Department of International and European Economic Studies

MSc in International Economics & Finance

Academic Year 2016-2017

Determinants of Economic Growth: An Empirical Analysis in a Panel of 28 OECD Countries

A dissertation submitted in partial fulfillment of the requirements for MSc International Economics and Finance

Tavoularis Stylianos 4150015

Supervisor: Professor George Economides

Athens

January, 2017

Acknowledgement

There are many people who have contributed to the completion of my dissertation and I would like to show them my gratitude. First and foremost, I would like to thank my supervisor, Professor George Economides, for his guidance and valuable cooperation at every stage of this dissertation paper, as well as his helpful advice and suggestions.

Furthermore, I would like to thank my family, for their constant support and encouragement while I was working this paper, and for the support they provided me in my student life so far.

Last but not least, special thanks to my friends and fellow classmates that they believed in me and for the assistance they provided me when needed.

Abstract

Aim of this paper is to identify the determinants of economic growth. In order to do so, an empirical analysis is conducted in a panel of 28 countries from 1960 to 2015. The empirical findings suggest that growth rate is enhanced and simultaneously stimulated by lower fertility rate, less ethnic tensions, better maintenance of rule of law, higher degree of international openness, lower inflation rate, higher investment ratio and lower tax burden. Growth is negatively related to the initial per capita GDP, ceteris paribus, something that supports the conditional convergence notion .We also find a positive relationship between democracy and growth where the former is measured in terms of political rights. To add more, there is strong indication of a nonlinear relation. In the absence of respect towards political and human rights, democratization tends to stimulate growth. But when a moderate degree of democracy is achieved, the effect of an improvement in democracy is not that intense as in the case where the degree of democracy is small.

Table of Contents

Introduction

Economic growth is one of the most researched topics for centuries. The main goal of every economy is to achieve the highest possible economic growth, even though most of the times this problem is subjected to restrictions. In that sense, every decision and every policy implemented by the country's government is subjected to this specific goal. Economic growth is so wanted due to the fact that the higher the aggregate income in an economy, the higher the welfare its residents enjoy. The rate of growth of the per capita GDP is the most commonly used measure of economic growth. There are many other indexes to measure economic welfare, such as the change of per capita consumption or the change of disposable income. However, these measures are directly dependent from per capita income. The growth rates vary across the countries all around the world. The most important question set by economists to be answered is why this phenomenon occurs and why some countries are very rich while other are so poor. In other words, what it is actually important is the factors that can affect the rate of growth and drive it into an increasing course. Especially nowadays, when financial crisis is at its peak and many countries run deficits for years and are trapped in recession or even depression it is important to focus the policies that they will implement in the pursue of boosting those factors that can actually stimulate growth. If they knew exactly which are the determinants of the rate of economic growth they would try to enhance them and the government policies would be more targeted and more efficient. Therefore it is important for the determinants of economic growth to be identified.

Many economists indicated different factors and developed different theories that can actually affect the rate of growth in an economy. Robert Solow clarified the role of the accumulation of physical capital and the importance of technological progress as the key to sustained economic growth. Paul Romer and Robert Lucas highlighted the significance of human capital in the growth process. Robert Barro pointed out the link between fiscal variables set by the government and economic growth. Frank Ramsey presented a rule that helped picking the optimal rate of savings at any point in time to maximize the growth rate. Many more factors have been proposed as determinants of economic growth by distinguished researchers, many of which are empirically proven to affect growth the way the theory predicts.

The main goal of this paper is to empirically identify the most important determinants of economic growth. But first, a literature review will be conducted in order to see the most important theories regarding economic growth and what they suggest it could stimulate or retard an economy's growth process. In section 1 of this paper a review of these theories that where milestones in the change of the way economic growth were perceived will be briefly analyzed. In section 2, the most widely acceptable determinants of economic growth will be analyzed in a theoretical framework and how they were incorporated in growth models. Finally, in section 3, the empirical model that is used to investigate the empirical factors of growth will be presented as well as its results.

1. Different Theories about Economic Growth

There are many researchers and analysts that developed different models and theories about the way they perceived the economic growth process in an economy. Each and every one of them contributed in the field in a different way but still added a pebble in the thinking of what factors actually stimulate growth in an economy and why economies exhibit different rates of growth. In this chapter, the most important theories of economic growth will be described and analyzed, the ones that changed radically the way economic growth is understood and what policies should be implemented in order to trigger the economy to grow. Theories old enough will be illustrated, from Solow's and Ramsey's theories to most recent like Romer's and Barro's. But first I will briefly review the history around economic growth and how the latter was faced by economists throughout the years.

1.1 A Brief History Review of Economic Growth Theories

Classical economists like Adam Smith (1776), David Ricardo (1817) and much later Frank Ramsey (1928), Allyn Young (1928) and Joseph Schumpeter (1934), among others, are the first economists that contributed in the field of economic growth by setting the stage for the basic elements of modern growth theory. These elements embody ideas such as diminishing returns and their relationship with the factors of production's accumulation, the effects of technological progress with the form of increased specialization in labor and the discovery of new products and production methods as well as the part of the monopoly power as motive for technological innovation.

After the original attempts of Adam Smith and the other supporters of classical theory, not many researchers devoted their time into developing new theories about growth or improving the old ones for two reasons mainly. First of all, they lacked the mathematical and computational methods to analyze complex dynamic problems like the intertemporal maximization problem. The second reason is that they lacked the statistical data to check and prove or disprove the dominant economic theories up to that point in time. Researchers managed to overcome these two difficulties and start again the occupation with the growth theory in the middle of 80s. The introduction of new computational methods and the creation of databases for many countries which allowed the comparison amongst them offered the needed push in both the theoretical and empirical research in the field of economic growth. Nowadays, economic growth constitutes an important branch of economic theory and has attracted many great economists to work at it. Due to new methods and databases a new theory of economic growth has been developed with main element the use of endogenous technological growth models. In this kind of models, except for the physical capital in its normal form, human capital and technology have a fundamental role, while special emphasis is given to externalities and increasing returns.

In chronological order, the first one who contributed in the modern growth theory was Ramsey (1928) who developed a theory about the intertemporal household's maximization problem. A great contribution in the field was the parallel use of neoclassical production function by both Solow (1956) and Swan (1956). This function combined with the assumption of a constant saving rate produce a simple general equilibrium model, which predicts convergence of incomes, and that without technological progress economic growth cannot be sustained in the long run and eventually it will stop. Cass (1965) and Koopmans (1965), by using the Ramsey model, managed to render the saving rate endogenous and extend in that way the Solow model, despite the fact that the assumption of exogenous technological changed remained unchanged while it was necessary in order for economic growth to be produced.

The introduction of an endogenous technological progress theory in the neoclassical model is hard to be incorporated due to the competitive assumptions of the model. Technology, in a way, is a public good. Since the production function is characterized by constant returns regarding the competitive inputs of labor and capital, the production function will be characterized by increasing returns if technical expertise is included as an input. Increasing returns, however, cannot be incorporated in a perfect competition framework, as the evaluation of expertise with the marginal production cost does not provide the necessary economic motives for research and development of technology.

Based on an idea of Kenneth Arrow, Sheshinski (1967) build a model where expertise constitutes an indirect outcome of production and investment. In that way, externalities can be incorporated in a classic model, and as a direct implication its solution is not Pareto optimal. The main conclusion is that the competitive model falls apart when endogenous technological progress is introduced, and modifications have to be made in order to construct a successful technological change theory, like introducing imperfect competition. Therefore, the main point of modern economic growth theory is that research for technological progress is a costly procedure and individuals are willing to bear that cost only if they expect a benefit from it.

All these changes were introduced in the modern bibliography by Romer (1986, 1990), in order for the modern endogenous growth theory to be constituted. This theory examines the existence of economic growth as an endogenous outcome of the production procedure, instead of considering the technology as a factor of production which is improved exogenously. In this framework, researchers such as Lucas (1988), attributed to human capital, the creation of endogenous economic growth, while others like Barro (1990), analyzed the role of the government through its ability to provide public goods which behave as factors of production, and examined issues such as taxation and the optimal size of the public sector.

1.2 Ramsey's Theory of Economic Growth

The first theory I am going to analyze is Ramsey's Theory. Frank P. Ramsey (1928) tried to provide a solution to a problem faced by every economy, at every point in time, which is what the optimal saving rate should be. In other words, as he quoted in his paper: "How much of its income should a nation save?" Many researchers in their model take the saving rate as a constant. What Ramsey actually achieved is that he created a rule to determine the portion of each person's income which needs to be saved. According to him, the saving rate in an economy multiplied by the money's marginal utility should be at any given point of time equal to the amount of the total enjoyment of utility rate which is less than the maximum possible utility rate. To someone's surprise this rule remains valid even under too general conditions. However, the choice of the saving rate is now endogenous, making it the exact innovation of this theory. This model studies the maximizing behavior of the representative household and incorporates the decision of each household in an infinite time framework of perfect maximizing behavior. In that sense, a new dimension is given in the study of economic growth, as an arbitrary percentage of income is not adopted as saving rate.

Of course, in order for such a rule to remain valid under general conditions and be justified at all times, many simplifying assumptions took place. First of all, the economy remains unchanged throughout time in numbers, in the aversion people have to labor and the enjoyment's capacity. Furthermore, both sacrifices and enjoyments can be calculated at different points of time and then added with no restrictions. Something that should definitely be mentioned is that it is assumed that later enjoyments do not get discounted compared to earlier ones. This assumption can create difficulties and therefore is taken into account in a different version of the solution to the original equilibrium. Ramsey also ignores distributional considerations so that the total satisfaction in the economy is a function of total consumption and total labor. In addition, it is assumed that every different good and every different form of labor is expressed on fixed terms. In that sense, we do not need to differentiate between forms of capital, labor and consumption but we address them as one form. Foreign trade is not excluded, providing that we assume that the foreign nation is in a stable condition. However, an economic agent cannot be indebted to foreigners indulgently and forever. Last but not least, we need to assume that the motives regarding accumulation remain the same throughout time and there is no danger that a later generation will consume selfishly the accumulation done from the previous ones, as well as that no catastrophic event or misfortune will occur to force the community to instantly consume everything which have been accumulated until that point of time. Someone can easily understand that the assumptions made by Ramsey are great in number and very important to hold at all times.

As for the model itself, the key to the solution is the maximization problem faced by every household in the economy. Ramsey states that every agent in the community maximizes the net enjoyment per unit of time, subject to the fact that what someone consumes cannot be higher than what he can produce given his labor and capital he owns. A person receives positive utility by his consumption and negative utility (disutility) by the amount of labor he supplies. The rate of enjoyment is increasing to capital but it can stop for two reasons. Firstly, maybe the person has already reached their maximum attainable rate of enjoyment or secondly, further capital increase might not enable them to improve their leisure or their income. Either way, there should be a finite amount of capital that provides the highest enjoyment's rate that an economic agent can obtain even if it is not the highest rate that someone can conceive. By contrast, the enjoyment which is received by capital may continue to increase indefinitely. There are two cases here as well; the rate of enjoyment may never stop to increase or it will approach a certain finite limit asymptotically. The first one is dismissed because economic causes could not provide more enjoyment than a certain amount. In the second case, the rate of enjoyment which is near the finite limit may be the maximum conceivable rate but it may not be as well. This enjoyment rate, which is the maximum someone could obtain, but it is not the greatest someone has imagined, Ramsey calls it "bliss". In that sense, every person in the economy should save a certain proportion of its income in order to reach bliss. The more he saves, the faster he gets there, but he decreases the enjoyment he receives at the present. Therefore, these two facts contradict each other and a certain rate of saving should be calculated in order to maximize both.

A feature this model has, which is remarkable, is that the rule for the rate of savings is independent of the production function directly, but only indirectly to the extent that it determines bliss and the present rate of interest. If we discount the future at a constant rate while the rate of interest is constant as well, then the amount of income that we must save is dependent on the discount rate to rate of interest ratio.

Before proceeding to the presentation of the equilibrium of the model, it is worth considering the changes that Ramsey's assumptions would bring about if they did not hold. First of all, the population cannot stay the same forever, it will probably increase in numbers and therefore the saving rate should be greater. Furthermore, future inventions may increase the level of bliss to a higher level than it is right now or appears to be with the present knowledge, e.g. new needs may arise. Inventions, however, can have a contradictory role as well. They may make income more easily obtainable, with less sacrifice, which is a clear reason to save less portion of your income. Lastly, the gravest factor that is neglected and can have serious consequences in the decision of the rate of saving is the possibility of future destructions due to natural phenomena or even wars. These incidents cannot be accounted for adequately and can have severe implications to the behavior of the saver. If the saving rate is set too low considering a long-run horizon, an incident like the ones mentioned before could destroy both the interest and the principal.

Now returning to the equilibrium of the Ramsey model, one can obtain all the necessary information to understand what is actually going on in the economy by looking the following graph. Figure 1 is a phase diagram and shows how much of his income someone should save and how much he should spend given the maximizing behavior we have already mentioned. But first of all, let's explain what it is pictured in this graph: Y_t shows the unearned income which is consumption minus the earned income, r is the rate of interest, c is capital, z is the total unearned income which is equal to bliss in the equilibrium, Q is the tangent to the curve from point P and η is the greatest excess of earnings over consumption compatible with continued existence.

From the point Q and taking the abscissa to the horizontal axis, we see how much of his unearned income a person should save. In the special case where y is negative, that means that not only the unearned income should be saved, but a portion of his earned income should be saved as well.

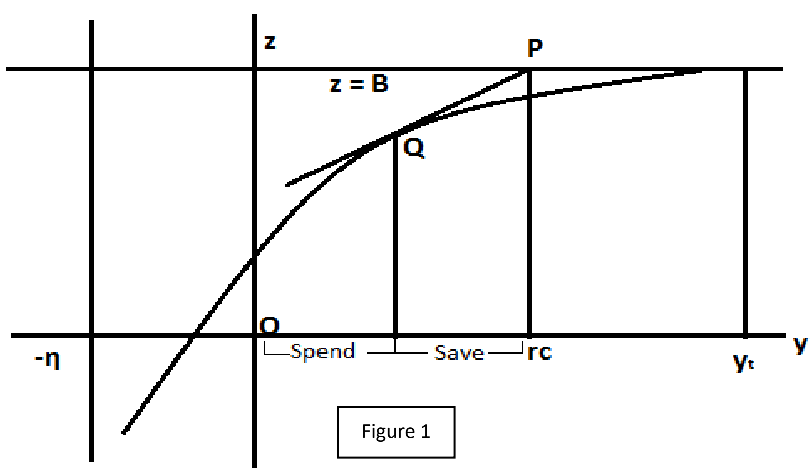


Figure 1

The graph above is the case when the time horizon of the maximization process is infinite. If the time horizon is finite, the procedure remains almost the same but must be taken into account one extra parameter; how much capital one wants to bequeath to his heirs.

The last modification Ramsey does in order to escape from the restrictions posed by his own assumptions is to discount utilities and disutilities at a constant rate. This is a bit tricky and it must be stated that this discount rate use for utilities is not the same as the one used for discounting money units. When Ramsey assumes that the discount rate is constant, it means that the present value of a specific enjoyment at any future point in time is to be received by discounting it at the predetermined constant rate. He discounts in this way in order to remain consistent with another one of his original assumptions, which is that successive generations are motivated by the same preferences. Again, even though the procedure is a bit more cumbersome than the first scenario with which Ramsey worked, the main conclusion is confirmed.

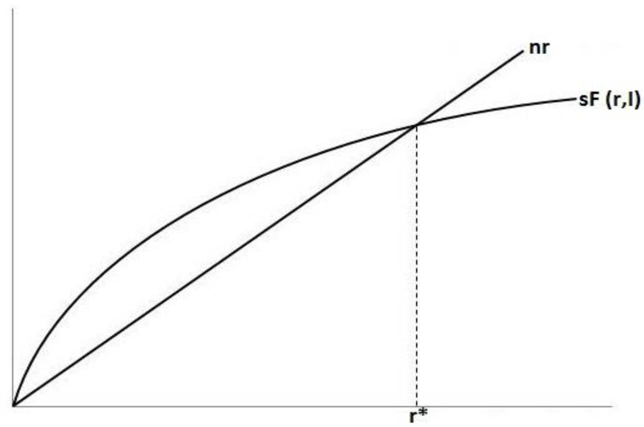
In conclusion, Ramsey determined a pioneering way to compute the optimal rate of saving an economy should use in order to maximize its utility. The Ramsey model, and the intuition behind it, is used very widely in the study of economic growth and in the development in growth models. To be precise, it actuated an extension of the neoclassical model in which the results are similar to the Solow-Swan model, meaning that in the steady state of the economy there is no long-run growth.

1.3 Solow's Theory of Economic Growth

Robert M. Solow (1956) managed to develop one of the most important and simplest dynamic model of general equilibrium ever created, the neoclassical model of exogenous growth. This model is regarded as a starting point in the study of the economic growth phenomena and, of course, a benchmark for every growth theory that was developed afterwards. Solow with his model achieved to highlight the main reason that determines the existence, or not, of economic growth in a consistent way. He pinpointed that the only way to maintain a positive rate of growth in the long run is the elimination of the diminishing returns of the inputs used in the production. The only way that this can be attained in capital accumulation is with the introduction of exogenous technological change. The assumptions used to substantiate the model are a bit restrictive, but as he quotes himself "that is what makes it a theory".

First of all, there is a closed economy which produces only one commodity. In that sense, we can speak regarding the community's real income. For each commodity, a part of it is consumed and the rest is saved with the intention of investing it. Therefore, in this economy the stock of capital consists of the accumulation of the saved part of this commodity. In the production, only two factors are used, capital and labor. The production itself exhibits constant returns to scale, indicating that the production function is homogeneous of first degree. Solow regards population growth as exogenous, which means that the labor force increases at a constant rate. When the time path of both capital and labor is determined then the time path of real output can be computed from the production function.

In order to present and explain the solution of the model, consider the following figure.



In the graph above, n stand for the population growth rate, s for the saving rate, F(r,l) for the production function with respect to capital-labor ratio, r for the ratio of capital to labor and r* for the first derivative of r. This graph shows, firstly, that no output is produced unless both factors of production are positive. That is something logical and easily understood; with no factors of production, the production procedure cannot take place. Additionally, the marginal productivity of capital is subjected to diminishing returns. Those two facts can be derived from the shape of the production function; it starts from 0 and follows a continuing a convex upward route. Equilibrium is established at the intersection point which depicts the steady state of the economy. If and when, the economy achieves its steady state goal, capital and labor will grow in proportion henceforward. At this point it is clear that once the steady state is attained then there is no growth in the output as it will also grow at the same rate as labor and capital which is the population growth rate. The only point of time when economic growth occurs is when the capital to labor ratio is above or below the steady state value. Whatever its initial value may be, the economy will develop a stable growth path at the natural rate towards the steady state. If the initial stock of capital is less than the equilibrium ratio, then it will grow at a faster pace than the labor force such as the output, until the equilibrium ratio is established. If the initial ratio is greater than the equilibrium one, then both output and capital will grow slower than the labor force. The graph may not have always this shape, there may be 3 intersection points between the two lines, but the idea is going to be the same. The capital to labor ratio will always converge to its steady state.

The main conclusion that the Solow model reaches to, is that there cannot be long-run economic growth, but only short-run, when it satisfies the neoclassical assumptions. Without technological change, the accumulation of capital itself cannot trigger long-run economic growth. The economy will always move towards a steady state in which the rate of growth will be constant and equal to zero. This conclusion, therefore, is not completely realistic as the model is too simplified.

An extension of the model which incorporates long-run economic growth is the introduction of neutral technological change. An easy way to embody the technological change is to simply multiply the production function by an increasing scale factor. In that case, the capital stock increases faster than the previous case in the long-run. But the capital stock is not the only factor that grows faster, real output does as well. The intuition behind this result is that as real output grows, future saving and investment grow as well which makes the growth rate to increase more rapidly. Now the capital to labor ratio never reaches an equilibrium value but continues to grow evermore. So, someone can now understand how the incorporation of technological change may cause long-run economic growth.

There are more extensions of the Solow model that Solow himself suggested. One of them is the modification of supply of labor into a function that depends on the real wage rate and time. In the benchmark case Solow assumed that the supply of labor is completely inelastic to wage. Someone could develop the model with the assumption that no matter what is the size of the labor force, the proportion of labor offered is dependent to the real wage. With this change, the capital to labor ratio has the same steady state value as before, but in the long-run both the real output and the stock of capital will grow at the same rate that the labor force will.

Another extension is regarding the saving rate variable. In the model so far, everything that occurred affected both capital and labor factors. Although, the labor force was set by exogenous factors and capital stock was known from the beginning as it was assumed that agents in the economy saved a constant amount of their income. With positive real income, every period new capital was formed as a fixed proportion of the income was saved and then invested. To expand this assumption, instead of the saving ratio being held fixed, it could depend on the yield of capital. In that sense, there could be a scenario where saving rate is zero even if the income is positive and therefore the stock of capital would be at least stationary. That change can be incorporated in the model if the portion of income that is saved depends on the real return of capital. It is already assumed that the production function exhibits constant return to scale, so the owners of capital will rent their capital with respect only to the capital to labor ratio. The results of this model differ from the original in the sense that the equilibrium value of capital-labor ratio could be smaller or larger. There are many possibilities and many possible shapes and patterns for the curves, even though the net effect has the tendency to become stabilizing. The general rule is that when capital-labor ratio is high then the saving ratio is significantly reduced and vice versa, when it is low then saving is encouraged. But there might even be polar cases where savings are zero when the ratio is too high, but the growth of labor force will eventually reduce it.

Lastly, Solow considered two more extensions regarding the population growth variable and taxation. As for the first one, a different assumption can be made and suppose that population does not grow with a constant rate but it grows endogenously, meaning it can depend for example on the capital-labor ratio. In that scenario, the economy could lead to different steady states where the capital accumulation is low and economy returns to stagnation or the investment is so large that the economy reaches a self-generating expansion of both per capita income and capital. As for taxation, it can be easily incorporated into the model. Let's assume that the tax is proportional and is applied to the income; then the only thing changing is the effective savings rate which could be larger or smaller. If the government consumes immediately the tax profits then the effective savings rate is smaller. On the other hand, if a proportion of them is invested, then the value of the effective savings rate could go either way.

1.4 Romer's Theory of Economic Growth

Paul Romer (1986) tried to indicate the significance of human capital in economy's aggregate output. He assumed that firms take action in research and development producing knowledge and that this procedure has positive spillovers that actually improve the public stock of knowledge. In that sense, he pinpointed the role of knowledge in the growth process. To be more exact, Romer provided the necessary conditions so that increasing marginal productivity in knowledge can be accommodated in a model of long-run growth.

The dominant theory for long-run growth, before Romer's contribution, was that both the rate of return on investment and per capita growth was decreasing functions of per capital stock and that wage rates tend to converge over time. Therefore, when technological progress remains unchanged, there should be no long-run effect on the level of output and consumption and the economy is moving to a steady-state price of per capita output with no per capita growth.

The model that Romer is proposing in his paper in 1986, suggests that not only the rate of return on investment and per capita growth can be increasing functions of capital stock, but also that in a competitive equilibrium per capita growth can be positive and possibly monotonically increasing over time. Furthermore, he argued that different countries may not converge over time in per capita output terms. Developing countries do not necessarily grow at rates greater than the developed ones but they may grow persistently slower or even not at all. The key point, in which the results are based, is the departure from the assumption that most models nest, which is the assumption of diminishing returns. To be precise, Romer's model can be regarded as a model of endogenous technological change that the driving force of long-run growth is nothing else but the knowledge accumulation by agents who wish to maximize their profits in a forward looking way. It is assumed that new knowledge is produced by research technology which exhibits diminishing returns. When you invest in new knowledge you actually create a natural externality. That is because if you create new knowledge, no matter how much you try to keep it a secret with patents, at some point there will be spillovers to the other firms as well, as knowledge cannot be patented perfectly, which will lead to the extension of their production possibilities too. The most important thing, that I have already mentioned, is that knowledge can have an increasing marginal product, which means that when a firm produces consumption goods as a function of knowledge it exhibits increasing returns. In that sense, knowledge can grow without any limit. It would not be optimal to stop producing when you reach a steady state where there is no new research and development procedure taking place and the stock of knowledge is constant, ceteris paribus.

To sum it up, these three main elements, the increasing returns in the production of the new good, the diminishing returns in the knowledge's production and the natural externalities, are all used together in order to create a well-specified model of growth in a competitive equilibrium framework. The equilibrium arising from this model can be used to explain historical growth when the government does not intervene in the economy at all.

In his effort to justify his work, Romer developed both a simple two period model and an infinite horizon one. As for the first one, someone should consider a discrete time growth model with only two periods. Every consumer in this framework is considered identical and consumes a single good in the two periods. Each consumer is given an initial endowment of the aforementioned output good in the first period. In the second period, the output good must be produced and it is a function of the state of knowledge and other factors such as labor and physical capital. It is assumed that only the stock of knowledge can be enhanced, in order to end up with a one-dimensional choice problem. There is a research technology that produces knowledge, used in period two, from forgone consumption in the first period. That means, the more an agent consumes today, the less knowledge can be used to produce more output and thus more consumption next period. There is a trade-off between them. We know that knowledge cannot be perfectly patented and thus cannot be used only by the creator of it forever, and therefore the technology used by the firms depends on the firm specific inputs knowledge and physical capital, labor etc and of course the aggregate level of knowledge in the economy. The equilibrium in this model is nothing else but a standard equilibrium with externalities. Each firm aims to maximize its profits, taking as given the aggregate level of knowledge. Each consumer provides a portion of their endowment and all the factors firms use as inputs, to them, during the first period. In the second period they purchase output goods with the rents they received from the factors they supplied in the previous period. Both the consumers and the firms take prices as given during their maximization process.

The case of the infinite horizon model in continuous time is analyzed exactly as in the simple two-period one already mentioned. There are though some differences due to the fact that in this case we no longer address time as discrete. For example, if the trade-off that we mentioned in the two-period model between forgone consumption and new knowledge still holds, you can create new knowledge by reducing current consumption, but it is no longer assumed to be one for one. In that sense, a form of diminishing returns is imposed in research. The marginal productivity of knowledge is still positive and therefore there is no point in time that it will be so low that there will be no benefit from investing in research. But some form of diminishing marginal productivity is exhibited.

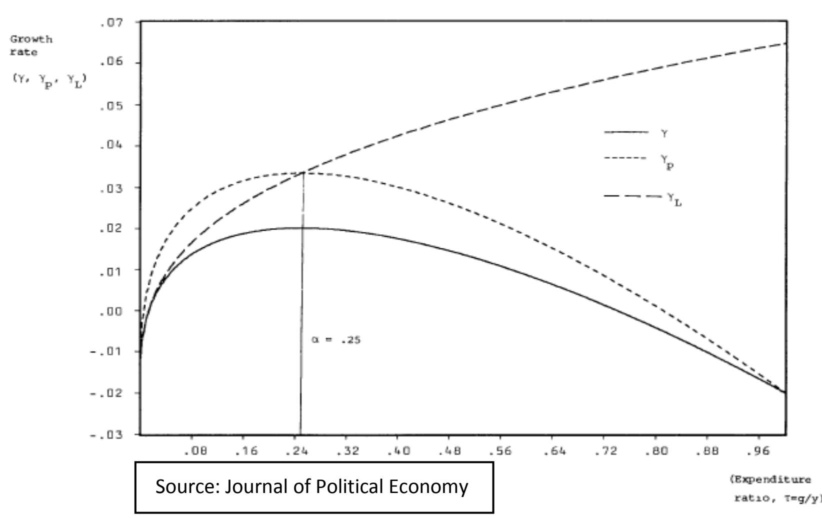
1.5 Barro's Theory of Economic Growth

Robert J. Barro (1990) made a great contribution to the field of economic growth by creating a model that links the actual growth of an economy to fiscal variables which are chosen by the government. In order to perform such a task he started from a model of endogenous growth. He then assumed that if the under consideration economy is closed, there are constant return to capital and constant population. The time horizon of the representative agent is infinite and he aims to maximize his overall utility. Each worker offers a fixed amount of labor in terms of time which means that there is no dilemma between choosing labor over leisure. The constant return assumption becomes believable if someone views capital more extensively in a way it can consist of both nonhuman (training and education of the labor force) and human capital. The key element to the study of the steady-state growth is the constant returns to scale in exactly these two types of capital, but we do not differentiate amongst them, we consider them as one. In order to make sure that there is going to be steady-state growth, Barro assumed that the technology of the economy is productive just as much to ensure that kind of growth, but not too productive, which causes the utility to grow without any bound. In this model, all the variables grow at the steady-state rate of growth; hence the economy itself is growing. In this framework, the public sector is introduced as the provider of public services to the households, while the later are not charged for when they use them. These public services are considered as inputs to private production. This is the link between growth and government. So considering everything mentioned up to this point, production exhibits constant return to scale in both government spending and capital but in capital it exhibits diminishing returns separately.

The way that the government provides services which are used as a production's input might cause concerns regarding their specification. The first concern is about the services' flow. It is not mandatory for this flow to correspond to purchases conducted by the government. This issue needs to be solved beforehand in order for the model to be empirically implemented. It is adequate to consider that the government has no capital in its possession and does no production on its own. If both the private sector and the government face the same function of production then the outcome would be the same as if the government produces the final good on its own by buying the private inputs needed, instead of buying them from the private producers which is exactly what Barro assumes is this model. The second concern that might arise is the nature of the public good to its user, and to be more precise if it is rival or nonrival for him. If it is indeed nonrival then public services are the total purchases performed by the government and not the per capita amount that concerns each person individually. The nature of the public services is crucial in order to determine the scale of the government's activity. Barro argues that only few of the government's services are actually nonrival, while most of them are rival.

Back to the model, it is assumed that the government finances its spending contemporaneously, with an income tax whose rate is flat. It should be mentioned that the government's budget must be balanced at all times. It can sustain no deficits by borrowing or accumulate assets and cannot run surpluses. Furthermore, regarding the representative producer, it is assumed that the amount of services received from government do not change when his amount of output and capital changes.

Taking everything into consideration, Barro concludes that in order to achieve the maximum rate of growth in the economy, the government should manage to set its gross national product's share equal to the one it would receive if there were a competitive market of production's inputs and the public services were supplied in it. The following graph depicts the relation between the growth rate and the variables set by government, the tax and expenditure rates.



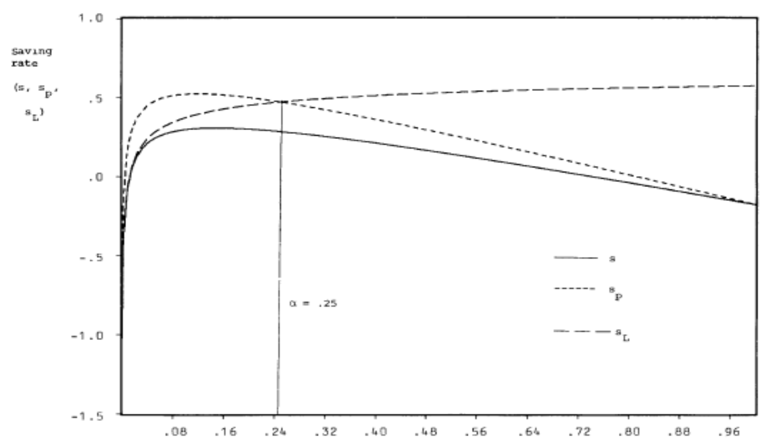
Source: Journal of Political Economy

As it can be understood by looking at the graph, the solid line depicts the previously mentioned relationship and specific numerical values are assumed for illustrative purposes. It is observed that, over some range, the growth rate has positive value if the economy's productivity is sufficient in relation to the time preference rate. In his paper, Barro mentions the exact relationship which needs to be satisfied in order for a range with positive growth to take place and it is the following:

$$A^{\frac{1}{1-a}} * (1-a)^2 * a^{\frac{a}{1-a}} > p$$

As it is mentioned in the beginning of the analysis, the economy's productivity is not so high that achieved utility can become unbound.

Instead of growth, a government could maximize the savings rate. The second graph depicts the relation of the saving rate with the tax rate for the case of Cobb-Douglas technology. As someone can easily observe, the rate of savings peaks before the rate of growth does. There is no specific reason to pick the saving rate as a maximizing parameter over the growth rate per se. A compassionate government in this model aims to maximize the representative's household utility. But we have assumed that the economy is constantly in a steady-state growth position. Therefore the achieved utility can be computed directly only if the flat-tax rate remains stable over time. However, the maximization of attained utility corresponds to the maximization of the growth rate in the Cobb-Douglass technology framework. In that sense, a compassionate government would chose to maximize the economy's growth rate and not the savings rate.



Source: Journal of Political Economy

All the analysis conducted before on the government's size provides solutions to second-best policy problems. Taxation and public expenditures cause externalities and therefore the decentralized saving choices create results which are not Pareto optimal. If anyone wanted to assess the decentralized results, he should compare them with the ones from a planning problem which is unrealistic. Comparing these two cases, Barro concluded that due to the income tax in the decentralized case, the saving and consumption choices result in too little growth.

If the government replaces the income tax with a lump-sum tax (such as a consumption tax) the consumers choose higher consumption's rate (and saving rate) due to the higher capital's return. In the

Cobb-Douglas technology framework a lump-sum tax is preferred to the income one. But in an economy where there is a large government, the income tax is much more preferred.

Going back to the income tax situation, if the government increases its expenditure in a sense that the property rights are improved, from the investors' point of view, it is viewed as marginal tax rates' reduction. Hence, in terms of the previous figures, a property rights enhancement causes an upward shift of the solid lines, like moving from the solid to the dashed curves. This means that both growth and saving rate increase. By increasing the public spending in areas that property rights are improved, the government actually manages to reduce the effective value of the income tax and not cause a direct effect on the function of production. In this case again, the implications on saving and growth rate are the same as before.

Last but not least, Barro considered two more alternative cases the model can incorporate. The first one is the case where the government uses the income tax to finance services that are included in the consumer's utility function. In this case, the share of government expenditure that maximizes the economy's growth rate is lower than if it would not finance other spending types with the flat-rate income tax. However, this government's choice does not maximize the utility achieved by the representative consumer. The second case, elaborated by Barro, is the case where the government does not work in favor of the households but is, in reality, a dictator who aims to maximize his own utility. The difference from the original case, analyzed in the beginning, is that the government now is not forced to run a balance budget but it can acquire the net revenue. This net revenue is used by the governing agent in order to obtain his own consumer goods which are used to increase his utility in the same manner as the households do. The result is that the self-interested government picks the same value for the optimal expenditure rate as the compassionate one. This agent aims to maximize the whole tax base the economy has to offer. The self-interested agent's consumption actually has the same outcome as the consumption services offered by the benevolent government like mentioned before. Hence, in both cases, the conditions needed for productive efficiency still hold no matter the consumption flows taking place. The difference is that in the first case the exceeded revenues are used to provide consumption to the households and in the second one they are used to increases the governing agent's own consumption.

2. Determinants of Economic Growth

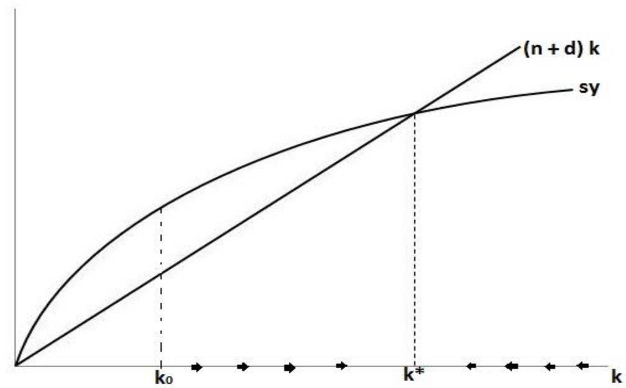
Economies and economic agents aim to maximize their income's rate of growth, it is their top priority. In order to do so, they need to know what factors can increase the growth rate so that they can accumulate them, or more generally focus on the augmentation of these factors. Researchers throughout time attempted to pinpoint the significance of some factors among others. To achieve that, many models that incorporated economic growth and specified how different factors affect the rate of growth in both equilibrium and the transition to equilibrium were developed. In many cases the convergence to equilibrium speed matters as well to equilibrium itself. The first approach to study economic growth leads to the result that economic growth can only be achieved through technological progress. However, technological progress was regarded as exogenously given. In that sense, the only way to sustain long run growth is to constantly invent new technology, like new methods of production. These models are models of exogenous technological progress. Thankfully, as research intensified, new models were developed that considered the technological process as endogenous, meaning that it could be determined and affected by the economy's operations. These were models of endogenous technological change and they led to sustained long run economic growth. The endogenous technological progress can be achieved through two ways. The first one is by accumulating education and personal skills by the labor force and the second is by new inventions through research and development process. Under this framework, in this section the effect of the most important factors that determine economic growth will be analyzed, mainly as a result of technological progress. Economists have pinpointed many factors that actually do affect growth but only the most important and widely accepted will be described.

2.1 Technology

Up to this point, someone would have already understood the great importance of technology in the growth process of an economy. Without its contribution economic growth could not be achieved. The first developed and detailed attempt to incorporate technological progress in a growth model was by Solow (1956) and Swan (1956). In the first section of this paper, Solow's growth theory has already been described. But now technological progress will be specifically described, as an extension of the neoclassical growth model. Firstly, the basic results of the neoclassical model will be presented briefly and then we will focus on the outcome of technological change.

The basic results of the simple neoclassical model are the following. First of all, in the absence of technological progress, physical capital accumulation and an increase in the size of the labor force cannot constitute economic growth sources. Furthermore, a way for the per capita income of the economy to grow constantly is the elimination of the diminishing returns.

It is already presented that the economy has the tendency to move to a steady state. The steady state is the equilibrium of the model. When the economy reaches the steady state, its rate of growth is zero. The output per worker is constant. The output, however, is growing but only at the population's growth rate. The long run equilibrium is presented in the following figure. As the reader can see, the equilibrium is reached in the cross point of the two curves. The straight line represents the new per person investment in order for the capital per worker to remain constant. The other one represents the investment per person. When the economy has a value of capital lower than the steady state value, then it is growing in order to reach equilibrium (which means that the capital to labor ratio will increase), and vice versa. The reason that in the long run steady state there is no positive growth rate is that the per capita output, capital and consumption remain constant while the aggregate amount increase with the rate of the population growth.



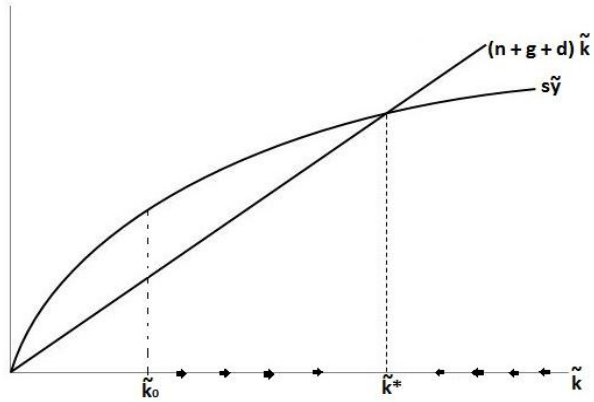
In order to introduce exogenous technological progress in the model a technology variable is added to the function of production. When the variable enters this way, it is said to be Harrod neutral[1] or labor augmenting. In that sense, when the value of the technology variable increases then the technology of the economy advances. This means that the economy cannot do anything to produce technology, it comes as a given. Therefore, an assumption of the neoclassical model with exogenous technological progress is that the technology in the economy grows at a constant rate. In addition, given a balanced growth path, both capital per worker and output per worker grow at a rate equal to the one that exogenous technology grows. This implies that exogenous technological change is indeed the origin of growth in an economy. The analysis of the model is the same as the simple neoclassical model but has one key difference. That is the fact that the capital variable is no longer constant over the long run and therefore the model is needed to be solved in terms of another variable. The role of the new variable will be played by the capital/worker to technology ratio. The Solow diagram for the case is presented by the following figure.

Again, the equilibrium of the economy holds at the cross point of the two curves. These curves differ from before as we can see the growth rate is present in the straight line's equation. Imagine a situation where the economy finds itself below the steady state. Then the capital to technology ratio will start to increase over time until it reaches the steady state value, where the economy grows towards a balanced path of growth. That happens because the individuals invest more than it is needed in order for the capital to technology ratio to stay constant. If, on the other hand, the economy happens to be above its

[1] An innovation is defined as Harrod Neutral if the relative shares of inputs remain stable for a certain capital to output ratio

steady state, then the capital to technology ratio will start to decrease over time, as the investment undertaken by the agents operating in the economy is less than the one actually needed in order for the capital to technology ratio to remain constant.

So, this is how exogenous technological progress is incorporated in the neoclassical growth model and its presence means that an economy continues to grow in the long run as long as technology improves. The growth rate is actually the rate of technological progress.



However, the exogenous technological progress assumption is considered by many economists unrealistic. This is the case because, by exogenous technological progress it is implied that the economy’s function cannot affect the technology at all. To be more precise, the economic agent’s decisions who operates in the economy cannot affect the rate of technological advance. Of course, in the real world this is not the case. Technological progress demands great research effort and a great amount of resources are needed to be allocated in this action. Both the government and the private firms devote a great amount of funds in order to absorb and exploit the benefits that arise from the improvement of the technology. In that sense, research and therefore technology are economic phenomena which need to be determined endogenously from the economy’s function.

These considerations lead to the development of various theories of endogenous technological change, many of them described in this paper. However, the exogeneity technological assumption is a great way to pinpoint the importance of technology in economic growth.

2.2 Human Capital

An important factor that can affect the growth rate of an economy is the human capital. Human capital is the total expertise and technological know-how that can be obtained and accumulated by individuals. In that sense, human capital is nothing more than the abilities and knowledge of the labor force. By accumulating human capital, the diminishing returns in the production can be eliminated and the economy can achieve long run growth, which is now an endogenous process of the economy’s function. In order to present the effect of the human capital factor in an economy, two kinds of model will be analyzed. The first one is a learning-by-doing model which firstly introduced by Kenneth Arrow (1962) and then by Paul Romer (1986). Then, a one sector and a two sector models will be explained in which the human capital accumulation process coincide with the accumulation of physical capital. The key feature of this kind of models is that the economy itself allocates resources in order to create new human capital. The only problem of them is that the equilibrium is not Pareto optimal as the human capital's stock is less than it should be. A way, of course, to reach Pareto optimality is to let the government intervene in the economy with the optimal policy in order to provide the necessary human capital and achieve higher growth rate in the equilibrium.

Let us start with the learning-by-doing model. In this model, there are two factors of production, physical and human capital. The human capital does not simply correspond to the number of workers but embodies their talent, education and knowledge. Every factor that affects the labor's productivity is contained in the term human capital. It is also assumed that the economy's population is constant. Thus the effect of human capital accumulation will be the real effect. The only way for long run economic growth to be achieved is by eliminating diminishing returns in the factors that can be and are accumulated. In order to do so in the human capital accumulation, it is assumed that its creation is an indirect effect on allocating resources in investment in human capital. When a firm decides to invest in physical capital, what it actually achieves is to learn how to produce more efficiently. Each firm in the economy considers the human capital factor in its production function as the total number of workers that the firm has in its disposal multiplied by a factor that presents the level of expertise available. This is exactly the idea that Arrow (1962) elaborated, that advancements in expertise and productivity originate from investments and production. Another important assumption in this model is the technological know-how is a public good, in the sense that its effect pervade in all the economy and every firm has access to it without need to pay any fee. Considering this, the implication is that every firm operating in the economy takes the level of expertise as constant as it is the same, as the economy's level, and proportional to the economy's total level of capital. Each firm chooses the level of capital and labor in order to maximize its profits. In this decision, it considers the rent for the capital and the wage for labor constant. An additional assumption is that they consider the total capital as constant, as it is assumed that their size is so small that they do not considers their contribution to the total economy's capital. Solving the system of equation that is derived from this set of assumptions the following results are obtained. First of all, the per capita consumption's growth rate is constant due to the fact that the population is assumed constant as well, and equal to the capital to labor ratio. Therefore the output's growth rate will be constant and positive. This means that in the long run the economy is growing, and it is proved that the human capital accumulation does lead to endogenous economic growth. However, the equilibrium is not Pareto optimal. The growth rate that a social planner could have achieved is higher than the one achieved by the decentralized economy. This happened as the firms do not take into consideration the existence of positive external effects in production due to the human capital accumulation in their maximization of their profits. Back to the equilibrium, the attained result is subjected to a scale effect. It is observed that the growth rate of the economy is larger when the size of economy's population is higher. This means that if two countries are considered are identical but differ only in their population's size, then the bigger one in terms of population will have consequently a greater growth rate as well. The reason that the scale effect takes place is that it is assumed that higher aggregate capital leads to productivity's improvement for each worker. Thus the economy with the larger population, even though it has the same level of physical capital, will gradually accumulate more human capital as the desirable effects of physical capital will spillover to more individuals.

The previous model considers the human capital accumulation as an outcome of the workers' occupation with the production process. Of course, this is a way for human capital to be created but in most cases it is produced by the various agents operating in the economy. In these type of models, once again, the creation of human capital can eliminate diminishing returns and create economic growth in the long run even in the absence of technological progress. Two models will be considered here. In the first one it is assumed that the same technology is used in the production of both physical and human capital, while in the second one two different technologies are needed. In that sense, the physical's capital production is intensive in physical capital while the human's capital production is intensive in human capital. This means that in order to produce physical capital, more physical than human capital is needed and respectively in the human's capital production, it is needed proportionally more human than physical capital.

Let us start with the one sector model. Again, an economy with constant population size is considered to produces one good. The production function is a Cobb-Douglass one with constant returns to both human and physical capital. The human capital can be assumed as the number of workers multiplied by the human capital owned by the representative worker. These two factors affecting human capital are considered to be perfect substitutes and thus only the aggregate size of them matters in the economy. However, given the fact that the population's size is fixed, the only thing that can affect human capital is the amount of human capital of the typical worker. Thus the production function presents constant returns in factors that can be accumulated. The doubling of physical and per capita human capital will lead to the doubling of the aggregate output while the labor will be the same. This is the reason why endogenous economic growth occurs. Furthermore, the economy's final output can be used for consumption or investment in human or physical capital purposes. Nevertheless, both physical and human capital depreciates at the same constant rate. The net investment of both types of capital is the new investment minus the depreciation. Solving the model in this framework, the following result is obtained. All variables in the economy grow at the same constant rate, which equal to the growth rate of consumption. Thus, endogenous growth does occur.

The model with the two sectors of production was introduced by Uzawa (1965) first and then by Lucas (1988). Lucas assumes that physical and human capital is produced with different functions of production. In that sense, different technologies are used in order to create new capital, meaning that the physical's capital production in physical capital intensive. In this model it is assumed that in order to produce human capital, there is no contribution from physical capital. Considering these assumptions, in equilibrium once again the physical to human capital ratio is going to be constant and every variable is growing with the same constant rate of growth. As in the one sector model, the constant growth rate denotes that the ability to produce new human capital lead to endogenous economic growth. It should be mentioned that the economy's growth rate is an increasing function of the technology's constant in the human's capital production function, which means that the better that technology with which the human capital is produced the higher the rate of economic growth that can be achieved. However, as in the one sector model, the results are not Pareto optimal. Again the firms do not realize that their behavior in attempting to maximize their profits in sot only affected by the chosen amount of private production function, but they are affected by the aggregate amount of these factors which are available in the whole economy. A way, of course, to solve that problem is by letting the government, intervene in order to achieve Pareto optimality. As for the dynamics, the Uzawa-Lucan model is a bit different from the one sector model in terms of the effects that imbalances between human and aggregate capital cause in the economy. In the one sector model, any imbalance between these two factors leads to an increase in both the economy's growth and consumption rates. The growth rates in the Uzawa-Lucas model have the tendency to increase if the physical capital is more scarce than the human capital and decrease if the physical capital is abundant than the human one. In the extreme case of a war, if the outcome was great physical capital destruction, the economy would recover much faster than if the outcome would reduce significantly the human capital. These results are present due to the assumption that the one of the two sectors, the education sector, is intensive in human capital. In the case where the human capital is scarce, its marginal products in the sector where the goods are produced would be high and therefore the main reason why economic growth will occur is because of the human's capital high rate of growth. Furthermore, the high aggregate capital to human capital ratio indicates that the wage rate in the education sector will be high (high cost to operate) and therefore create incentives for the individuals to allocate human capital in the goods' production and not in education. However this last effect has the tendency to hold back the growth rate. Similarly to Uzawa (1965) and Lucas (1988) Rebelo (1991) worked a two-sector production model that leads to almost the same results.

Taking everything into consideration, the importance of the human capital in the growth process is significantly important as, under the right conditions it can help to eradicate diminishing returns in the function of production, which are the main reason that long run growth cannot be attained by an economy. The accumulation of knowledge, skills and education can definitely endogenise the growth process as a result of the economy's operation, as all the previous models clearly depicted.

2.3 Research and Development

As we have seen so far, technology is by far the surest way for an economy to grow in terms of GDP in the long run. Human capital can also provide the necessary conditions for an economy to grow, even in the absence of technological progress. The problem with human capital is that it can solve the problem of economic growth via the elimination of diminishing returns only in the short run. In reality, by accumulating both physical and human capital constantly, it is possible to reduce the long run rate of return and therefore to stop the economy from growing, without any technological advance. Considering this, we should definitely examine the ways to improve the economy's technology in order to eliminate the impact of diminishing returns in the long run. When we talk about technological progress we actually talk about new types and better quality of goods or new methods of producing them. A way to progress in terms of technology is to devote resources in research and development actions. In order to justify how technological advance can be achieved through research and development we will use two models as benchmarks. The first one is a model where technology advances by creating new products and the second model is a creative destruction model where R&D leads to the creation of new products but the new outplace the already existing products.

Considering first the case where technological change is achieved by developing new products through a research and development process (Barro, Sala-i-Martin (2004)). In the economy operate three agents. First of all, there are the final output producers, who rent the labor from households and intermediate goods, and then use them to produce the final output. Then, there are the R&D firms which operate in order to create new products. When they manage to create a new good they obtain a patent for it which allows them to exploit the new good by charging whatever price they see fit. Of course, the firm chooses the price which maximizes its profits. Last but not least, there are the households which maximize their utility.

As for the producers of final output, as it is already been mentioned, they combine the labor they obtained from the household with all the intermediate goods given the technology of production that they have in their disposal to produce the output which then sell in the market. The function of production suggests that all inputs present constant returns to scale. Furthermore, the new developed type of product is independent of the goods already produced in the economy meaning there is no direct substitutability or complementarity with the already existing goods. In that sense, the old goods do not become obsolete after the innovation of the new products. It should be mentioned, though, that technological progress, is not presented in the model with an increase of the technological parameter existing in the production function but it is considered as a raise in the number of the intermediate goods used by the final output's producer. This is the way that endogenous technological progress is achieved, as the constant increase in the number of intermediate goods does not create diminishing returns in the production function. The final goods created by the firms are identical and can be used either for consumption purposes or intermediate goods' production or of course for the R&D process in order to produce new intermediates.

The second agent in the considered economy is the R&D firms. They conduct the research needed in order to achieve technological advance in terms of inventing something that can allow the creation of a new type of intermediate good. Each firm confronts a decision process of two stages. The first decision which needs to be taken is whether the firm will use its resources in order to invent a new intermediate good. A firm is willing to do so only if the present value of the profits that the firm will earn if it decides to proceed with the R&D is greater or at least equal to the actual expenses of the R&D. Then, in the next stage, the firm will have to choose the price in which it is going to sell the new products. This price affects the first decision stage, as the profits of the firm depend on the price it will charge. This problem is solved backwards. The selling price is considered first, and then the net present value of the profits. Therefore, if this present value is greater than the cost of R&D, the firm undertakes the invention. Of course the firm needs to have the proper incentives. If, after the R&D, the new method was available to everyone and the firm could charge the same price as all the other firms, it would not be willing to undertake the investment. So in order to do so, after the R&D, the firm receives monopoly rights to the new product which could be enforced through patenting or secrecy. To be realistic, the R&D process involves uncertainty. No one can be sure about the success of the invention or the amount of resources needed in order to create a new product. It is assumed, though, that a deterministic amount of resources is needed to create a new product. This is the framework needed for the creation of new products to produce economic growth.

Last but not least, the households just maximize their total utility subjected to their budget constraint in an infinite horizon.

Taking everything into consideration and solving the model to obtain the equilibrium values we conclude to the following results for the growth. A higher savings rate and a superior technology have as a result an increase in the growth rate. Furthermore, a decrease in the cost of a new invention, increases the rate of investment's return and thus improves the growth rate as well. The model considered here has a scale effect in the sense that the new product can be used throughout the economy in a nonrival way. So, the higher the number of the economic agents (the labor force) in the economy, the lower the invention's cost per unit of labor. Therefore, if the labor force increases in number, the growth rate increases as well indirectly.

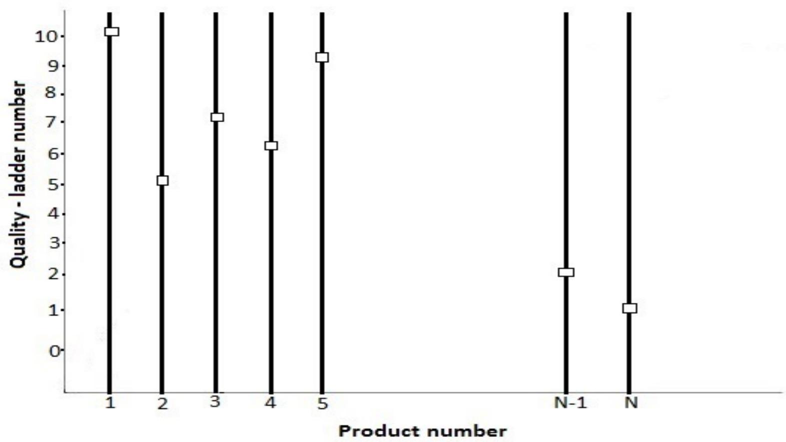
The scale effect, however, can be eliminated by altering one key assumption of the original model. It is assumed that the cost to create a new variety of intermediate products is fixed. One could assume that the previous mentioned cost is not fixed but it is proportional to the extra amount of output created by the R&D. With this assumption the investment's rate of return and rate of growth is no longer connected to the labor's endowment in the economy. Consequently, no scale effects take place in the economy, but it is still available to grow endogenously.

The only problem with this set framework, and maybe someone has already assumed, is that the equilibrium solution is not Pareto optimal. This is the case because after the invention of a new intermediate good, the R&D firm obtains a monopoly right. Because of that the decentralized economy dedicates fewer resources than a "social planer" would allocate and thus achieve a reduced output level. However, the government could push the economy in a Pareto optimal equilibrium by providing subsidies to the final good's production, or to the production of the intermediate goods or even to the research sector.

Another researcher whose paper was one of the first which applied the varieties structure formally in the endogenous growth framework was Romer (1990). The main difference in Romer's model is that a discovery needs a fixed amount of labor and not of the final product. Hence, when the number of intermediates increases, the real wage increases as well which leads to the raise of the R&D cost. Another difference is that he assumes that the more the inventing cost is reduced, the more ideas are accumulated by the society. This model concludes in some similar implications. First of all, the more willing the households are to save, the higher is the rate of growth. Additionally, the lower the R&D cost is, again the higher the rate of growth is. And finally, the same scale effect holds. A difference of the Romer's model is that the growth rate is independent of the economy's productivity parameter, which is a component of the production function of goods. That happens because it is assumed that no intermediate goods are used as inputs in the research sector. If they did, an increase of the productivity factor would improve the rate of growth.

The second model that leads to technological progress is a Schumpeterian model where the research and development has as a result the improvement of the quality of each good type, or its productivity. These kinds of models are known as the Schumpeterian models of quality ladders. The important difference in this model is that when a new product or technique is enhanced, then the old one is displaced by the brand new. Hence, different grades of quality for a certain type of good are modeled as substitutes. In that sense, the invention of a new higher quality good tends to "destroy" the old one which is now inferior. This process is established by Schumpeter (1934) and Aghion and Howitt (1992) as "creative destruction".

The structure of the model is as follows. Again, there are three sectors in the economy exactly as before; the final output producers, the firms which conduct R&D and the consumers. There is a demand for intermediate goods from the firms conducting research by the final output's producer. The latter, again, uses N varieties of inputs, but this time the amount of the intermediate ones is constant. Every one of them has a quality ladder that indicates what improvements can be made in this particular good. At any time, there is specific knowledge that can produce a range of qualities for every different intermediate good's quality. In order for the equilibrium to take place, however we assume that only the highest possible quality of each intermediate good is produced in each sector. The basic setup of the quality ladders is depicted in the following graph.



The R&D firm devotes resources in order to enhance the quality of an already existing intermediate good. After it manages to produce such a new input, it receives exclusive rights to it in the sense that it can sell the input in the monopoly price to the final output's producers. By that action, it receives a profit flow which it uses for the calculation of the net present value. The researcher who discovered the latest technology and produced brand new input with higher quality puts to an end to the profit flow of the previous monopolist. For that reason, in the decision stage where the amount of resources which will be allocated in the R&D sector is chosen, both the volume and the duration of the profit flow are taken into account. The framework, as it is set so far, indicates that the briefer the expected monopoly's duration, the lower are the payoffs from the R&D procedure. Furthermore, a portion of the benefit from successful R&D is the "creative destruction" effect which leads to a profit transfer from the innovator to the previous "innovator". This is actually an additional incentive, because the transferred mentioned has no value in a social perspective. The net effect of these two (which are almost the same) results in a raise of the private return from R&D in comparison to the social one.

In the research sector, the newest innovator may benefits from a clear advantage in terms of efficiency over the prior one but it will be a disadvantage soon enough as a new innovator will rise and create an input with higher quality.

Considering the equilibrium of this model we obtain the following results. First and foremost, the profit flow increases if the productivity parameter or the population size grows. Therefore, economy's growth rate increases as well. Another result is that when the research cost decline, the growth rate of the economy rises again. Lastly, an increase in the step size between new innovations has the same impact as well, which is an increase in growth rate. However, in terms of efficiency, the equilibrium, as in the model mentioned before, is not Pareto optimal. This is the case due to the privilege to price, as a monopolist, the intermediate goods.

It is logical to assume that the leader of the under consideration industry has a first mover advantage in research and development and maybe even reduced costs to conduct R&D. This assumption has as an impact the fact that the industry's leader tends to conduct all the research in the industry. If the leader's cost advantage is very large then he can act as a researcher operating under monopolistic market. If, however, it is not that big, the success of the research depends on the threat of a potential entry to the industry from a new firm.

A valid consideration about the growth of both the follower and the leader is how fast the technology discovered by the leading economy diffuses to the others. This consideration affects both economies. The general idea is that the follower has the tendency to reach the leader's output level instead of inventing, by himself, new technology. Specifically, he prefers to imitate the leader, as it is much cheaper than conducting R&D by himself. In a sense, a convergence process takes place.

Consider the first benchmark model analyzed before. Let us assume that researchers in country 1 devote resources in R&D in order to invent new intermediate goods that are used in the production of final goods and obtain monopolistic rights in their use. Country 2, instead of inventing new types of intermediate goods, imitates the ones produced in 1, but in order to use them, it needs to endeavor effort to adapt them. This effort is considered as the R&D cost. The one that absorbs this cost obtains monopoly rights in country 2. The imitation is less costly than the invention of new intermediate goods, while the inventor does not receive any compensation. However, the imitation process is subjected to limitations, as in order to imitate a new product, it needs to be invented first somewhere else. Hence the amount of possibly imitated goods is a finite number. This imitation cost is small at first but increases the less ideas are there to copy. Furthermore, the bigger the technological gap, the higher the follower's growth rate. In the equilibrium, both countries, however, present the same rates of growth. This means that in the long run the two economies are equal in growth rate terms even if they are different in terms of savings rate and R&D cost.

Something that should definitely be mentioned is that a way the diffusion takes place is by foreign direct investment from the leader to the follower. In that case the inventing country receives compensation for the technological progress it achieved and therefore there is a strong incentive for the leader to allocate resources in R&D. In addition, both the leader and the follower have higher growth rates in the long run equilibrium.

2.4 Labor Force and Population

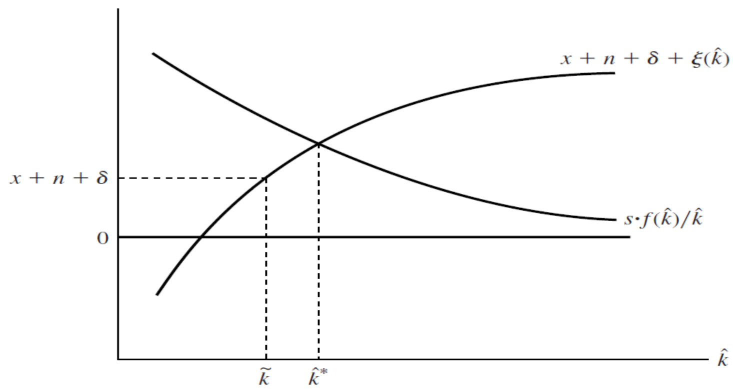
Another determinant of economic growth is the growth rate of the labor force and the population. In all the models analyzed and theories presented in this paper regarding the growth rate of every economy, it is assumed that the economy's population and labor force increase with the same exogenous rate. However, this assumption is unrealistic, the labor force of an economy does grow but not exogenously and not with steady pace. Nevertheless, there are ways to endogenise this problem as the population's growth rate does affect the output's growth rate. A way to do so is by allowing the population to immigrate to a foreign country and emigrate from a foreign country, if there are unexploited economic opportunities. Another way is by introducing fertility choices. People now have the option to pick the right number of children for their household subject to certain conditions.

To begin with, consider the migration process. Migration can cause increase or decrease in an economy's population. Labor force has the tendency to leave economies which offer low wage rates and have other disadvantageous elements and move to the ones that provide high wage rates and have many advantageous attributes for the workers. What labor mobility can actually cause in the economy's growth rate is that it speeds up the convergence to the steady state. Furthermore, migration is a different concept from natural growth of population in the sense that there is difference in the correspondence of birth and deaths. Moreover, the economy from where people emigrate is translated as a loss in terms of resources and vice versa. In a sense, migration implies a degree of mobility of capital as the immigrants "carry" with them the human capital, that they have accumulated so far in their lives.

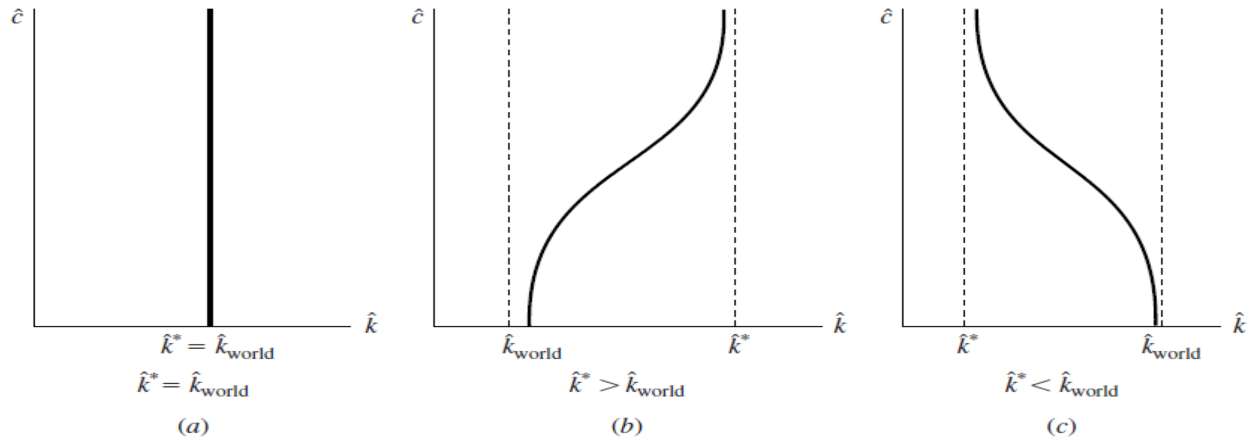
In order to study the effects of migration, three models will be considered. The first one will be the Solow-Swan model in which a closed economy is assumed but it is opened to some extent, so that labor can move, and a constant rate of saving which is exogenous as well. Then, the analysis is extended to the Ramsey framework and last but not least the Braun model of migration and growth is considered.

In the Solow-Swan framework, the only difference in the assumptions is that people can migrate and emigrate carrying no physical capital but only human capital with themselves. The domestic population grows in the net fertility to mortality rate[2] which is an exogenous rate, while the whole economy's labor force depends on the net migration rate[3] as well. The total capital in the economy changes due to migration as well, via the human capital brought by the migrants. Note that with capital, it is considered the broad concept and there is no distinction between human and physical capital. In this framework, appositive relationship between the migration rate and the growth rate of capital per worker is assumed. The equilibrium of the model is presented in the following growth diagram. The steady state of the economy is the cross point of the two curves. The steady state in this situation is higher than the one where migration does not occur and, of course, the migration rate is positive because the domestic economy is the one receiving migrants in the equilibrium. It should be noted that the economy remains in the steady state due to the constant immigration of new labors. The effective depreciation rate in the figure below has a positive slope. That happens as the response of net migration is positive to the rate of wage and thus the population's growth rate has a positive relation with the growth of capital. In the special case that the conditions in foreign economies aggravate, the domestic's economy steady state capital intensity falls due to the little capital the immigrants bring with them. However, the speed that the economy reaches its steady state is higher due to the income of migrants. Many researchers devoted their time and resources to analyze and prove this exact statement with the additional assumption of a Cobb-Douglas production function.

[2] The total births minus deaths over the total population
[3] Migrants minus emigrants over the total labor force



In order to use the Ramsey model and incorporate the migration of population, the Blanchard's (1985) model is used with a modification of Weil's (1989) extension. It is assumed that the domestic population consists of families with immortal life. Again, as in the Solow-Swan framework, every family grows in an exogenous and constant rate. Migration is then incorporated in the model as before and the migrants are assumed to bring with them only the human capital that they have accumulated so far. Maybe the most important assumption of the model is that the domestic population does not care about the immigrants at all, but only for their own children. In that sense, the domestic residents' utility functions do not have any element for the immigrants' consumption. The per capita consumption of the domestic population depends on the inflow of migrants in the following way. If the net ratio of immigrants is positive and the human capital they carry with them is lower than the one the domestic residents own, then the domestic population's per capita consumption in reduced. In the Blanchard (1985) framework, migrants are treated as the children the parents did not want, as Weil (1989) pointed out. The steady state of the Ramsey model is depicted by the figure below. The first panel presents the steady state where the economy's rate of capital is the same as the rest of the world. The second panel depicts the case there the economy's capital intensity is greater than the world's one and per capita consumption is less than before. This is the case where the domestic economy is appealing to immigrants in the steady state where no migration takes place. The third one, of course, is the case where the world's capital intensity is higher and the per capita consumption is larger than before. Furthermore, in the second panel, if the economy was attractive to migrants in the no-migration steady state, the immigration itself would cause the economy to move to a positive migration steady state where the capital intensity would be less. The opposite conclusions hold for the third panel. In addition, assuming a Cobb-Douglass function of production, researchers have found again that a higher propensity to migrate would lead the economy to converge faster to its steady state with positive migration, if the human capital brought by the immigrants is lower than the capital of the domestic economy. These are the same results as in the Solow-Swan framework.

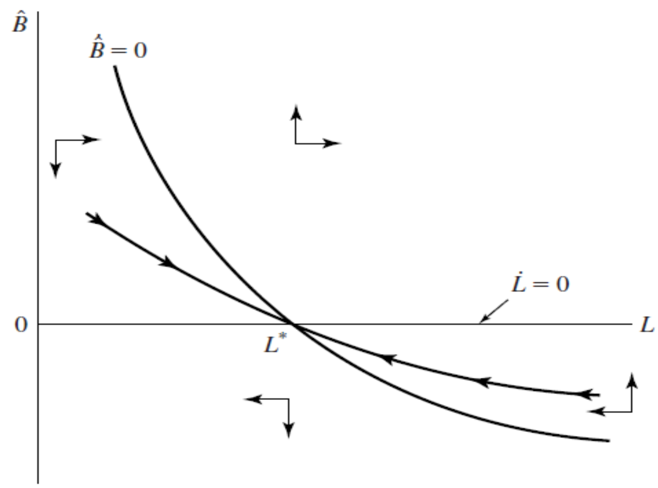


Source: Economic Growth Second Edition, Barro & Sala-i-Martin

Last but not least, the Braun model of migration and growth will be presented. Braun (1993) analyzes numerous models where migration is considered in the optimization process and where different levels of capital mobility are assumed. The models analyzed before have two important weaknesses. Firstly, immigration is determined by a migration function and not by considering an optimization process in order to find the ideal place to immigrate into. Secondly, only human capital can be carried and no physical one and this is the only origin of capital mobility. On the contrary, Braun (1993) in his model assumes that there is a perfect credit market in the world and hence the choice to migrate from an economy to another is taken solely by the path of wage rates across the world. Braun worked with different concepts of capital mobility but in this analysis only the economy with perfect capital mobility would be considered. The considered economy in assumed to be small, with a given world rate of interest in real terms which will be constant. Furthermore, the country with the better technology tends to be the destination of the immigrants. Given the cost of migration function assumed in the long run, only the country with the better level of technology will be populated given the fact that the world's natural growth rate is going to be zero. In order to avoid such a result, it is assumed that too many immigrants have the tendency to congest other factors like land. This is the key assumption that leads to a steady state where no country runs out of population.

In the migration and growth model, the congestion effect is introduced with a variable representing natural resources in which domestic residents have free access. Someone could assume that the immigrants need to pay rent in order to use it. In addition, the choice to migrate would be affected by a tax imposed by the government. For example, the incentives to migrate would decrease if the receiving country would impose a head tax to immigrants. But this will not be the case. The immigrants will share automatically the land and will pay no taxes at all to immigrate into a country. The factors of production prices, equal to their marginal product while their payments exhaust the domestic GDP. Therefore the wage rate paid equals to the marginal product of labor. If the domestic economy has in its disposal a high per capita quantity of the mentioned natural resources and high technology's level, then the domestic wage is higher than the wage offered in foreign economies.

In order for an individual to choose whether to migrate or not, the only relevant factor is the wage rate offered by different countries. In this sense, assuming there is a world wage rate, if the domestic economy offers higher wage rate than the "world", all the immigrants will have the tendency to migrate into the domestic economy and vice versa. To make matters simpler, it is assumed that the domestic economy's population growth rate in total depends solely from the migrants' flow. The key element is how the cost of migration is specified. This cost is assumed to be increasing to the flow of immigrants over the total labor force and it takes the form of forgone time of work. In that sense it is proportional to the wage they would have earned in their home country. While more and more immigrants come to the domestic economy, the domestic wage rate and the natural resources availability tend to decrease until the domestic wage rate equals the world wage rate where the incentives to migrate fade. Only then equilibrium takes place where there is not new migration, the labor force is constant as well as the capital intensity. In equilibrium the total benefit of migration equals the total cost and thus no more individuals tend to migrate as their net benefit is zero. The following figure depicts the steady state of the domestic economy.



If the economy starts at a population rate lower than the steady state's rate then there is benefit for individuals to immigrate. This means that as more immigrants come to the domestic economy, the population rises, the domestic wage rate falls and the incentives to migration decrease. In steady state the net benefit is zero, the population is constant and the domestic wage rate equals to the world one. The convergence's speed to the steady state depends on the sensitivity of migration rate to the relative benefit from migrating. The population's convergence speed is the also the convergence speed for the per capita output. When population is below its steady state level the per capita output rate is above its steady state value and vice versa. Thus the rate of growth of per capita output is related to its level in an inverse manner.

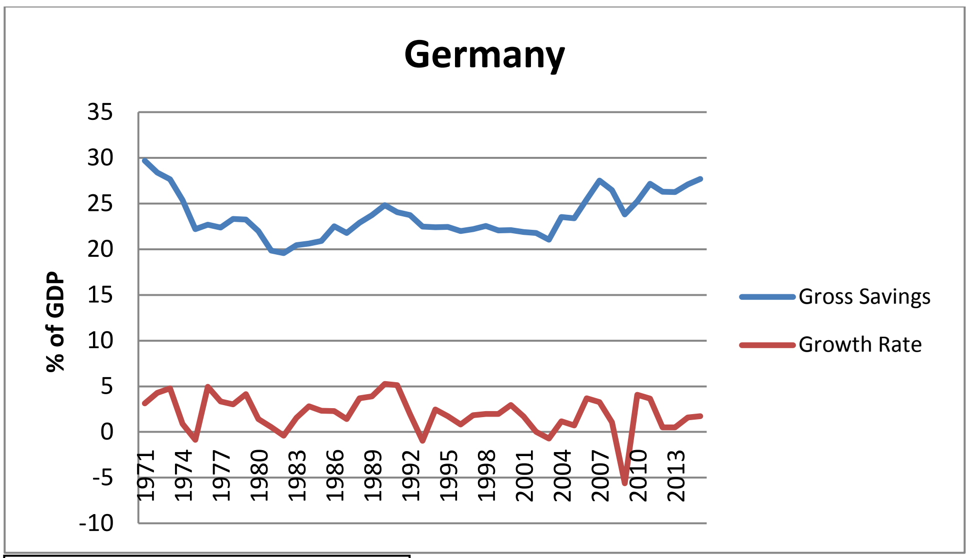
Another way to endogenise the population growth rate is like Becker and Barro (1988) did, by introducing the fertility choice. In their theory, parents are linked with their kids with altruism. Children are subjected to raising costs but they offer positive utility to their parents. So the decision about how many children the parents want should be made with the decisions about consumption and transfers through generations. If the marginal utility that is attached to each child decreases as their number increases, or if the cost of raising an additional child rises with the number of them, then this model can determine the optimal fertility rate by using a standard first-order condition. Becker and Barro (1988) use an overlapping-generations framework where individuals live and operate in the economy for only two periods, childhood and, of course, adulthood. An individual obtains utility from three sources; from consumption in each period, from having children in adulthood and from the expected happiness of their offspring when they become adults. It is assumed that all children are identical and they receive the same treatment from their parents, so the utility that a child obtains is the same. They introduce an altruism function as well, which depicts how much utility each parent attaches to each and every one of their children. To complete the set of assumptions and the model's framework, Becker and Barro specified the cost that parents are subjected to in order to have and raise children by introducing a budget constraint but with intergenerational horizon. What every individual in the economy has to do is to pick the right amount of consumption and fertility in order to maximize his utility given the intertemporal constraint of their budget.

The maximization of such a utility implies an arbitrage condition for over time consumption. Furthermore, it implies the equation of the marginal benefit of having one more child to the net cost of having it. The arbitrage condition implies fertility's response to changes in the degree of altruism and interest rates. Becker and Barro show that the number of children in every generation is dependent on the net cost of having them. Therefore, fertility depends on these kinds of expenses. In that sense, a permanent tax on children has as an outcome the reduction in the fertility rate of the generation which first comes across with the tax and reduces as well the number of children the following generations will have so forth. However, the fertility rate picked by the generations after the tax remains unchanged. This result is then used in order to justify why a decrease of the mortality rate might increase the growth of population in the first place but it has no long run effect on the population's growth.

Another consideration of Becker and Barro is the same setup but in open economies which face the same interest rate worldwide. In such economies, fertility rate is a positive function of the interest rate, the altruism's degree, and of the probability that a child will survive, while it is a negative function of technological progress and on the rate of growth transfer payments. Lastly, they added life cycle elements by letting the individuals to attain utility by consuming in various ages, discounted by the time preference while children discounted with the level of altruism as well. This has as a result that the life cycle consumption path is dependent on the interest rate again, but on the time preferences as well. However the consumption's rate of growth among generations is dependent on the rate of growth of the net cost of having children and not on the factors mentioned before. But, in the long run the consumption's growth among generations will rule the alterations in each person's consumption for the whole economy. This can explain why the real interest rate is unrelated with the per capita consumption's rate of growth.

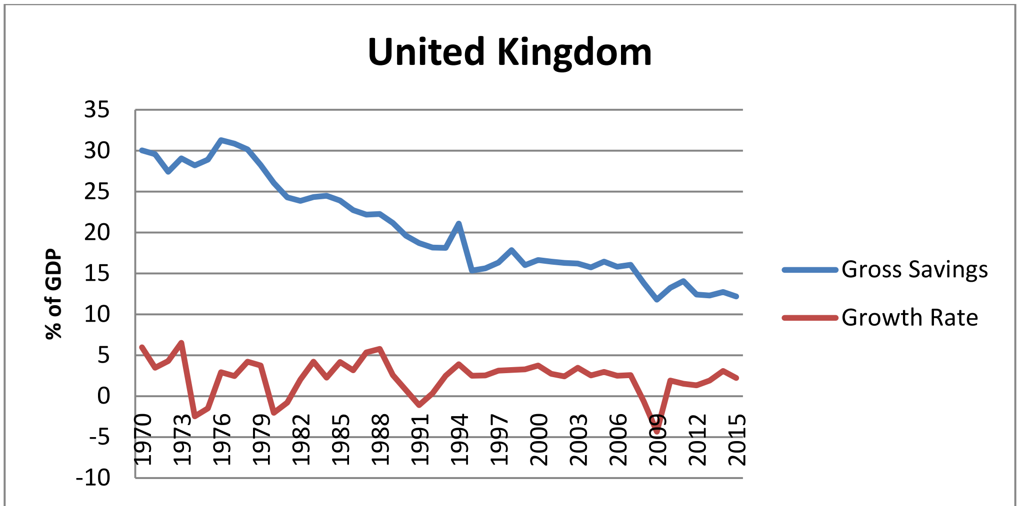
2.5 Economy's Savings rate

A critical factor that affects the level and the speed of economic growth is the proportion of the income the households in an economy save, more generally the saving rate of an economy. The main assumption about the effect of the rate of savings is that it is a positive function of economic growth. This means that when an economy saves more, it tends to present higher growth rates. However, there are concerns from analysts that the increase in the nation's savings can have the opposite outcome as in order to save more, the consumption must decline. Meanwhile, the consumer expenditures are a large component of the aggregate demand, and even a small decrease in its level could and may have a noticeable effect in the gross domestic product. Nevertheless, most economists support the case that economic growth in a long run perspective is affected directly by the economic fundamentals such as the capital stock, the government policy, the technology in the economy and so forth. In that sense, a higher saving rate might mean less consumption, but in the same time it could stimulate investment and hence higher economic growth rate. In order to have a general idea of what actually happens in the real economy before starting analyzing the economic relationships behind the savings rate I would like to present the course of economic growth and gross savings as percent of gross domestic product from 1970 to 2015 for Germany, Greece and United Kingdom and observe if the trend of those variables for each country is positive or negative. The data has been obtained from the world's bank indicator database.



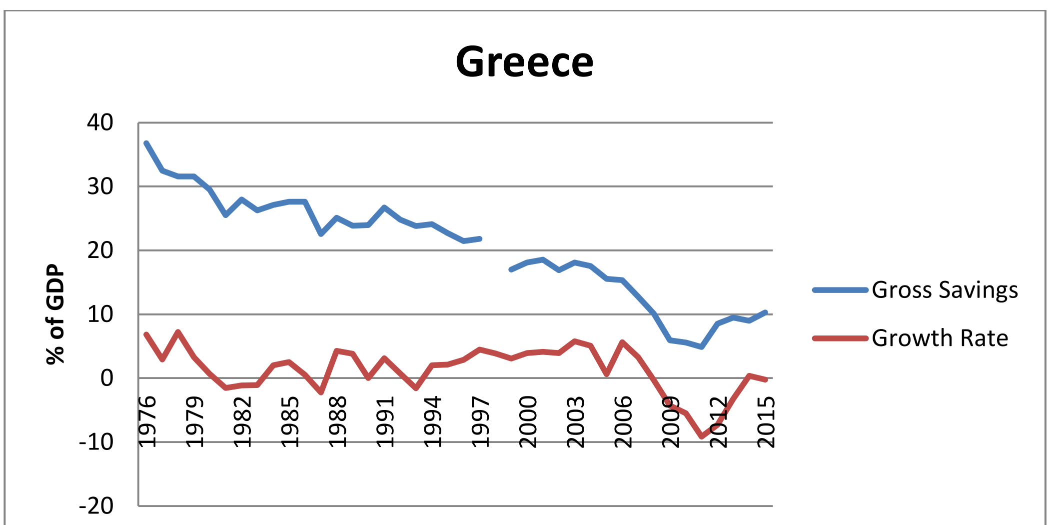
Source: World Bank's Indicator Database

Looking at the whole period presented in this figure for Germany, a positive relationship between savings rate and economic growth can be derived. Even though the savings rate tends to have a positive overall trend, when there is a decrease in its value, the German economy's growth rate tends to fall as well. However, this conclusion is merely an observation. The direction is positive but we cannot deduct that the higher saving rate is responsible for the faster economic growth due to the fact that many things that can affect economic growth are not accounted for in such a simple observation. The saving rate and economic growth can be positively related in the long run, but they could be negatively correlated in the short run as well. To be consistent and see if this positive relationship does hold, a more thorough investigation and analysis should be conducted. For this reason, I will examine the behavior of the saving rate as a determinant of growth as many significant models dictate. But first let me present the same graph for two more countries in order to have a more clear view about why a first glance of the relation of savings rate and economic growth could possibly prove to be useful.



Source: World Bank's Indicator Database

The data for UK used in this figure is from 1970 to 2015. The same observations that hold for Germany, hold for United Kingdom as well, although the drop in growth rate is more intense. That means that the changes in the rate of growth is not attributed to a change in the rate of changes solely, but a positive relationship between them is exhibited.



Source: World Bank's Indicator Database

For the case of Greece, the data of gross savings and rate of growth are for the time period of 1976 to 2015 with one missing value for 1998. However, this graph is included, even though a value is missing, just to have a visual representation of the examined relationship in Greece, where the financial crisis is at its peak. Again, the changes of growth are more intense than the ones of savings rate, but still have the same directions. In that sense, there is definitely a correlation if not causality.

Before I begin, I want to pinpoint something about the savings rate. In many theoretical models, some of them being fundamental for the way economic growth is considered in the minds of many economists during the historical development of the theory, savings rate are to be taken as constant and exogenously given. Nevertheless, some of them have found a way to endogenise the process with which economic agents operating in an economy chose the optimal rate of savings given the maximization problem they face and the maximization behavior they exhibit.

First, we will see how the rate of saving behaves in the Solow-Swan (1956) framework. In this model, the savings rate is assumed to be constant and exogenously given in the economy. The assumptions and the results of the model have already been analyzed in other sections of this paper, so I will focus just on the effect of alterations of the steady state in the Solow diagram. When the savings rate is increased the curve that depicts the function of production shifts upwards. The result is that the steady state value of the capital to labor ratio will be increased. In the new steady state, the growth rate of course is zero as in the Solow-Swan model the long run growth rate is zero but the per capita income is higher. However, it is not possible for an economy to constantly increase the marginal propensity to save and increase its per capita income. What actually matters is to find the exact rate in which the highest per capita income is achieved by achieving the maximum possible consumption as well. By solving the model, the rule that helps an economy to obtain that maximum rate of savings is derived and called the golden rule of capital accumulation[4]. This rule originates from the biblical golden rule and, in terms of economic purposes, can be considered as what provides the consumption that maximizes the consumption of the current and all future generations, when no generation receives higher consumption than the others. Of course, it is hard to end up with the optimal saving rate as in order to do so, an objective function is needed. In that sense, assuming that the economy's rate of saving is higher than the "optimal", the per capita consumption for all generations can be increased by reducing the savings rate as the economy is oversaving. Such an economy is considered as dynamically inefficient as due to the fact that the per capita consumption's path falls below alternative paths that are feasible as every point in time. In the opposite scenario, an increase of the savings rate can lead to higher per capita consumption. In this framework, however, we cannot conclude about what would be best, as we are unaware of how the households weigh the present against the future. We need a rule about how they discount future to determine the optimal savings rate.

Mankiw, Romer and Weil (1992) tried to check the validity of the Solow model. In order to do so, they used a data set, constructed by Summers and Heston (1988), that includes real income, private and government consumption, investment and population for almost all world's countries except the ones whose economies are centrally planned for the time period of 1960-1985. What they actually concluded into is that the Solow model is consistent with the evidence. Therefore, the savings rate has indeed the predicted effect and it is positively related with the per capita income and with the growth rate of an economy in its transition period to the steady state. However, the magnitudes are not predicted correctly. Given the used dataset, the effect of an increase or decrease in the savings rate is too large. In order to improve the results of their analyses, Mankiw, Romer and Weil augmented the Solow model to accommodate the human capital accumulation. They chose human capital to solve the magnitude problem mainly for two reasons. Firstly, human capital may be correlated with population growth and

[4] The idea for the golden rule of capital accumulation firstly introduced by Phelps (1966).

the savings rate and, by not including it in the regression, it would cause the estimator to be biased (omitted variable bias). Secondly, by letting individuals to accumulate human capital, they would allocate a portion of their income to this process. Furthermore, an increase to the savings rate will result in higher income and hence to more accumulation of human capital. What they found is that human capital was indeed correlated with savings and that by accounting for it in the regression the direction of the effect on the income was the same but not so large anymore.

A more realistic assumption, nonetheless, is that the savings rate in an economy is not exogenous as in the neoclassical model, but endogenous, and is determined by the maximization behavior of the individuals. This process was introduced by Ramsey (1928). Although Ramsey's theory has already been analyzed in the first section of this paper, a brief review of it will be presented for consistency purposes, as an extension of the neoclassical model in which the household maximize their utility subjected to an intertemporal budget constraint. In the considered economy, there are households that live indefinitely and that receive wage as a payment for the labor they offer and rents for the assets they accumulate while they consume and save by accumulating new assets. The total population is constant. A key assumption is the transversality condition. In that sense, the households cannot borrow without boundaries in order to finance their consumption and end up on the end of their life with debt. The present value of the current and future asset must be asymptotically not negative. An important formula that is obtained by solving the problem is the Euler condition that shows how the households allocate their consumption throughout time. The firms are identical and produce one homogeneous good. They pay the wage for the labor they receive and rents for the capital they rent. The production function used by the firms satisfies the neoclassical assumptions. The representative firm in the economy chooses the labor and the capital it needs in order to maximize its profits. In the steady state, as in the Solow-Swan model, the growth rate of the per capita consumption and capital to labor ratio is zero as well as the per capita income's growth. Therefore, no long run economic growth can be achieved in this model. The only way to sustain positive economic growth is by technological progress. In order to examine the effect of a change in the saving rate, a change of the time preference coefficient must be investigated. This is the case as a reduction in the time preference coefficient means that the households are less impatient and therefore they care more about the future consumption. Hence they save more now in order to consume more later on. The time preference coefficient's change does affect the consumption but not the capital accumulation. The new steady state is characterized by higher capital per person and per capita consumption as well as the per capita income. The problem for the zero rate of growth is due to the diminishing returns that are present in the function of production.

In order for economic growth to take place in the long run, as I already mentioned throughout this paper, the elimination of the diminishing returns is important. This is achieved by using a production function that exhibits constant returns to scale. This is done by the AK model with consumer's maximization behavior. The only difference in the setup of the model is the use of different production function. In this case, the consumption's growth rate is constant and positive as it no longer depends on the capital to labor ratio. Furthermore, the capital to labor ratio's and the per capita income's growth rates are equal to the consumption's rate of growth. In this framework, an increase in the willingness to save, which appears as a decrease of the time preference coefficient, does increase the economy's rate of growth. So, in the absence of diminishing returns, growth rate can be achieved and an increase in the savings rate does relate positively with the per capita income's growth. Generally, in most models where economic growth is achieved in the long run, an increase in the rate of savings does lead in an increase in the rate of growth of the economy.

2.6 Inequality

One of the most controversial factors that can affect and determine the economic growth of an economy is economic inequality. Many researchers have tried to pinpoint the redistributive effects of taxation and how taxes can be used to reduce the income inequality amongst the different population groups in an economy. However, every policy maker faces a dilemma during his decision about the policy that best fits the goals he wants to attain. There are two things a policy maker cares about in the economy, the attained growth rate and the inequality, if we assume that he does care about inequality. In order to promote the one, he has to neglect the other at some rate. It is not possible to achieve the highest possible growth rate and in the same time reduce the economic inequality completely. There is a conflict between these two goals. For example, structural changes that aim to increase the standard of living affect the income distribution but retard the economy's rate of growth. Some tax reforms, though, which aim to improve the growth prospects, end up restricting the income redistribution. Therefore, it is clear that inequality tends to affect the growth rate.

Alberto Alesina and Dani Rodrik (1991) worked on a paper that links the distributive politics with economic growth. They constructed a simple model in which growth is achieved endogenously with distributive conflicts amongst capital and labor. In their model, economic growth is subjected to policy decisions that are created by the conflict for shares of distribution. What they actually do is that they endogenise the government policy in an endogenous growth model. The study is focused in the political conflict of two population groups, the individuals that acquire their income from labor and the ones who acquire it from capital. In the decision about what policy is going to implemented, two important issues are involved. First of all, the capital tax rate which will be implemented needs to be determined. Secondly, what needs to be determined is the portion of the government revenues that will be devoted for redistributive purposes in the form of lump-sum transfers to the labor force and the portion of them that will be used for productive public investment. If the public expenditure's composition is held constant, then the higher the implemented tax, the higher the achieved economic growth for relatively small tax rates on capital, while economic growth is a negative function of tax when the tax rates are relatively large. If, however, the tax rate is held constant, then the economic growth is a negative function of redistribution via transfers to laborers.

There are two political models that can be used in order to present how public finance decisions are resolved, which of course affects the growth rates as well. In the first model, it is assumed that the government cares for only two population groups in the economy, workers and capitalist, and applies a certain weight to the welfare of each group. The weight is proportional to the lobbying or other political influence the two groups have. Given this framework the following results are derived. First of all, when the policy maker does not care for the workers at all but only for the capitalists, the economy's rate of growth is the highest that can be achieved as the maximization of economic growth is the best policy. However, if the policy maker cares for the workers as well, even a little, then some redistribution will occur and thus the growth rate will be less than the maximum that can be achieved. It is interesting though that workers always seem to be in favor of lower rate of growth than the capitalists, although they personalize the benefits created in the long run by the accumulation of capital. Furthermore, the model highlights the fact that welfare and economic growth can never be achieved by the same policies. These results are based to the fact that both workers and capitalists have the same discount rate. In the case in which they do not discount with the same rate, a time inconsistency problem emerges. In order to avoid the time inconsistency, a social planner should arbitrage across time so that he can please both the goals of capitalists and the workers, while the maximum level of growth is achieved in the same time. In the scenario where the capitalists are more patient than the workers, it is optimal for the policy maker to implement a tax that is time-varying on capital with which the economy's rate of growth would increase over time, as the tax rate would be high in the beginning and will decrease henceforth. The only problem with this policy is that it is not time consistent. In order to achieve a time consistent policy, the policy maker should impose a tax with constant rate and redistribute with constant transfers that in the end of the day have as a result a constant rate of growth. Regarding the optimal policy, when a time consistency solution is achieved, the capitalists benefit in the beginning when the tax rate is high and start to lose henceforth. The opposite holds for the workers, which means that they benefit later on when the tax rate has been reduced.

The second model that Alesina and Rodrik (1991) examine is more general than the first one, in which there are not two population groups anymore, but there is a distribution of people, each of whom owning different amount of capital and labor. This is the way an individual in the economy is classified among others. In this model, the policy maker decides what tax rate to impose according to the majority rule. Furthermore, a clear link is established between the previously analyzed model and this one that incorporates a continuous distribution of types. By solving this model, Alesina and Rodrik reached at the following relation for growth rate and wealth inequality. Economies that are more democratic and whose capital is more unequally distributed, tend to achieve lower growth rates than economies that have more equally distributed capital endowment.

As for the empirical implication of the model, Alesina and Rodrik wanted to see if the relationship between the rate of growth and wealth distribution does hold. In order to do so, they ran cross-country regressions where the explained variable is the per capita GNP growth rate and the explanatory variables are; the per capita income in 1960, the primary school enrollment ratio for the same year and a variable that presents the distribution of income. Instead of wealth distribution data, however, they use income distribution data as the former is very scarce and insufficient for many countries. Even the data for income distribution is hard to find, so they assembled what they could find for the most countries where complete databases existed. The results in which their research ends up, seem to be consistent with the theory that the model indicates. More specifically, when policy choices are highly susceptible to voting, it is expected that countries that have more unequally distributed wealth to present lower growth rates than countries in which the wealth is distributed more evenly. Furthermore, in countries that the policy maker operates in a less democratic way, economy's growth is determined by the weights the government attributes to the different classes' welfare. If the policy maker cares more about capitalist then the maximization of growth will be his priority. If he cares about labor then the growth rate will be less and the redistribution will be higher.

To sum everything up, the connection between growth rate and inequality seems to be pretty clear and, on top of that, a connection with the regime type of the economy holds as well. Democracies that suffer from high inequality in terms of wealth demonstrate lower growth than the ones in which the wealth is more equally distributed. This happens as the existence of a larger class which owns little capital will lead to a vote for high capital taxes. Then the workers would receive transfers and therefore their income would augment, but at a cost of economic growth for the economy. On the contrary, economies in which the policy making is in the hands of the capital owners, have the tendency to exhibit high growth no matter what the resources' distribution may be. As for non-democratic countries that tend to act as populist governments, the achieved economic growth is low and redistributive programs are implemented during which, in fact, wealth is transferred from capital owners to the working class. The reader must have already understood that in the case of high inequality, the economy grows much slower.

Other researchers worked on models of endogenous growth that introduced distributive issues that focused on the human capital as the driving force of economic development. Galor and Zeira (1989) concentrated their attention on the imperfection of the credit markets. The individuals that were relatively poor could not access the credit market and borrow in order to invent in education and increase their human capital. When the number of those individuals is high, it means that few people can become educated and the economy's growth rate is relatively low. Perotti (1990) analyzed a model that the amount of investment an individual can allocate in education depends on the original income's distribution and the redistribution that the government achieves via taxes and direct transfers. Hence the political equilibrium regarding the chosen tax rate is affected by the distribution of income that occurs before the tax implementation. Last but not least, Persson and Tambellini (1991) also analyze a model that incorporates investment in human capital and income redistribution in form of tax. They too come to the result that inequality is harmful for economic growth, as in a society that conflicts over distribution are of high importance, policy makers will implement policies that focus on redistribution rather than promoting activities that enhance economic growth, like capital accumulation and knowledge.

3. Empirical Model: Main Determinants of Growth

As we have seen so far there are plenty factors that can actually affect the growth rate of a country's output. In the previous sections of this paper, the main determinants of growth according to theoretical models have been analyzed. But what are the empirical results regarding the growth rate? Which are the factors that do affect the economy's growth rate according to the data? Are they consistent with what the theory dictates? In this section, I will try to answer exactly these questions. Therefore, a dataset from 1960 to 2015 will be used, for the 28 countries[5] that constitute the European Union, in order to explore the main determinants of growth.

3.1 Methodology

I have already mentioned that, in this section, the empirical determinants of growth will be explored. An interesting question that can be answered in the process is whether impoverished countries tend to converge with the richer ones. What it meant to be achieved is that the growth rate of poor countries is higher than the rich countries' growth rate. This is the concept of absolute convergence. But we know from theory that conditional convergence is predicted by the neoclassical model and not absolute convergence. In that sense, we will have to see the relation of the growth rate with the income's initial level in order to be able to answer that, holding everything else constant. In this paper an empirical framework is applied, which uses as dependent variable the real per capita rate of growth and correlates it with variables of two kinds. The first kind of variables that I am going to use is state variables and specifically their initial level, like human capital (education and health) and physical. The second kind is environmental and control variables like the investment to GDP ratio, the degree of openness, the government consumption to GDP ratio, taxation revenues, measures of democracy and rule and order and the fertility rate. According to this approach the per capita growth rate for every country is a function of all these variables and in time period t it can be written as

$$Dy_t = \Phi(y_{t-1}, c_{t-1}, \dots)$$

where, y_{t-1} is the initial GDP per capita, c_{t-1} is the initial per person human capital and all the omitted variables are the ones mentioned before.

Therefore, in order to identify the empirical determinants of growth, a dataset is used from 1960 to 2015. To be more precise, I created five year intervals by taking the average values for each variable in that time period and run a panel regression and robust standard errors with growth rate as explained variable, and ended up with 133 observations. The rate of growth variable is constructed as follows. First I grouped the per capita GDP values for each five-year interval. Then I took the logarithm of each average and finally, to create the growth rate, I took the first difference of the logarithms for every two periods of time. I chose this approach as the results will have less standard deviation. An alternative way of defining the growth rate is considered in a later section, in robustness checks.

[5] The detailed list of the countries used in this analysis is presented in Table 4 in the appendix

3.2 Data

In the main regression that I run, the independent variables are the initial per capita GPD, the upper schooling as a measure of education, the degree of openness, the fertility rate, the life expectancy as a measure of quality of health, the government consumption to GDP ratio, the investment ratio, the ratio of taxation revenues to GDP, a subjective measure for rule of law and democracy and the rate of inflation. But let's explain why each one of them is taken into account and what data is used in order for them to be created. Again I want to point out that for all the variables, as I did for the dependent one, I constructed five-year averages.

With the inclusion of initial per capita GDP, and to be precise, the logarithm of the initial GDP per capita, I aim to see if there is conditional convergence according to the used dataset. In order to do so I used the logarithm of the initial per capita GDP for every 5-year time group. The data for per capita GDP were obtained from Penn-World Tables version 6.1 and are from 1960 to 2007.

To capture the effect of human and health capital, and more specifically of education, two variables are used, the upper schooling for males and the life expectancy at age one. As for the upper schooling, I chose to use this measure because Barro (2003) concluded that it has the most intense effect on growth rates amongst others. What is meant with the term upper schooling is the secondary and tertiary education. This educational attainment measure is based on average years of schooling that is not adjusted for the quality of the educational system. These data are obtained from Barro & Lee (2013) who created a new dataset for educational attainment. As for the life expectancy, the data is obtained from the World Bank's indicator database and is used to show the relationship between the health system and rate of growth for the panel of countries that is taken under consideration. The structure with which the life expectancy variable is entered in the regression system is as a fraction where the nominator is the number 1 and the denominator is the life expectancy average value for every 5-year period.

Another effect I would like to examine regarding its relationship with the rate of growth is the consumption of the government. This effect, however, is controversial. On the one hand, someone would think that the bigger the size of the government, which means higher consumption from the government, the lower the achieved rate of growth as a big government's size could not be productive. On the other hand, there are supporters of the existence of a positive effect on growth, in the sense that a government whose size is big can have strong demand effects. Therefore is easily understood that researchers cannot universally agree if the size of the government does affect negatively or positively the growth rate. The data used for this variable is obtained, again, from the World Bank's Indicator Data and is grouped in 5-year averages.

As dependent variable, a measure for the degree of openness is used, which is the imports plus exports to GDP ratio. Openness is not the same for every country, it highly depends on its size as the larger a country is, the less open it is, and vice versa. This happens because, if a country is large, it can perform internal trade in higher intensity than international trade, it can play a substitute role. Furthermore, this variable reflects influences like the ones of tariffs, restrictions on trade and international policies. Once more, the Penn-World Tables version 6.1 was used to obtain the data for international openness, although an alternate dataset in used for this variable later on, constructed from data for imports and exports that is obtained from World Bank's indicator database.

Tax revenues as a percent of GDP and inflation are used as explanatory variables as well. The tax revenues to GDP ratio is expected to have an ambiguous effect; it can be either negative or positive. As it is mentioned in the previous section, the smaller the ratio of tax revenues to GDP, the higher the growth rate and vice versa, for given public's expenditure composition. So it is not clear what we should expect from the regression. The inflation is used as a macroeconomic stability measure.

The fertility rate is definitely an important variable we should examine. In the regression considered in this paper, the logarithm of fertility rate is used. Fertility rate as a measure reflects the effect of population's growth on the output's growth rate. We know from intuition, that in the neoclassical growth model the population affects negatively the steady state value of the capital to effective worker ratio. As a result, we expect a negative effect of the rate of fertility to the economic growth rate. Another reason that someone can expect a negative relationship between those sizes is the fact that the more children a household has to raise, the more resources it needs to devote to them. That means that less resources are used for savings and investment and consequently the growth rate is lower.

The effect of the rate of saving that affects the steady state in the neoclassical model is captured, at least empirically, by the real investment to real GDP ratio. As we know from intuition, we expect a positive relation between these two variables. The data that are used for this variable are obtained from Penn-World Tables 6.1 version.

Last but not least, three subjective measures are included in the main regression; one for the rule of law, one for ethnic tension and one for democracy. It is assumed that when the rule of law improves, it is implied that an enhancement is taking place in terms of property rights and that can stimulate investment and consequently growth. A variety of subjective country indexes were created by International Country Risk Guide (ICRG) for investors that are willing to buy them. Knack and Keefer (1995) discussed all of them in their work. Amongst the different indexes there is the rule of law, which I am going to use in the main regression, the quality of bureaucracy, corruption, government stability and many more. Some of them I will consider them in the regression system later. The most appropriate and relevant index, however, seemed to be the rule of law. This index was measured in 7 different categories from 0 to 6, where 6 is the most favorable situation, while 0 is the worst. I rescaled this variable with the new value being between 0 and 1, where 0 again is the worst case scenario and 1 is the most favorable environment.

The second subjective measure, which is included in the regression analysis and is obtained from the ICRG dataset, is an index that assesses the degree of tension inside a country that is attributed to racial, nationality or language division. Low ratings are given to countries in which racial and nationality tensions are high because the opposing groups cannot compromise and are intolerant, while high ratings are given to countries that the racial and nationality tensions are low even though these differences may exist. This measure receives values from 0 to 6, where 6 is the most favorable environment and vice versa. In this case, again, I rescaled the variable to receive values between 0 and 1 exactly as I did for the rule of law variable.

The last subjective indicator used to reflect the quality of democracy in every country, was obtained by the Freedom House. The quality of democracy is considered in the sense of electoral rights. According to theory, we cannot be sure on the effects of democracy on growth. Democracy, one the one hand, can stimulate growth by creating an environment of certainty and could potentially be the reason for the government to commit that it will not abuse and waste the capital that was accumulated by the private sector. On the other hand, the political models that suggest that its main effects are negative, underline the fact that elected parties, which are the majority, have the incentive to abuse their power and reallocate resources from rich groups that are minorities. Nevertheless, it is possible for a linear and a squared term to exist in the regression which indicates that the effect which prevails depends on the democracy's extent. The rule of law index takes values from 1 to 7, where countries with value 1 enjoy complete freedom and countries with value of 7 are not free. Again I rescaled the value of the index from 0 to 1 scale, where countries with 0 are not free while countries with value 1 are completely free.

3.3 Main results for growth rate determinants

Table 1 presents the results of the regression on the real per capita GDP's growth rate. By looking at this table, someone can easily understand which the empirical determinants of growth rate are. I will gradually enter the explanatory variables into the regression system in order to show how their effects change by adding a new independent variable that is needed in the regression and how important role every factor has. Firstly, we control for education and health parameters, then we control for institutional characteristics and in the end we add the variables that reflect investment characteristics in the system.

The first variable I am going to discuss is the initial level of real per capita GDP which is entered in the system as a logarithm. For every 5-year period the observation of the first of the five years is considered. This means that, for example, in the 1965 group the value of the variable for 1961 is used, in the 1970 group the value for 1966 used and so on. The estimated value of the coefficient for log(GDP) is -0.0254 (s.e.=0.0142). Given the sign of the beta coefficient we can conclude that the conditional convergence property, that many researchers like Barro have reported in their research, does hold. In that sense, it is predicted that a countries rate of growth is higher, the lower its initial level of per capita GDP is, when every other factor is held constant. So our model is consistent with intuition as far as the effect of initial per capita GDP is considered.

The next variable that is considered in the regression and captures the effect of educational attainment is the upper schooling for males. It is measured in average years of both secondary and tertiary schooling. This variable is observed only in the start of each 5-year period, for example for 1965, 1970 and so forth and it is obtained from Barro and Lee tables for educational attainment. The coefficient of male upper schooling is -0.0016 (s.e.=0.0014). This result seems to contradict with the theory as someone would expect that more education would result in higher rates of growth for the economy, while our model points out exactly the opposite, although the variable is statistically insignificant. It may seems paradoxic but do not forget that the dataset is not homogeneous. Countries that are pioneers in the technological frontier do need more education and especially higher tertiary education in order to produce higher growth rates. However, countries for which this is not the case, higher education do not necessarily lead to higher growth rates. It could be considered a waste of resources or, not to exaggerate, a not so efficient allocation.

Table 1:

	(1) Growth rate	(2) Growth rate	(3) Growth rate	(4) Growth rate
Log of GDP per capita	-0.0378**	-0.06**	-0.045**	-0.0254*
	(0.0174)	(0.0237)	(0.0213)	(0.0142)
Upper-level of male	0.0016	-0.0031*	-0.0013	-0.0016
schooling	(0.0018)	(0.0018)	(0.0019)	(0.0014)
1/(Life Expectancy)	-11.3735**	-17.2835**	-7.6772	-3.2145
	(4.6534)	(8.5445)	(7.5847)	(6.6876)
Log of fertility rate		-0.0079	-0.0165	-0.0338**
		(0.0142)	(0.0159)	(0.0142)
Government Consumption		-0.0037***	-0.003***	-0.0008
Ratio		(0.0007)	(0.0008)	(0.0005)
Rule of Law				0.0212***
				(0.0077)
Ethnic Tension				-0.0147**
				(0.0071)
Democracy				0.2395***
				(0.0551)
Democracy Squared				-0.1478***
				(0.0417)
Degree of openness			0.0001	0.0002***
			(0.0001)	(0.00005)
Investment Ratio			0.0007**	0.0007***
			(0.0003)	(0.0002)
Inflation rate			-0.0001**	-0.0001***
			(0.00003)	(0.00003)
Taxation Revenues		0.0002	0.0002	-0.0002*
		(0.0002)	(0.0002)	(0.0001)
Constant	0.3075***	0.5628***	0.3481**	0.0831
	(0.1057)	(0.1844)	(0.1577)	(0.1094)
Number of observations	229	175	166	133
R-squared	0.5882	0.6713	0.7579	0.854

Notes: This table contains the results of the main determinants of growth as it emerges from the data used for the 28 countries. The dependent variable in this regression is the difference in logarithms of the per capita GDP. In the parenthesis below the betas of the independent variables are the robust standard errors for each beta. The stars in some variables aim to point out the statistical significance for that specific variable. One star is for 10% level of statistical significance; two stars are for 5% and 3 stars are for 1% level of statistical significance.

As I mentioned earlier, a great way to measure the health aspect of the human capital is the life expectancy at birth which enters the regression as a fraction of 1 over the life expectancy's value. The beta of life expectancy's value is -3.2145 (s.e.=6.6876) and suggests that better health leads to higher rates of growth. This result is consistent with intuition and with what we would expect before running the regression, however the variable is statistically insignificant and in that sense it plays no significant role on the change of growth rate in an economy. Nevertheless it is good that the sign is consistent with what was expected beforehand.

The fertility rate, which actually is the total birth for a typical woman over her lifetime, enters into the system as a logarithm. Its coefficient is -0.0338 (s.e.=0.0142) and is significant at 95% confidence interval. The negative effect of the fertility rate it is consistent with the theory of Solow and so it is consistent with what someone should expect from a growth regression. Thus, a decline in the fertility rate would result in an increase in the rate of growth of an economy. Furthermore, the faster a country's population is growing, the slower its economic growth will be.

The consumption ratio of the government is measured as the ratio of real government consumption to the real per capita GDP. The estimated coefficient is -0.0008 (s.e.=0.0005) and statistically insignificant. Once again we cannot be sure if this effect is the desired one as the academic community is fragmented. In our model, however, the negative sign of the coefficient indicates that bigger the consumption ratio, the lower the achieved rate of growth. This could be the case as the government's consumption ratio does not include any investment expenditure done by the government and it consists of merely redistributive expenditures.

The rule of law variable and ethnic tension, as mentioned, come from a subjective measure provided by International Country Risk Guide (ICRG) created by Political Risk Services. They way these two variables were constructed is explained in detail in the previous section. The earliest data used for these two explanatory variables start from 1982 but the procedure can be presumed satisfactory as data like them exhibit, at least substantial, persistence over time. The estimated coefficient for the rule of law variable is 0.0212 (s.e.=0.0077) which is statistically significant even at 1% level of statistical significance. In that sense, an increase in the rule of law index will lead to a higher rate of growth. As for ethnic tension, the estimated coefficient is -0.0147 (s.e.=0.0071) but this one is statistically significant at 5%. This means that the more tension happening inside a nation, the less growth it tends to present. Both of those results are consistent with intuition.

An important factor that can stimulate growth in an economy as it emerges from theoretical models and this empirical analysis is democracy. The democracy variable is obtained from a subjective measure created and provided by the Freedom House. A square of democracy variable is included into the regression system in order to allow for a nonlinear effect on economic rate of growth. The effect of democracy is positive and statistically significant with a value of 0.2395 (s.e.=0.0551) while the effect of squared democracy is negative and statistically significant with a value of -0.1478 (s.e.=0.0417). These results are expected and imply that for countries that are not democratic, an improvement in the regime can stimulate growth. However, for countries that are very democratic or at least have attained a substantial level of democracy, a further improvement in democracy can retard economic growth.[6]

Another factor that affects the economic growth rate of a country is the degree of openness. International openness is measured as the ratio of imports plus exports to GDP. The relationship between openness and growth is positive and statistically significant even at 99% confidence interval. The coefficient's value is 0.0002 (s.e.=0.00005). In that sense, there is strong statistical evidence that the more extrovert an economy is, the higher the growth rate it will achieve is going to be.

The investment ratio variable is included in the regression system in order to capture the effect of the savings rate in an economy. The measure is created as the ratio of real gross domestic investment to real GDP. The coefficient of the investment ratio is positive and statistically significant in 1% level of statistical significance. The estimated value is 0.0007 (s.e.=0.0002) and it implies that an increase in

[6] This result is consistent with Barro (1996) and as published in his book with Sala-i-Martin (2004).

investment in the economy can stimulate growth, so it is consistent with the theory regarding savings. This result highlights the importance of private investments to achieve higher growth rates.

As for inflation, the prediction of our regression model is fully expected. Its beta is negative and strongly statistically significant. The estimated coefficients value is -0.0001 (s.e.=0.00003) and it implies that the higher the inflation rate of an economy, the lower the economic growth rate. This is normally the case, as inflation indicates the existence of uncertainty. Investors cannot know for sure the real return of their investment which is a disincentive for them to proceed with the investment. In that sense, lower inflation can stimulate economic growth.

Last but not least, the taxation revenues where entered into the regression system as a percent of GDP. The estimated coefficient is -0.0002 (s.e.=0.0001) and is statistically significant only at 10% level of statistical significance. The negative sign of this factor indicates that the more taxes the government imposes on households the less economic growth rate the economy can achieve. As I mentioned in a previous section there is a trade-off between taxation and growth as they are contradictory roles. Hence, it is expected that higher taxation revenues can retard the rate of growth.

3.4 Robustness Checks

In this section, additional explanatory variables are considered the original regression system in order to observe how the rate of growth is affected by these new factors. I decided to do such and analysis as the empirical literature on the determinants of growth has become so large in terms of numbers and many different factors have been suggested as growth rate determinants. Furthermore, another way of defining the growth rate variable is considered and alternative data for certain variables which are already included in the main regression system. In Table 2 the new explanatory variables, that are considered, are presented but only the new coefficients. If someone wants to see how they coefficients from the basic regression change, he could check the appendix for the analytical regressions' outputs. In. Table 3, the complete regressions' results are presented as I do not just add a new variable; I alter a variable's data or the regression's methodology so we care about the changes in all coefficients

The first new explanatory variable that is entered in the regression system is the log of population. The reason that this variable is examined is the fact that we want to see if the scale of a country seems to matter for its economic growth outcomes. The estimated coefficient's value is -0.0829 (s.e. 0.0454). The fact that log of population is statistically significant at 90% confidence interval indicates that there is statistical evidence that support the negative relationship between the scale of the country and its economic growth. The larger the population is, the lower the attained economic growth.

After the population, alternative measures for the education are considered, all of which entered in the regression simultaneously with the upper schooling for males. The only exception are the secondary and tertiary male schooling, which actually is the upper schooling variable split in to other variables, due to high correlation and collinearity problem. Firstly, the female upper schooling is entered in the system and the estimated coefficient is 0.0028 (s.e.= 0.0032). This variable, when entered in the same time with upper schooling for males, has the desired sign, but it is statistically insignificant. When the average years of primary schooling for both males and females are entered, the estimated coefficients are -0.0120 (s.e.= 0.0076) and 0.0091 (s.e.= 0.0059) respectively. Once again the sign for the female measure

Table 2

New Explanatory Variable	(1) Coefficient	(2) Additional New Variable	(3) Coefficient
Log of Population	-0.0829*		
	(0.0454)		
Upper-level of female	0.0028		
schooling	(0.0032)		
Male primary schooling	-0.0120	Female primary schooling	0.0091
	(0.0076)		(0.0059)
Male secondary schooling	-0.0013	Male college schooling	-0.0045
	(0.0015)		(0.0112)
Corruption	-0.0085	Quality of Bureaucracy	0.0171
	(0.0062)		(0.0106)
Logarithm of Researchers'	-0.0018	Expenditure on R&D	0.0014
Number	(0.0130)		(0.0093)

Notes: This table contains the results of the new explanatory variables as determinants of growth as it emerges from the data used for the 28 countries. The dependent variable in this regression is the difference in logarithms of the per capita GDP. In the parenthesis below the betas of the independent variables are the robust standard errors for each beta. The stars in some variables aim to point out the statistical significance for that specific variable. One star is for 10% level of statistical significance; two stars are for 5% and 3 stars are for 1% level of statistical significance. The complete regression for each new explanatory variable can be found in the appendix section

of schooling is the desired one, while for the males it is not. However, they are both statistically insignificant and therefore they have no effect on growth. Last but not least, the secondary and college variables are entered in the regression system and their estimated coefficients are -0.0013 (s.e.= 0.0015) and -0.0045 (s.e.= 0.0112) respectively. Both of them have the same sign as the upper schooling variable, but they are also statistically insignificant. What we observe in all these measures is that the variables of the male education present a negative effect on growth, which as I mentioned in the analysis of the main regression, is kind of paradoxic. However, the female variables exhibit the expected sign but are statistically insignificant.

Another set of results refers to alternative measures to the rule of law and ethnic tension indicators. The alternative measures which are entered simultaneously in the regression are the official corruption and the quality of bureaucracy. These new subjective measures are processed in the same way as the rule of law and ethnic tension in the sense that their values where adjusted in 0 to 1 scale, while an increase in their value suggests a better system with less corruption and more efficient bureaucracy. Both of them entered in the same time in the system because, even though they are correlated, the correlation is not high enough to cause collinearity problems. Their estimated coefficients are -0.0085 (s.e.= 0.0062) and 0.0171 (s.e.= 0.0106) respectively. Although they are not statistically significant, their signs are as expected. More corruption leads to less growth and an improvement in effectiveness of bureaucracy can cause a boost in economic growth as it simplifies many procedures.

In an earlier section, the importance of research and development was highlighted. In order to capture this effect and check for empirical evidence in favor of the theoretical back ground I chose to include two variables that can indicate this effect in our regression system, the logarithm of the number of researchers in each country and the expenditure devoted to R&D. Their estimated coefficients are -0.0018 (s.e.= 0.0130) and 0.0014 (s.e.= 0.0093) respectively and both statistically insignificant. There were not many available data for these two variables though, so that must me the reason of the statistical insignificance. To be precise, there was data only for the last three 5-year periods. However, by looking at the signs on both variables, we can obtain an idea of what we should expect from R&D. In that sense, more resources allocated to R&D could stimulate growth although according to these results more researchers would retard growth. That could be the case if, for example, professionals that were needed in other sectors changed occupation to occupy themselves in R&D. Nevertheless, do not forget that the variables are insignificant and cannot be strongly taken into account unless more data become available. The R&D expenditure variable, though, is consistent with intuition on research and development literature.

Now, let's consider the results of the regressions on Table 3. In the regression (1) an alternative way to define the dependent variable of our regression system is considered. To do so, I used data for the growth rate as a percent of GDP from World Bank's Indicator Database, which takes the form of the difference of the per capita GDP from period t and the one from t-1 and divide them with the GDP from period t-1. As someone can see, the effects of all variables remain the same on the new explanatory variable as they were in our main form of the explained variable, but the new model has less explanatory power over the growth rate as the subjective measures of rule of law ethnic tension and democracy, even though they have the same sign, are statistically insignificant. Furthermore, the life expectancy's sign is the opposite in this new regression but it is not important, as in both cases it is insignificant as well. The only improvement of this model is that the log of the initial level of per capita GDP in now significant even at 1% level of statistical significance. But the effect on growth seems to be even bigger and more intense on this dependent variable.

In the regression system (2) we go back in using the original explained variable which is the difference in the logarithms of real per capita GDP but we now use a different dataset for the degree of openness. Instead of using the measure provided by the Penn-World Tables 6.1, I constructed the same one but with data for imports and exports that I collected from the World Bank's Indicator Database. Someone can see even with a quick glance that the results are close to the one's obtained from the main regression as the effects of the explanatory variables are predicted with the same direction suggested by their signs. However, there is a small loss in terms of statistical significance and explanatory power in the rule of law and ethnic tension variables and the degree of openness itself, with the new dataset, does not imply such strong relationship between international openness and the rate of growth. The main problem when comparing these two, is that the taxation revenues do not affect statistically significant the rate of growth of an economy. This could mean that maybe the revenues themselves do not play an important part in the evolution of economic growth but the way they are used. Nevertheless, the fact that there is a significant effect of tax revenues on growth from the main regression even in 90% confidence interval constitutes the inability of the model (2) to predict it a drawback. The only advantage of model (2) of Table 3 is the fact that it predicts a statistically significant negative relationship between the government's consumption ratio and the rate of growth.

Table 3

	(1) Rate of growth	(2) Growth rate	(3) Growth rate	(4) Growth rate	(5) Growth rate
Log of GDP per capita	-18.3380***	-0.0302*	-0.0317	-0.0264	-0.0439**
	(3.1882)	(0.0155)	(0.0256)	(0.0258)	(0.0176)
Upper-level of male	-0.4884*	-0.0020	-0.0017	-0.0047**	0.0011
schooling	(0.2839)	(0.0014)	(0.0025)	(0.0022)	(0.0014)
1/(Life Expectancy)	939.4185	-4.8023	13.1266	-34.1759***	16.6004**
	(1381.5780)	(6.9158)	(13.0139)	(10.8601)	(7.5671)
Log of fertility rate	-9.9869***	-0.0330**	-0.0209	-0.0438	-0.039**
	(3.1984)	(0.0147)	(0.0253)	(0.0385)	(0.018)
Government	-0.1808*	-0.0010*	-0.00004	-0.0025*	-0.0008
Consumption Ratio	(0.1071)	(0.0005)	(0.0008)	(0.0013)	(0.0006)
Rule of Law	2.2360	0.0189**	0.0281**	0.0096	0.0112
	(1.7367)	(0.0078)	(0.0110)	(0.0199)	(0.0072)
Ethnic Tension	-0.0359	-0.0133*	-0.0218**	-0.00003	-0.0008
	(1.4618)	(0.0076)	(0.0099)	(0.0159)	(0.0068)
Democracy	16.0052	0.2551***	0.1535	-0.3272*	0.0464
	(11.1296)	(0.0548)	(0.1457)	(0.1915)	(0.1616)
Democracy Squared	-8.8397	-0.1564***	-0.0781	0.1699	-0.0182
	(8.7282)	(0.0422)	(0.1253)	(0.0417)	(0.0961)
Degree of openness	0.0315***		0.0002**	0.0001	0.0002***
	(0.0118)		(0.0001)	(0.0002)	(0.0001)
Openness[a]		0.0001*			
		(0.0001)			
Investment Ratio	0.1235**	0.0007***	0.0006**	0.0006	0.0005**
	(0.0387)	(0.0002)	(0.0002)	(0.0005)	(0.0002)
Inflation rate	-0.0317***	-0.0002***	-0.0001***	0.0005	-0.0006*
	(0.0057)	(0.00003)	(0.00004)	(0.0003)	(0.0003)
Taxation Revenues	-0.0085	-0.0002	-0.0002	-0.0004	-0.0001
	(0.0239)	(0.0001)	(0.0002)	(0.0004)	(0.0001)
Constant	64.7784***	0.1296	-0.1243	0.7865**	-0.0398
	(23.4849)	(0.1111)	(0.1537)	(0.2996)	(0.1588)
Number of observations	133	133	69	64	98
R-squared	0.7944	0.8469	0.8388	0.9242	0.8363

Notes: This table contains the results alternate regressions which are explained in the text as it emerges from the data used for the 28 countries. In the parenthesis below the betas of the independent variables are the robust standard errors for each beta. The stars in some variables aim to point out the statistical significance for that specific variable. One star is for 10% level of statistical significance; two stars are for 5% and 3 stars are for 1% level of statistical significance.

[a] This variable refers to an alternative index for the degree of openness constructed with data from World Bank's Indicator Database.

The results we obtained about the government's consumption ratio and the controversy that exists in the academic community about their effect, led us to split the dataset in two groups in order to examine that effect in both groups; one with low government's consumption ratio (below the average) and one with high ratio. The regressions (3) and (4) on Table 3 present exactly this procedure. Regression (3) is for the group of countries with low ratio and (4) for the group with high. It is observable that by splitting the dataset in two groups, many variables lose their explanatory power in terms of statistical significance. As for the under consideration factor, in the low consumption ratio group, it is statistically insignificant with the same negative sign though, while in the high consumption group its value is negative and statistically significant at 10% level of statistical significance. The fact that the negative sign persists through the split must mean that it is indeed attributed to the fact that this variable consists of purely consumption expenditure for redistribution purposes and not at all for investment. It is also worth remembering that there is a trade-off between redistribution and maximizing the rate of growth goals.

Finally, we thought that the so significant effect of democracy on growth could be attributed to ex-soviet countries and their democratization after the fall of Soviet Union. My sample contains ten ex-soviet countries; Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. Instead of running a regression for them exclusively, due to lack of sufficient data, I run a regression for all the other countries while excluding those ten to check if the high statistical significance of democracy still persists. Model (5) is the representation of exactly this regression and, as we see, the explanatory power of democracy is lost after the exclusion of these ten ex-soviet countries. Now, in the regression (5) democracy and its squared effect are not statistically significant, even though their effect has the same direction. Furthermore, the rule of law and ethnic tension variables seem to lose their explanatory power as well, as they are not statistically significant too. This means that this intense effect of democracy on growth is indeed attributed to the transition of the ex-soviet countries which are included in this dataset from communism to democracy. In that sense it can be induced that when a country moves from a totalitarian system to a democratic one, an improvement in terms of political rights tends to have disproportionate effect on growth as if a moderate amount of democracy is achieved.

Summary and Conclusions

Taking everything under consideration, it is easily understood that the data which are available nowadays for a large panel of countries for over 40 years provide the necessary information in order to identify the factors that do affect the economic rate of growth. The empirical evidence indicate that the higher the initial per capita GDP a country exhibits, the less rate of growth it will achieve. This means that the data support the existence of conditional convergence on this panel of countries. Furthermore an enhancement in the maintenance of rule of law and less ethnic tensions can lead to an improvement in the country's growth rate. An improvement in terms of political rights tends to increase growth, and to be precise, in a disproportionate level when a country has a low level in the democracy index but not that much when a moderate amount of democracy is achieved. Growth is also stimulated by higher degree of openness, greater investment ratio, lower rates of fertility and inflation and reduced revenues from taxation. Most of the obtained results are consistent with intuition and theoretical models as explained in the section 2 of this paper. It is of highly importance the fact that the theoretical findings are proved by the empirical work. In addition, when the determinants of growth are identified, it will be possible for every country to choose the appropriate policy mix in order to allocate resources in these factors that it can affect and stimulate their economies' rate of growth.

Although the analysis conducted in this paper is thorough and covered a great variety of candidate factors that can determine the growth rate in an economy, there is a broad variety as well that needs to be examined and taken under consideration for their effect on growth. In that sense, this analysis can be expanded by checking for the relationship of other factors that are suggested as determinants of economic growth, but further investigation still needs to be conducted in order to be sure about the outcome. Moreover, alternative datasets can be used to verify the effect of the factors used in this regression. For example, the effect of education which was found insignificant in this framework was measured by the average years of schooling for every age and sex group. However, we did not control for the quality of education, only for the quantity. This could be a possible interesting extension of this regression model which should be investigated. Additionally, when more data become available, it would be interesting to investigate the relationship with the rate of growth of factors which in theoretical models are identified as a possible economy's driving force in terms of growth, but the available data are still short and inconclusive, such as the effect of research and development. An alternative regression method could also been applied in this framework such as a three stage least squares (3SLS) approach, like Barro and Sala-i-Martin (2004) did in their work regarding the determinants of growth rate. Last but not least, a broader dataset for more countries can be used to check if the results of this paper will be the same if the regressions would be run for all OECD countries, for example.

Appendix

In this section the analytical regression outputs will be presented for the careful reader or just for someone that wants to look in detail the regressions which I run. First of all the variables will be explained right after the table which reports in detail the countries that are included in the dataset. So, Table 4 consists of all 28 countries of European Union.

Table 4

Countries Included in the Dataset

Austria	Italy
Belgium	Latvia
Bulgaria	Lithuania
Croatia	Luxembourg
Cyprus	Malta
Czech Republic	Netherlands
Denmark	Poland
Estonia	Portugal
Finland	Romania
France	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Ireland	United Kingdom

In the following table all the variables that I used in the regressions will be explained so that anyone can read efficiently the stata outputs.

Table 5

Variable Definition

lgrowth = difference in the logarithms of growth rates	open = degree of openness (World Bank)
growth = growth rate as $(y_t-y_{t-1})/ y_{t-1}$	invrat = investment ratio
loggdp = log of initial per capita GDP	inf = inflation
upsch = upper schooling for male	taxrev = tax revenues
lifeexp = 1/ (Life expectancy at birth)	primarymale = primary schooling for male
lfert= log of fertility rate	primaryfem = primary schooling for females
gconsrat = government's consumption ratio	upschfem = upper schooling for females
rol = rule of law	secmale = secondary schooling for males
ethten = ethnic tension	collegemale = tertiary schooling for males
democ = democracy	lresearchers = log of number of researchers
democsq = square of democracy	rndexpen = expenses on R&D
openness = degree of openness (Penn-World Tables)	corruption = official corruption
	bureaucracy = quality of bureaucracy

The following output refers to the regression (1) of Table 1

Number of obs	229
F(39, 189)	8.3
Prob > F	0
R-squared	0.5882
Root MSE	0.01051

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0377978	0.0173656	-2.18	0.031	-0.0720532	-0.00354
upsch	0.0016086	0.0017951	0.9	0.371	-0.0019323	0.00515
lifexp	-11.37353	4.653389	-2.44	0.015	-20.55278	-2.19427
_cons	0.3074783	0.1057007	2.91	0.004	0.0989736	0.515983

The following output refers to the regression (2) of Table 1

Number of obs	175
F(40, 134)	9.39
Prob > F	0
R-squared	0.6713
Root MSE	0.00964

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0599627	0.0236826	-2.53	0.012	-0.1068027	-0.01312
upsch	-0.0031441	0.0017975	-1.75	0.083	-0.0066991	0.000411
lifexp	-17.28351	8.544491	-2.02	0.045	-34.18302	-0.38399
lfert	-0.0079098	0.0141883	-0.56	0.578	-0.0359718	0.020152
gconsrat	-0.0037033	0.0007302	-5.07	0	-0.0051475	-0.00226
taxrev	0.0001754	0.0002096	0.84	0.404	-0.0002391	0.00059
_cons	0.5627899	0.1843679	3.05	0.003	0.1981423	0.927438

The following output refers to the regression (3) of Table 1

Number of obs	166
F(43, 122)	11.42
Prob > F	0
R-squared	0.7579
Root MSE	0.00847

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0450368	0.02129	-2.12	0.036	-0.0871824	-0.0028912
upsch	-0.001283	0.001873	-0.68	0.495	-0.0049908	0.0024249
lifexp	-7.677165	7.584682	-1.01	0.313	-22.6918	7.33747
lfert	-0.0164548	0.0159308	-1.03	0.304	-0.0479914	0.0150818
gconsrat	-0.0029596	0.0008101	-3.65	0	-0.0045632	-0.001356
openness	0.0000924	0.000069	1.34	0.183	-0.0000442	0.000229
invrat	0.0006504	0.0002618	2.48	0.014	0.0001321	0.0011687
inf	-0.0000682	0.0000266	-2.56	0.012	-0.0001209	-0.0000155
taxrev	0.0001599	0.000165	0.97	0.334	-0.0001667	0.0004866
_cons	0.3481427	0.1577075	2.21	0.029	0.0359449	0.6603405

The following output refers to the regression (4) of Table 1

Number of obs	133
F(45, 87)	22.36
Prob > F	0
R-squared	0.854
Root MSE	0.00541

lgrowth	Coef	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0254167	0.0141646	-1.79	0.076	-0.0535704	0.002737
upsch	-0.0016313	0.0013864	-1.18	0.243	-0.0043869	0.001124
lifexp	-3.214484	6.687614	-0.48	0.632	-16.50684	10.07787
lfert	-0.0337965	0.0141543	-2.39	0.019	-0.0619296	-0.00566
gconsrat	-0.0007985	0.0005218	-1.53	0.13	-0.0018357	0.000239
rol	0.0212143	0.0077142	2.75	0.007	0.0058815	0.036547
ethten	-0.0147498	0.0071311	-2.07	0.042	-0.0289237	-0.00058
democ	0.2395441	0.0551094	4.35	0	0.1300082	0.34908
democsq	-0.1477794	0.041682	-3.55	0.001	-0.2306269	-0.06493
openness	0.0001516	0.0000548	2.77	0.007	0.0000427	0.000261
invrat	0.0006951	0.0001823	3.81	0	0.0003328	0.001057
inf	-0.0001427	0.0000346	-4.13	0	-0.0002115	-7.4E-05
taxrev	-0.0002087	0.000121	-1.73	0.088	-0.0004491	3.17E-05
_cons	0.083065	0.1093743	0.76	0.45	-0.1343282	0.300458

The following outputs refer to the regressions of Table 2 respectively with the order the variables are presented

Number of obs	133
F(46, 86)	22.68
Prob > F	0
R-squared	0.8614
Root MSE	0.0053

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0128521	0.0162913	-0.79	0.432	-0.0452381	0.019534
upsch	-0.0011898	0.0014011	-0.85	0.398	-0.0039751	0.001596
lifexp	0.4341457	7.016629	0.06	0.951	-13.51445	14.38274
lfert	-0.0352746	0.0137139	-2.57	0.012	-0.0625369	-0.00801
gconsrat	-0.0004993	0.0005274	-0.95	0.346	-0.0015478	0.000549
rol	0.0266362	0.0079766	3.34	0.001	0.0107792	0.042493
ethten	-0.0182899	0.0073482	-2.49	0.015	-0.0328977	-0.00368
democ	0.1897596	0.0542872	3.5	0.001	0.0818403	0.297679
democsq	-0.118562	0.0389248	-3.05	0.003	-0.195942	-0.04118
openness	0.0001698	0.0000577	2.94	0.004	0.0000551	0.000285
invrat	0.0005251	0.0001912	2.75	0.007	0.000145	0.000905
inf	-0.0001253	0.0000315	-3.98	0	-0.0001879	-6.3E-05
taxrev	-0.0002308	0.0001206	-1.91	0.059	-0.0004706	8.99E-06
ltotpop	-0.0828732	0.0453897	-1.83	0.071	-0.1731051	0.007359
_cons	0.5664879	0.2946383	1.92	0.058	-0.0192337	1.15221

Number of obs	133
F(46, 86)	23.61
Prob > F	0
R-squared	0.8549
Root MSE	0.00542

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.024849	0.0142241	-1.75	0.084	-0.0531256	0.0034275
upsch	-0.004178	0.0036734	-1.14	0.259	-0.0114805	0.0031245
lifexp	-3.107905	6.708268	-0.46	0.644	-16.4435	10.22769
lfert	-0.0352219	0.0141023	-2.5	0.014	-0.0632564	-0.0071874
gconsrat	-0.0007362	0.0005204	-1.41	0.161	-0.0017708	0.0002984
rol	0.0219533	0.0078206	2.81	0.006	0.0064065	0.0375001
ethten	-0.0146204	0.0071302	-2.05	0.043	-0.0287948	-0.000446
democ	0.2458825	0.0558327	4.4	0	0.1348908	0.3568743
democsq	-0.1523628	0.0419775	-3.63	0	-0.2358113	-0.0689143
openness	0.0001524	0.0000561	2.72	0.008	0.000041	0.0002639
invrat	0.0007057	0.0001859	3.8	0	0.0003361	0.0010752
inf	-0.0001429	0.0000343	-4.16	0	-0.0002111	-0.0000747
taxrev	-0.0002137	0.0001215	-1.76	0.082	-0.0004553	0.0000278
upschfem	0.0027515	0.003157	0.87	0.386	-0.0035244	0.0090274
_cons	0.0780944	0.1099768	0.71	0.48	-0.1405323	0.2967211

Number of obs	133
F(47, 85)	20.8
Prob > F	0
R-squared	0.8579
Root MSE	0.0054

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0248576	0.0143	-1.7400	0.0860	-0.0533	0.0036
upsch	-0.0012922	0.0015	-0.8500	0.4000	-0.0043	0.0017
lifexp	-1.946744	6.6536	-0.2900	0.7710	-15.1758	11.2824
lfert	-0.0316082	0.0146	-2.1600	0.0330	-0.0607	-0.0026
gconsrat	-0.0007015	0.0006	-1.2100	0.2290	-0.0019	0.0004
rol	0.0203333	0.0077	2.6400	0.0100	0.0050	0.0357
ethten	-0.0141415	0.0084	-1.6900	0.0950	-0.0308	0.0025
democ	0.2424492	0.0560	4.3300	0.0000	0.1312	0.3537
democsq	-0.1500815	0.0429	-3.5000	0.0010	-0.2354	-0.0647
openness	0.000148	0.0001	2.5900	0.0110	0.0000	0.0003
invrat	0.0006963	0.0002	3.6700	0.0000	0.0003	0.0011
inf	-0.0001367	0.0000	-4.4200	0.0000	-0.0002	-0.0001
taxrev	-0.0001938	0.0001	-1.6700	0.0990	-0.0004	0.0000
primarymale	-0.0119722	0.0076	-1.5700	0.1210	-0.0272	0.0032
primaryfem	0.0091236	0.0059	1.5500	0.1250	-0.0026	0.0208
_cons	0.0709972	0.1080066	0.66	0.513	-0.1437489	0.2857433

Number of obs	133
F(46, 86)	21.95
Prob > F	0
R-squared	0.8542
Root MSE	0.00543

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0234772	0.0155212	-1.51	0.134	-0.0543324	0.007378
secmale	-0.0013018	0.0015134	-0.86	0.392	-0.0043104	0.0017067
collegemale	-0.0045168	0.0111976	-0.4	0.688	-0.0267768	0.0177432
lifexp	-2.77222	7.148009	-0.39	0.699	-16.98199	11.43755
lfert	-0.0340581	0.0142524	-2.39	0.019	-0.0623909	-0.0057253
gconsrat	-0.0007722	0.0005302	-1.46	0.149	-0.0018261	0.0002818
rol	0.0218982	0.0080072	2.73	0.008	0.0059803	0.0378161
ethten	-0.0150361	0.0072737	-2.07	0.042	-0.0294957	-0.0005764
democ	0.2362694	0.0560383	4.22	0	0.124869	0.3476698
democsq	-0.1455817	0.0422993	-3.44	0.001	-0.2296699	-0.0614935
openness	0.000158	0.0000616	2.56	0.012	0.0000355	0.0002805
invrat	0.0006886	0.0001832	3.76	0	0.0003244	0.0010528
inf	-0.0001413	0.0000348	-4.06	0	-0.0002105	-0.0000721
taxrev	-0.0002235	0.0001247	-1.79	0.077	-0.0004714	0.0000245
_cons	0.0610023	0.1268242	0.48	0.632	-0.1911157	0.3131204

Number of obs	133
F(47, 85)	25.62
Prob > F	0
R-squared	0.859
Root MSE	0.00538

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0327628	0.0150815	-2.17	0.033	-0.0627489	-0.0027767
upsch	-0.0012942	0.0014042	-0.92	0.359	-0.0040862	0.0014978
lifexp	-4.576999	6.779513	-0.68	0.501	-18.05649	8.902489
lfert	-0.0237963	0.0155225	-1.53	0.129	-0.0546593	0.0070666
gconsrat	-0.0008644	0.0005264	-1.64	0.104	-0.0019111	0.0001823
rol	0.0202356	0.0086376	2.34	0.021	0.0030619	0.0374094
ethten	-0.0157977	0.0073319	-2.15	0.034	-0.0303756	-0.0012199
democ	0.2414646	0.0554364	4.36	0	0.1312421	0.3516871
democsq	-0.1485165	0.0419908	-3.54	0.001	-0.2320054	-0.0650276
openness	0.0001472	0.0000544	2.71	0.008	0.0000391	0.0002553
invrat	0.0006107	0.0001833	3.33	0.001	0.0002462	0.0009751
inf	-0.0001369	0.0000348	-3.93	0	-0.0002061	-0.0000677
taxrev	-0.0001947	0.0001126	-1.73	0.087	-0.0004185	0.0000291
corruption	-0.0084671	0.0062001	-1.37	0.176	-0.0207946	0.0038603
bureaucracy	0.0171067	0.0105799	1.62	0.11	-0.003929	0.0381424
_cons	0.1240473	0.1119516	1.11	0.271	-0.0985424	0.346637

Number of obs	78
F(44, 33)	125.15
Prob > F	0
R-squared	0.8888
Root MSE	0.00606

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0514472	0.0319661	-1.61	0.117	-0.1164827	0.0135883
upsch	0.0001068	0.0026576	0.04	0.968	-0.0053001	0.0055136
lifexp	-16.5598	14.8195	-1.12	0.272	-46.7103	13.59071
lfert	-0.0639263	0.0433698	-1.47	0.15	-0.1521629	0.0243103
gconsrat	-0.0016384	0.0011098	-1.48	0.149	-0.0038963	0.0006195
rol	0.024206	0.0170206	1.42	0.164	-0.0104227	0.0588347
ethten	-0.0209613	0.0166865	-1.26	0.218	-0.0549102	0.0129877
democ	-0.2985477	0.2004702	-1.49	0.146	-0.7064075	0.1093121
democsq	0.1500316	0.1172609	1.28	0.21	-0.0885375	0.3886008
openness	0.0002848	0.0001606	1.77	0.085	-0.000042	0.0006116
invrat	0.0015275	0.0006646	2.3	0.028	0.0001753	0.0028797
inf	-0.0000812	0.0000597	-1.36	0.183	-0.0002026	0.0000403
taxrev	-0.0002118	0.0001913	-1.11	0.276	-0.000601	0.0001774
lresearchers	-0.0017777	0.012952	-0.14	0.892	-0.0281289	0.0245734
rndexpen	0.001408	0.0093097	0.15	0.881	-0.0175328	0.0203489
_cons	0.5825674	0.3435516	1.7	0.099	-0.1163936	1.281528

The following output refers to the regression (1) of Table 3

Number of obs	133
F(45, 87)	12.78
Prob > F	0
R-squared	0.7944
Root MSE	1.2073

growth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-18.33796	3.188151	-5.75	0	-24.67476	-12.0012
upsch	-0.4884233	0.283944	-1.72	0.089	-1.052793	0.075946
lifexp	939.4185	1381.578	0.68	0.498	-1806.617	3685.454
lfert	-9.986884	3.198415	-3.12	0.002	-16.34408	-3.62969
gconsrat	-0.1808473	0.1070844	-1.69	0.095	-0.3936891	0.031995
rol	2.236031	1.736688	1.29	0.201	-1.215824	5.687886
ethten	-0.0359232	1.46182	-0.02	0.98	-2.941449	2.869603
democ	16.00523	11.12964	1.44	0.154	-6.116126	38.12659
democsq	-8.839666	8.728194	-1.01	0.314	-26.1879	8.508564
openness	0.0315205	0.0117772	2.68	0.009	0.008112	0.054929
invrat	0.1234865	0.0386587	3.19	0.002	0.0466481	0.200325
inf	-0.031726	0.0057199	-5.55	0	-0.0430948	-0.02036
taxrev	-0.0085087	0.0239008	-0.36	0.723	-0.0560141	0.038997
_cons	64.77838	23.48485	2.76	0.007	18.09969	111.4571

The following output refers to the regression (2) of Table 3

Number of obs	133
F(45, 87)	20.08
Prob > F	0
R-squared	0.8469
Root MSE	0.00554

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0302164	0.0154934	-1.95	0.054	-0.0610112	0.000579
upsch	-0.0019748	0.0013852	-1.43	0.158	-0.0047281	0.000779
lifexp	-4.802284	6.915751	-0.69	0.489	-18.54809	8.943521
lfert	-0.0329958	0.0147317	-2.24	0.028	-0.0622767	-0.00371
gconsrat	-0.0010223	0.0005382	-1.9	0.061	-0.002092	4.74E-05
rol	0.0189187	0.0078199	2.42	0.018	0.0033759	0.034462
ethten	-0.0133102	0.0076416	-1.74	0.085	-0.0284988	0.001878
democ	0.2551124	0.0547842	4.66	0	0.1462229	0.364002
democsq	-0.156397	0.0421687	-3.71	0	-0.2402118	-0.07258
open	0.0000996	0.0000525	1.9	0.061	-4.84E-06	0.000204
invrat	0.0007473	0.0001842	4.06	0	0.0003812	0.001113
inf	-0.0001511	0.0000337	-4.49	0	-0.0002181	-8.4E-05
taxrev	-0.0001885	0.000122	-1.55	0.126	-0.000431	5.39E-05
_cons	0.1295869	0.1111428	1.17	0.247	-0.0913214	0.350495

The following output refers to the regression (3) of Table 3

Number of obs	69
F(30, 38)	25.18
Prob > F	0
R-squared	0.8388
Root MSE	0.00573

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0316824	0.0255664	-1.24	0.223	-0.083439	0.020074
upsch	-0.0017368	0.0025448	-0.68	0.499	-0.0068885	0.003415
lifexp	13.12663	13.01386	1.01	0.32	-13.21855	39.4718
lfert	-0.0208858	0.0253421	-0.82	0.415	-0.0721883	0.030417
gconsrat	-0.0000364	0.0008154	-0.04	0.965	-0.0016871	0.001614
rol	0.0281349	0.0110266	2.55	0.015	0.0058128	0.050457
ethten	-0.021824	0.0099498	-2.19	0.034	-0.0419662	-0.00168
democ	0.1534923	0.1456891	1.05	0.299	-0.1414399	0.448425
democsq	-0.0780765	0.1252515	-0.62	0.537	-0.3316348	0.175482
openness	0.0002166	0.0000867	2.5	0.017	0.0000411	0.000392
invrat	0.0006129	0.0002469	2.48	0.018	0.000113	0.001113
inf	-0.0001173	0.0000396	-2.96	0.005	-0.0001975	-3.7E-05
taxrev	-0.0002071	0.0001569	-1.32	0.195	-0.0005248	0.000111
_cons	-0.1242977	0.1536795	-0.81	0.424	-0.4354056	0.18681

The following output refers to the regression (4) of Table 3

Number of obs	64
F(32, 31)	1164.33
Prob > F	0
R-squared	0.9242
Root MSE	0.00487

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.026388	0.0258482	-1.02	0.315	-0.0791057	0.02633
upsch	-0.0047035	0.002231	-2.11	0.043	-0.0092537	-0.00015
lifexp	-34.17588	10.86007	-3.15	0.004	-56.32514	-12.0266
lfert	-0.043818	0.0384763	-1.14	0.263	-0.1222909	0.034655
gconsrat	-0.0025148	0.0012994	-1.94	0.062	-0.005165	0.000135
rol	0.0095936	0.0198531	0.48	0.632	-0.030897	0.050084
ethten	-0.0000281	0.0159348	0	0.999	-0.0325274	0.032471
democ	-0.3272257	0.1914838	-1.71	0.097	-0.7177595	0.063308
democsq	0.1699078	0.1162029	1.46	0.154	-0.0670897	0.406905
openness	0.0001423	0.0001517	0.94	0.355	-0.0001671	0.000452
invrat	0.0006118	0.0005173	1.18	0.246	-0.0004433	0.001667
inf	0.0004831	0.0003054	1.58	0.124	-0.0001398	0.001106
taxrev	-0.0003504	0.0003917	-0.89	0.378	-0.0011494	0.000449
_cons	0.7865317	0.2996395	2.62	0.013	0.175413	1.39765

The following output refers to the regression (5) of Table 3

Number of obs	98
F(35, 62)	15.79
Prob > F	0
R-squared	0.8363
Root MSE	0.00421

lgrowth	Coef.	Robust Std. Err.	t	P>t	[95% Conf.	Interval]
loggdp	-0.0438886	0.0175685	-2.5	0.015	-0.0790077	-0.0087696
upsch	0.0010744	0.0013913	0.77	0.443	-0.0017067	0.0038555
lifexp	16.60038	7.567142	2.19	0.032	1.473875	31.72688
lfert	-0.0390008	0.0179596	-2.17	0.034	-0.0749015	-0.0031001
gconsrat	-0.0008435	0.0006253	-1.35	0.182	-0.0020935	0.0004066
rol	0.0112175	0.0071852	1.56	0.124	-0.0031454	0.0255805
ethten	-0.000835	0.0068334	-0.12	0.903	-0.0144948	0.0128249
democ	0.0464446	0.1616224	0.29	0.775	-0.276634	0.3695232
democsq	-0.0182449	0.0961144	-0.19	0.85	-0.2103748	0.173885
openness	0.0002251	0.000064	3.52	0.001	0.0000971	0.0003532
invrat	0.0004892	0.0002322	2.11	0.039	0.000025	0.0009533
inf	-0.000584	0.0003188	-1.83	0.072	-0.0012213	0.0000533
taxrev	-0.0000589	0.0001204	-0.49	0.627	-0.0002995	0.0001818
_cons	-0.0398298	0.1588151	-0.25	0.803	-0.3572966	0.277637

References

Aghion, Philippe, and Peter Howitt. (1992). "A Model of Growth Through Creative Destruction." Econometrica 60, no. 2: 323-351

Alan Heston, Robert Summers and Bettina Aten, Penn World Table Version 6.1, Center for International Comparisons at the University of Pennsylvania (CICUP), October 2002.

Alesina, A., & Rodrik, D. (1991). "*Distributive politics and economic growth* (No. w3668)." National bureau of economic research.

Arrow, Kenneth J. (1962). "The Economic Implications of Learning by Doing." *Review of Economic Studies,* 29, June, 155–173.

Barro, R. & Sala-i-Martin, X. (2004). "*Economic growth* (2nd ed.)". Cambridge, Mass.: MIT Press.

Barro, R. (1990). "Government Spending in a Simple Model of Endogenous Growth." *Journal Of Political Economy*, *98*(5, Part 2), S103-S125.

Barro, R. J. (1996). "*Determinants of economic growth: a cross-country empirical study* (No. w5698)." National Bureau of Economic Research.

Barro, R. J. (2003). "Determinants of economic growth in a panel of countries." *Annals of economics and finance*, *4*, 231-274.

Barro, R. J., & Sala-i-Martin, X. (1995). *Technological diffusion, convergence, and growth* (No. w5151). National Bureau of Economic Research.

Barro, Robert and Jong-Wha Lee, (2013). "A New Data Set of Educational Attainment in the World, 1950-2010." *Journal of Development Economics*, vol 104, 184-198.

Barro, Robert J., and Gary S. Becker (1989). "Fertility Choice in a Model of Economic Growth." *Econometrica,*57, March, 481–501.

Barro, Robert J., and Xavier Sala-i-Martin (1992b). "Regional Growth and Migration: A Japan–United States Comparison." *Journal of the Japanese and International Economies,* 6, December, 312–346.

Barro, Robert J., and Xavier Sala-i-Martin (1992c). "Public Finance in Models of Economic Growth." *Review of Economic Studies,* 59, October, 645–661.

Barro, Robert J., N. Gregory Mankiw, and Xavier Sala-i-Martin (1995). "Capital Mobility in Neoclassical Models of Growth." *American Economic Review,* 85, March, 103–115.

Becker, Gary S., and Robert J. Barro (1988). "A Reformulation of the Economic Theory of Fertility." *Quarterly Journal of Economics,* 103, February, 1–25.

Becker, Gary S., Kevin M. Murphy, and Robert Tamura (1990). “Human Capital, Fertility, and Economic Growth.” *Journal of Political Economy,* 98, October, part II, S12–S37.

Blanchard, Olivier (1985). “Debt, Deficits, and Finite Horizons.” *Journal of Political Economy,* 93, April, 223–247.

Braun, Juan (1993). “*Essays on Economic Growth and Migration.”* Ph.D. dissertation, Harvard University.

Cass, David (1965). “Optimum Growth in an Aggregative Model of Capital Accumulation.” *Review of Economic Studies,* 32, July, 233–240.

Chamley, Christophe (1992). “The Last Shall Be First: Efficient Constraints on Foreign Borrowing in a Model of Endogenous Growth.” *Journal of Economic Theory,* 58, December, 335–354.

Galor, Oded and Joseph Zeira (1988): "Income Distribution and Macroeconomics' Brown University Working Paper 89-25.

Jones, C. I. (1995). “R & D-based models of economic growth. *Journal of political Economy”*, 759-784.

Kaldor, N. (1961). “Capital accumulation and economic growth. In *The theory of capital* (pp. 177-222)”. Palgrave Macmillan UK.

Knack, Stephen, and Philip Keefer (1995). “Institutions and Economic Performance: Cross-Country Tests Using Alternative Institutional Measures.” *Economics and Politics,* 7, 207–228.

Koopmans, Tjalling C. (1965). “On the Concept of Optimal Economic Growth.” In *The Econometric Approach to Development Planning.* Amsterdam: North Holland, 1965.

Lucas, R. E. (1988). “On the mechanics of economic development.” *Journal of monetary economics*, *22*(1), 3-42.

Mankiw, N. G., Romer, D., & Weil, D. N. (1990). *A contribution to the empirics of economic growth* (No. w3541). National Bureau of Economic Research.

Nelson, R. R., & Phelps, E. S. (1966). “Investment in humans, technological diffusion, and economic growth.” *The American economic review*, *56*(1/2), 69-75. November.

Perotti, Roberto (1990): "Political equilibrium income distribution and growth," unpublished,
Persson, T., & Tabellini, G. (1991). “*Is inequality harmful for growth? Theory and evidence* (No. w3599)”. National Bureau of Economic Research.

Ramsey, F. P. (1928). “A mathematical theory of saving.” *The economic journal*, *38*(152), 543-559.

Rebelo, Sergio (1991). “Long-Run Policy Analysis and Long-Run Growth.” *Journal of Political Economy,* 99, June, 500–521.

Ricardo, David (1817). “*On the Principles of Political Economy and Taxation.”* Cambridge: Cambridge University Press, 1951.

Romer, P. M. (1986). “Increasing returns and long-run growth.” *The journal of political economy*, 1002-1037.

Romer, P. M. (1987). “Growth based on increasing returns due to specialization.” *The American Economic Review*, *77*(2), 56-62.

Romer, P. M. (1989). “*Endogenous technological change* (No. w3210).” National Bureau of Economic Research.

Romer, P. M. (1994). “The origins of endogenous growth.” *The journal of economic perspectives*, *8*(1), 3-22.

Sala-i-Martin, X. (1990). “*Lecture notes on economic growth (II): Five prototype models of endogenous growth* (No. w3564)”. National Bureau of Economic Research.

Schumpeter, Joseph A. (1934). “*The Theory of Economic Development.”* Cambridge, MA: Harvard University Press.

Sheshinski, Eytan (1967). “Optimal Accumulation with Learning by Doing.” In Karl Shell, ed., *Essays on the Theory of Optimal Economic Growth,* 31–52. Cambridge, MA: MIT Press.

Solow, R. M. (1956). “A contribution to the theory of economic growth.” *The quarterly journal of economics*, 65-94.

Solow, Robert M. (1957). “Technical Change and the Aggregate Production Function.” *Review of Economic*s *and Statistics,* 39, August, 312–320.

Summers, R., & Heston, A. (1988). “A new set of international comparisons of real product and price levels estimates for 130 countries, 1950–1985.” *Review of income and wealth*, *34*(1), 1-25.

Swan, Trevor W. (1956). “Economic Growth and Capital Accumulation.” *Economic Record,* 32, November, 334–361.

Uzawa, Hirofumi (1965). “Optimal Technical Change in an Aggregative Model of Economic Growth.” *International Economic Review,* 6, January, 18–31.

Weil, Philippe (1989). “Overlapping Families of Infinitely Lived Agents.” *Journal of Public Economics,* 38, March, 183–198.

Young, Allyn (1928). “Increasing Returns and Economic Progress.” *Economic Journal,* 38, December, 527–542.

Καλαϊτζακης, Π. & Καλυβίτης, Σ. (2008). “*Οικονομική Μεγέθυνση Θεωρία και Πολιτική* (Revised ed.).” Εκδόσεις Κριτική.