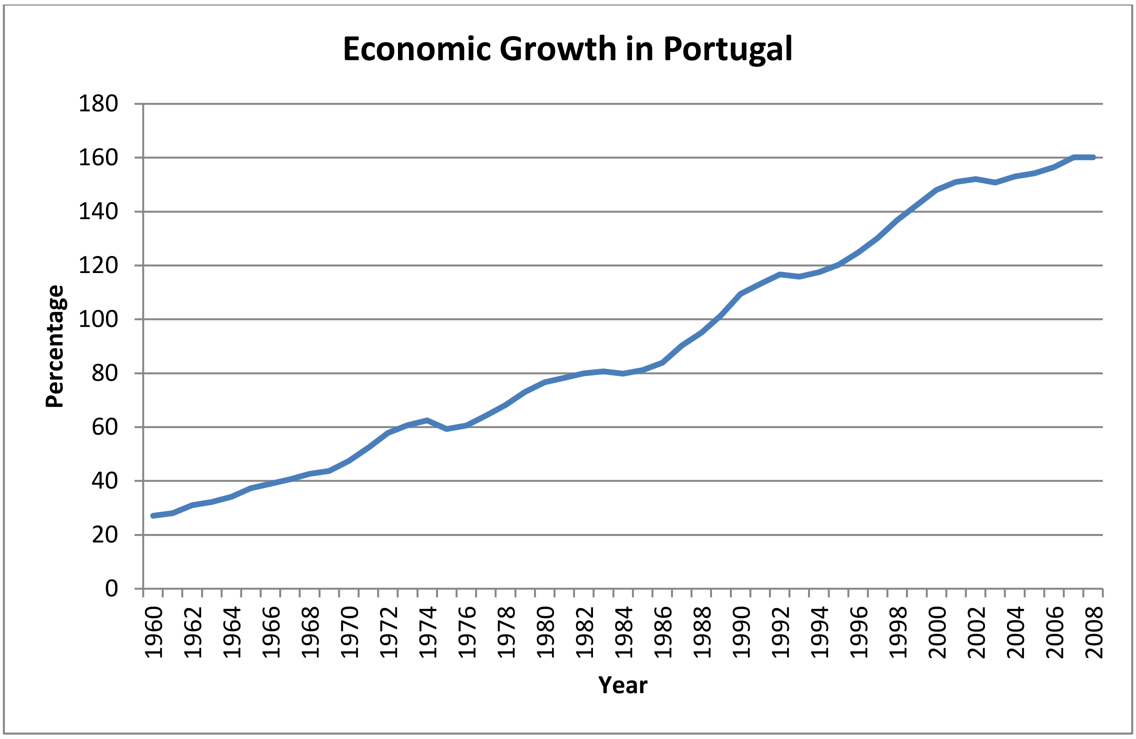
$$PTF = \dot{\mu} - (1-\alpha)(\dot{K} - \dot{L})$$

Appendix 5 - Evolution of the TFP in Portugal (1960-2008)



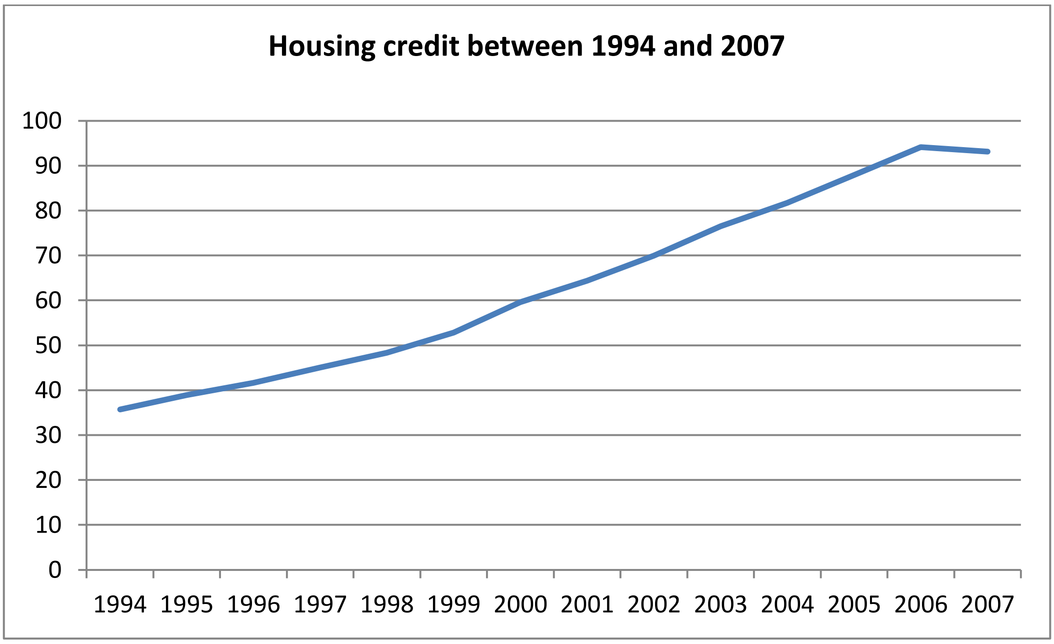
Source: AMECO

Appendix 6– Evolution of economic growth in Portugal (1960-2008)



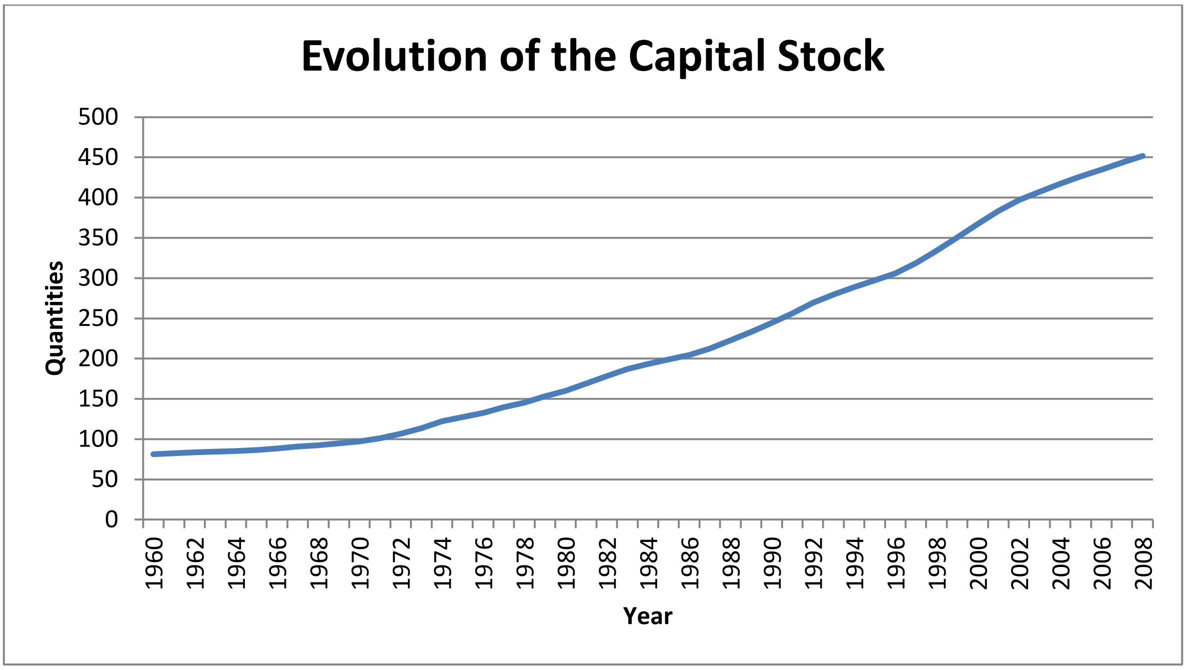
Source: AMECO

Appendix 7 - Evolution of housing credit (1994-2007)



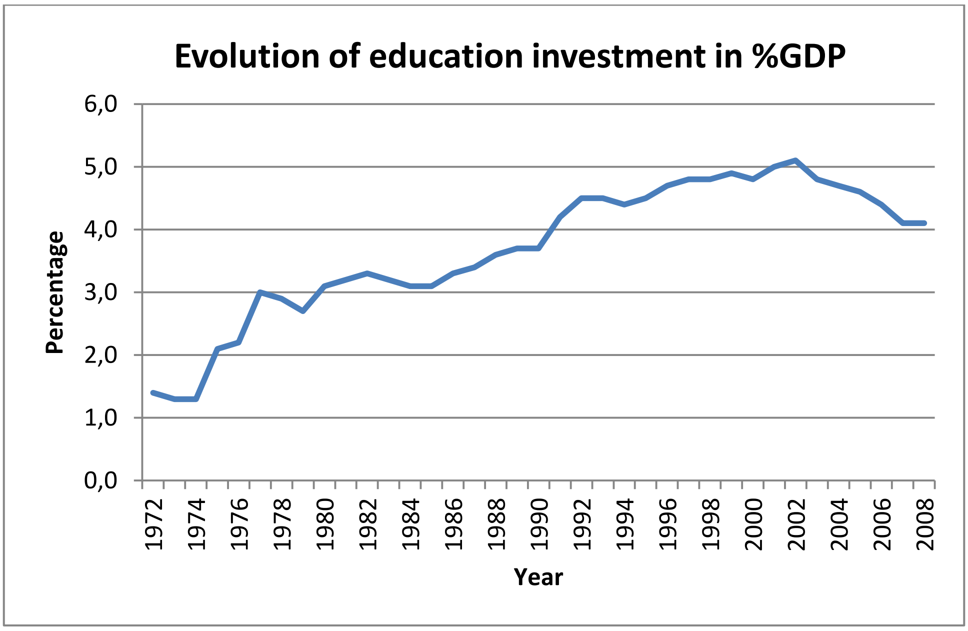
Source: Pordata

Appendix 8 – Evolution of the stock of capital (1960-2008)



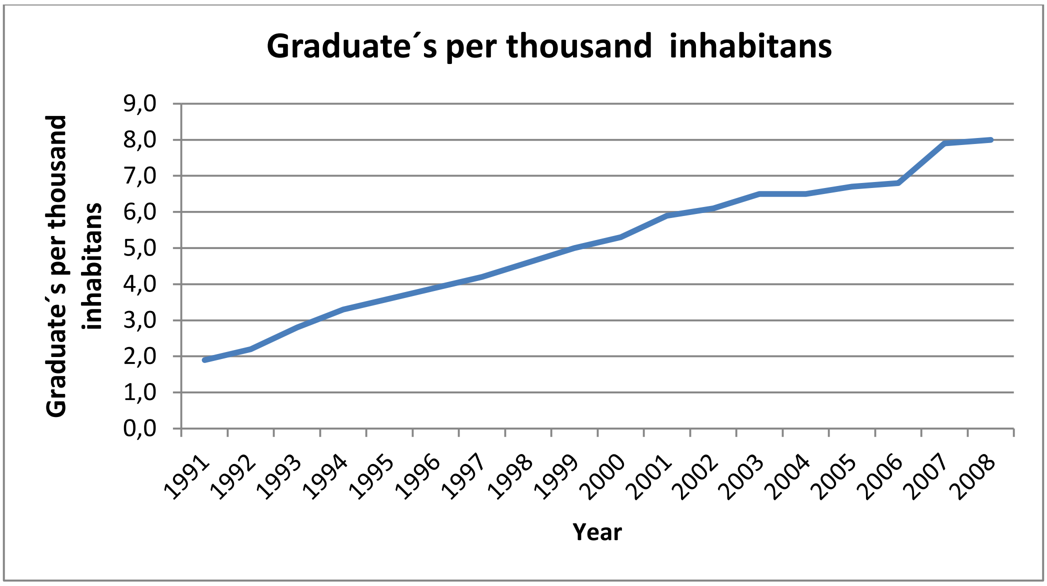
Source : AMECO

Appendix 9– Evolution of education investment in %GDP



Source: Pordata

Appendix 10 - The number of graduate's individuals per thousand inhabitants (1991-2008)



Source: Pordata

Appendix 11– Decomposition of CES production function

$$Y_t = [\delta(B_t L_t)^{\frac{\sigma-1}{\sigma}} + (1-\delta)(X_t K_t)^{\frac{\sigma-1}{\sigma}}]^{\frac{\sigma-1}{\sigma}} \; com \; 0 < \delta < 1 \; e \; \sigma > 0$$

First order condition:

$$y_t - l_t = \sigma(w_t - p_t) + (1-\sigma)b_t - \sigma \ln \delta$$

Relationship of long-run:

$$y_t - l_t = \sigma(w_t - p_t) + (1-\sigma)(\text{C} + \eta^L) - \sigma \ln \delta$$

Stay that:

$$B_t = \left(\frac{Y_t}{L_t}\right)^{\frac{1}{1-\sigma}} \left(\delta \frac{P_t}{W_t}\right)^{\frac{\sigma}{1-\sigma}}$$

$$Y_t = \left(\frac{1}{1-\delta} \left(\frac{Y_t}{K_t}\right)^{\frac{\sigma-1}{\sigma}} - \frac{\delta}{1-\delta} \left(\frac{L_t B_t}{K_t}\right)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma-1}{\sigma}}$$

The potential GDP is measure by production function. With the substitution of variables we have:

$$Y_t^* = \left(\delta (B_t^* L_t^*)^{\frac{\sigma-1}{\sigma}} - (1-\delta)(X_t^* K_t^*)^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma-1}{\sigma}}$$

Through of Taylor rule of first order for lineary the CES function we can get the *growth accounting method:*

$$\Delta Y_t = w_t^L \Delta b_t + w_t^L \Delta l_t + w_t^K \Delta x_t + w_t^K \Delta K_t$$

Where:

ΔY_t: Potential GDP growth rate

$w_t^L \Delta b_t$: Contribution of specific productivity of the labor factor

$w_t^L \Delta l_t$: Contribution of the labor factor

$w_t^K \Delta x_t$: Contribution of specific productivity of the capital factor

$w_t^K \Delta K_t$: Contribution of the capital factor

Appendix 12– Formulation of growth Accounting Method

Cobb-Douglas production funcion utilized the growth accounting method is:

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

Logarithmic:

$$\log\ (Y_t) = \log(A_t K_t^{\alpha} L_t^{1-\alpha})$$

$$\log\ (Y_t) = \log(A_t) + \log(K_t^{\alpha}) + \log(L_t^{1-\alpha})$$

$$\log\ (Y_t) = \log(A_t) + \alpha \log(K_t) + (1-\alpha)\log(L_t)$$

First differences:

$$\log(Y_{t+1}) = \log(A_{t+1}) + \alpha \log(K_{t+1}) + (1-\alpha)\log(L_{t+1})$$

$$\log(Y_{t+1}) - \log(Y_t) = [\log(A_{t+1}) - \log(A_t)] + \alpha[\log(K_{t+1}) - \log(K_t)] + (1-\alpha)[\log(L_{t+1} - \log(L_t)]$$

$$\Delta \log(Y_t) = \Delta \log(A_t) + \alpha \Delta \log(K_t) + (1-\alpha)\Delta\log(L_t)$$

Where:

$\Delta \log(Y_t)$: Potential GDP growth rate

$\Delta \log(A_t)$: Contribution of the Total Factor Productivity

$\Delta \log(K_t)$: Contribution of the capital factor

$\Delta\log(L_t)$: Contribution of the labor factor

Tables

Appendix 13 - Table 1: Estimation the initial equation

Dependent Variable: D(LY)
Method: Least Squares
Date: 03/13/14 Time: 11:48
Sample (adjusted): 1961 2008
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.003417	0.003930	-0.869343	0.3894
D(LA)	1.060744	0.047474	22.34346	0.0000
D(L)	0.000518	0.006204	0.083424	0.9339
D(LK)	0.477637	0.091868	5.199142	0.0000

R-squared	0.919862	Mean dependent var	0.037057
Adjusted R-squared	0.914398	S.D. dependent var	0.030990
S.E. of regression	0.009067	Akaike info criterion	-6.488713
Sum squared resid	0.003617	Schwarz criterion	-6.332779
Log likelihood	159.7291	Hannan-Quinn criter.	-6.429785
F-statistic	168.3510	Durbin-Watson stat	1.384203
Prob(F-statistic)	0.000000		

Appendix 14 – Table 2: Estimation the initial equation but with IV

Dependent Variable: D(LK)
Method: Least Squares
Date: 03/13/14 Time: 12:09
Sample (adjusted): 1961 2008
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.037570	0.003034	12.38138	0.0000
D(L)	0.004952	0.010095	0.490517	0.6263
D(LA)	-0.213038	0.088165	-2.416352	0.0200
D(LINV)	0.069678	0.027981	2.490211	0.0167
D(LEXP_PIB)	-0.012611	0.036985	-0.340962	0.7348

R-squared	0.168079	Mean dependent var	0.035770
Adjusted R-squared	0.090691	S.D. dependent var	0.014658
S.E. of regression	0.013977	Akaike info criterion	-5.604456
Sum squared resid	0.008400	Schwarz criterion	-5.409539
Log likelihood	139.5069	Hannan-Quinn criter.	-5.530797
F-statistic	2.171898	Durbin-Watson stat	0.421165
Prob(F-statistic)	0.088270		

Appendix 15 – Table 3: Estimation the residual

Dependent Variable: D(LY)
Method: Least Squares
Date: 03/13/14 Time: 12:11
Sample (adjusted): 1961 2008
Included observations: 48 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.029137	0.008706	-3.346884	0.0017
D(LA)	1.126344	0.047586	23.66966	0.0000
D(L)	0.001714	0.005639	0.303942	0.7626
D(LK)	1.153207	0.224641	5.133561	0.0000
RES	-0.783344	0.241897	-3.238342	0.0023

R-squared	0.935574	Mean dependent var	0.037057
Adjusted R-squared	0.929581	S.D. dependent var	0.030990
S.E. of regression	0.008224	Akaike info criterion	-6.665282
Sum squared resid	0.002908	Schwarz criterion	-6.470365
Log likelihood	164.9668	Hannan-Quinn criter.	-6.591623
F-statistic	156.1087	Durbin-Watson stat	1.402309
Prob(F-statistic)	0.000000		

Appendix 16 – Table 4: Final Equation

Dependent Variable: D(LY)
Method: Two-Stage Least Squares
Date: 03/13/14 Time: 11:52
Sample (adjusted): 1961 2008
Included observations: 48 after adjustments
Instrument specification: C D(LA) D(L) D(LEXP_PIB) D(LINV)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.029137	0.014330	-2.033235	0.0481
D(LA)	1.126344	0.078331	14.37934	0.0000
D(L)	0.001714	0.009283	0.184645	0.8544
D(LK)	1.153207	0.369778	3.118643	0.0032

R-squared	0.821372	Mean dependent var	0.037057
Adjusted R-squared	0.809193	S.D. dependent var	0.030990
S.E. of regression	0.013537	Sum squared resid	0.008063
F-statistic	74.72697	Durbin-Watson stat	0.762511
Prob(F-statistic)	0.000000	Second-Stage SSR	0.004057
J-statistic	9.54E-06	Instrument rank	5
Prob(J-statistic)	0.997536		

Appendix 17 – Table 5: Estimation of the HP filter

Dependent Variable: HPTRENDLY
Method: Least Squares
Date: 09/26/14 Time: 20:57
Sample: 1960 2008
Included observations: 49

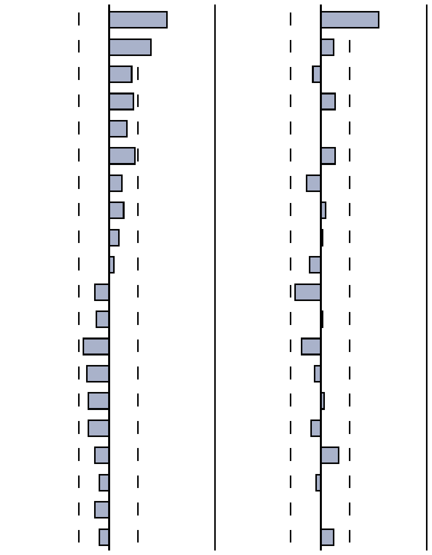
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-2.962589	0.175990	-16.83384	0.0000
HPTRENDLA	1.706417	0.040831	41.79197	0.0000

R-squared	0.973795	Mean dependent var	4.373781
Adjusted R-squared	0.973238	S.D. dependent var	0.535229
S.E. of regression	0.087559	Akaike info criterion	-1.993045
Sum squared resid	0.360330	Schwarz criterion	-1.915828
Log likelihood	50.82960	Hannan-Quinn criter.	-1.963749
F-statistic	1746.569	Durbin-Watson stat	0.027482
Prob(F-statistic)	0.000000		

Appendix 18 – Table 6: Histogram of the Errors Correlation

Date: 03/13/14 Time: 15:26
Sample: 1961 2008
Included observations: 48

Autocorrelation | Partial Correlation



	AC	PAC	Q-Stat	Prob
1	0.577	0.577	17.009	0.000
2	0.422	0.133	26.287	0.000
3	0.235	-0.080	29.233	0.000
4	0.244	0.149	32.480	0.000
5	0.184	0.003	34.376	0.000
6	0.256	0.152	38.129	0.000
7	0.128	-0.132	39.080	0.000
8	0.144	0.062	40.326	0.000
9	0.099	0.023	40.934	0.000
10	0.056	-0.102	41.133	0.000
11	-0.135	-0.240	42.320	0.000
12	-0.116	0.029	43.218	0.000
13	-0.244	-0.176	47.287	0.000
14	-0.218	-0.065	50.628	0.000
15	-0.197	0.043	53.455	0.000
16	-0.193	-0.091	56.239	0.000
17	-0.130	0.185	57.541	0.000
18	-0.095	-0.042	58.260	0.000
19	-0.127	0.000	59.604	0.000
20	-0.083	0.135	60.193	0.000

Appendix 19 – Table 17: Estimation of West and Newey Estimator Test

Dependent Variable: D(LY)
Method: Two-Stage Least Squares
Date: 03/13/14 Time: 15:36
Sample (adjusted): 1961 2008
Included observations: 48 after adjustments
HAC standard errors & covariance (Bartlett kernel, Newey-West fixed bandwidth = 4.0000)
Instrument specification: C D(LA) D(L) D(LEXP_PIB) D(LINV)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.029137	0.014018	-2.078563	0.0435
D(LA)	1.126344	0.067305	16.73488	0.0000
D(L)	0.001714	0.006048	0.283419	0.7782
D(LK)	1.153207	0.353357	3.263571	0.0021

R-squared	0.821372	Mean dependent var	0.037057
Adjusted R-squared	0.809193	S.D. dependent var	0.030990
S.E. of regression	0.013537	Sum squared resid	0.008063
F-statistic	74.72697	Durbin-Watson stat	0.762511
Prob(F-statistic)	0.000000	Second-Stage SSR	0.004057
J-statistic	9.54E-06	Instrument rank	5
Prob(J-statistic)	0.997536		

Appendix 20 – Table 8: Heteroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.359486	Prob. F(2,45)	0.2671
Obs*R-squared	2.734984	Prob. Chi-Square(2)	0.2547
Scaled explained SS	1.917862	Prob. Chi-Square(2)	0.3833

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/13/14 Time: 14:48
Sample: 1961 2008
Included observations: 48

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.000116	4.79E-05	2.422728	0.0195
FITTED	0.000744	0.001855	0.401379	0.6900
FITTED^2	0.009890	0.020749	0.476655	0.6359

R-squared	0.056979	Mean dependent var	0.000168
Adjusted R-squared	0.015067	S.D. dependent var	0.000219
S.E. of regression	0.000218	Akaike info criterion	-13.96693
Sum squared resid	2.13E-06	Schwarz criterion	-13.84998
Log likelihood	338.2064	Hannan-Quinn criter.	-13.92274
F-statistic	1.359486	Durbin-Watson stat	1.515480
Prob(F-statistic)	0.267136		

Appendix 21 – **Table 9: Vector Autoregression**

Vector Autoregression Estimates
Date: 03/13/14 Time: 15:45
Sample (adjusted): 1961 2008
Included observations: 48 after adjustments
Standard errors in ( ) & t-statistics in [ ]

	LY	LA
LY(-1)	0.671925	-0.219723
	(0.19549)	(0.16474)
	[3.43714]	[-1.33374]
LA(-1)	0.275533	1.140229
	(0.17761)	(0.14968)
	[1.55131]	[7.61787]
C	-0.425713	-0.158070
	(0.37491)	(0.31595)
	[-1.13550]	[-0.50031]
LK	0.135231	0.102058
	(0.09333)	(0.07865)
	[1.44896]	[1.29761]
R-squared	0.997352	0.994195
Adj. R-squared	0.997172	0.993799
Sum sq. resids	0.033473	0.023772
S.E. equation	0.027582	0.023244
F-statistic	5525.091	2511.961
Log likelihood	106.3278	114.5417
Akaike AIC	-4.263659	-4.605905
Schwarz SC	-4.107726	-4.449972
Mean dependent	4.396200	4.314694
S.D. dependent	0.518658	0.295181
Determinant resid covariance (dof adj.)		5.45E-08
Determinant resid covariance		4.58E-08
Log likelihood		269.3413
Akaike information criterion		-10.88922
Schwarz criterion		-10.57735

Appendix 22 – Table 10: Unit Roots Test

Null Hypothesis: A has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.438167	0.1371
Test critical values:	1% level	-3.577723	
	5% level	-2.925169	
	10% level	-2.600658	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(A)
Method: Least Squares
Date: 03/18/14 Time: 16:01
Sample (adjusted): 1962 2008
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
A(-1)	-0.028797	0.011811	-2.438167	0.0189
D(A(-1))	0.301806	0.138664	2.176520	0.0349
C	3.179487	1.013746	3.136376	0.0030

R-squared	0.254249	Mean dependent var	1.383509
Adjusted R-squared	0.220351	S.D. dependent var	1.760502
S.E. of regression	1.554483	Akaike info criterion	3.781865
Sum squared resid	106.3224	Schwarz criterion	3.899959
Log likelihood	-85.87383	Hannan-Quinn criter.	3.826305
F-statistic	7.500448	Durbin-Watson stat	1.887364
Prob(F-statistic)	0.001574		

Appendix 23 – Table 11: Unit Root Test

Null Hypothesis: Y has a unit root
Exogenous: Constant
Lag Length: 3 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		0.068724	0.9597
Test critical values:	1% level	-3.584743	
	5% level	-2.928142	
	10% level	-2.602225	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(Y)
Method: Least Squares
Date: 03/18/14 Time: 16:16
Sample (adjusted): 1964 2008
Included observations: 45 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Y(-1)	0.000493	0.007172	0.068724	0.9456
D(Y(-1))	0.568696	0.151280	3.759238	0.0005
D(Y(-2))	0.108187	0.177054	0.611039	0.5446
D(Y(-3))	-0.383186	0.151724	-2.525547	0.0156
C	1.940626	0.764227	2.539333	0.0151

R-squared	0.401416	Mean dependent var	2.845229
Adjusted R-squared	0.341557	S.D. dependent var	2.294440
S.E. of regression	1.861812	Akaike info criterion	4.185416
Sum squared resid	138.6537	Schwarz criterion	4.386157
Log likelihood	-89.17187	Hannan-Quinn criter.	4.260250
F-statistic	6.706081	Durbin-Watson stat	2.102229
Prob(F-statistic)	0.000315		

Appendix 24 – Table 12

Dependent Variable: Y
Method: Least Squares
Date: 03/18/14 Time: 17:07
Sample: 1960 2008
Included observations: 49

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-61.27102	6.307166	-9.714510	0.0000
A	1.970209	0.079160	24.88895	0.0000

R-squared	0.929478	Mean dependent var	90.25527
Adjusted R-squared	0.927978	S.D. dependent var	42.98177
S.E. of regression	11.53501	Akaike info criterion	7.768610
Sum squared resid	6253.653	Schwarz criterion	7.845828
Log likelihood	-188.3310	Hannan-Quinn criter.	7.797907
F-statistic	619.4598	Durbin-Watson stat	0.041761
Prob(F-statistic)	0.000000		

Appendix 25 – Table 13: Unit Root Test

Null Hypothesis: RES1 has a unit root
Exogenous: Constant
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-0.928655	0.7704
Test critical values:	1% level	-3.577723	
	5% level	-2.925169	
	10% level	-2.600658	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RES1)
Method: Least Squares
Date: 03/18/14 Time: 17:09
Sample (adjusted): 1962 2008
Included observations: 47 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RES1(-1)	-0.025393	0.027344	-0.928655	0.3581
D(RES1(-1))	0.586183	0.124704	4.700608	0.0000
C	0.047150	0.290278	0.162431	0.8717

R-squared	0.335229	Mean dependent var	0.086412
Adjusted R-squared	0.305012	S.D. dependent var	2.378359
S.E. of regression	1.982741	Akaike info criterion	4.268539
Sum squared resid	172.9755	Schwarz criterion	4.386634
Log likelihood	-97.31067	Hannan-Quinn criter.	4.312979
F-statistic	11.09411	Durbin-Watson stat	2.181704
Prob(F-statistic)	0.000126		

Appendix 26 – Table 14: Causality Test

Pairwise Granger Causality Tests
Date: 03/18/14 Time: 17:34
Sample: 1960 2008
Lags: 1

Null Hypothesis:	Obs	F-Statistic	Prob.
A does not Granger Cause Y	48	3.78689	0.0579
Y does not Granger Cause A		1.27037	0.2657