Analyzing economic growth: what role for public investment?

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Abstract

This paper discusses the role of public investment in the determination of output growth from different theoretical and empirical points of view. The light is shed on the factors that allegedly explain the success and/or the failure of public investment policies in enhancing productivity and supporting GDP, based on a review of empirical evidence in advanced and developing economies. The downstream objective is to provide decision makers with a set of general rules-of-thumb that are likely to help them improve the macroeconomic returns of public investment. The latter are found to be significantly influenced by efficiency and profitability-based selectivity of investment projects. Countries with a relatively low capital-labor ratio usually have higher public and private capital profitability, while the public-private investment substitutability increases the likelihood of crowding out effects. The paper also gives hints on the possible existence of an optimal growth-maximizing level of public investment.

Keywords: GDP growth, Public Investment, Productivity, Private Investment, Development

JEL Classification: E62, H54, O40

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I. INTRODUCTION

The concept of economic growth is still considered to be quite "modern", or at least the great attention that has been given to its mechanisms and to the improvement of its pace. Yet, it is a phenomenon that had seen the light back in the 18th century [Bairoch (1993) / Easterlin (1996)].

According to several empirical studies, economic growth plays an important role in the shaping of the living standards of a given population. Differences between countries in terms of growth rates are shown to lead, if maintained over a long period of time, to noteworthy gaps in human welfare between their respective populations. Some authors demonstrated the latter statement through a comparison between the East Asian economies and the Sub-Saharan African ones since the 1960s, i.e. more or less the end of the colonization[2]. The evident difference between these two sets of countries in terms of economic growth rates over the past decades and the respective average level of living standards has been used by some proponents of the Trickle Down theory in order to defend that economic growth actually "trickles down" to all the population, thereby contributing directly to the human development. Linking economic growth to –human- development has also been the subject of an important number of research papers during the last four decades. As an example, Rosenberg and Birdzell (1986) defend that in the short run people have the tendency to believe that the gains from economic growth are experienced exclusively by the wealthy. However, both authors explain that, in light of the accumulated economic growth through the twentieth century, working classes in developed countries were prospering and growing as a proportion of the whole population, as the incidence of poverty itself was reduced from 90 percent of the population to 20 percent more or less, depending on the country and on the definition criteria of poverty.

This argument is confirmed by Crafts (2003), who illustrates the propitious impact of economic growth on human development by showing its correlation with life expectancy and how the latter contributes to the enhancement of living standards.

It is important however to notice that demographic growth could blur the impact of economic growth on development, in the sense that an increase in GDP could be absorbed if matched with a proportional progression in the population. It is also possible to reach higher or lower per capita income through variations in the population. In this framework, Reynolds (1985) makes a distinction between *extensive* and *intensive* growth. The former is when GDP growth is fully absorbed by a demographic progression with no positive variation in per capita income; the intensive growth is when GDP growth is more important than population's expansion.

As History shows, extensive growth had been predominant for centuries, as the large majority of the world population was bound to subsistence standards of living as economies allegedly kept moving forward. This finds explanation in the fact that possibilities for sustained intensive growth were particularly scarce in primary sector-based economies.

[2] Snowdon & Vane (2005), P. 589.

According to Reynolds (1994), the availability and productivity of land determined the amount of extensive growth, but once the supply of suitable agricultural land was exhausted, decreasing incomes set in. This historical evidence provided contextual background to Robert Malthus's bleak prediction of an ineluctable long-run stationary state where nearly all humankind would be living on the strict minimum.

As for the intensive form of growth, it took place only during a relatively short period of time[3], and it is possible to make a distinction between "Smithian" intensive growth and "Promethian" one, mostly based on their level of sustainability. The former fits partially in the logic described above by Reynolds (*ibid.*), in the sense that the growth generated from productivity-enhancing resource reallocation, division of labor and trade, remains limited and the returns end up decreasing *in fine*. On the other hand, "Promethian" intensive growth, which is mainly driven by innovation and investment in new technologies, offers consistent elements of sustainability and provides larger perspectives of evolution for the economy.

In order to get more insight on the ins and outs of economic growth according to the literature, the first section of this paper discusses the main contributions of the Growth Theory School, which regroups several economists that dedicated the most part of their theoretical research to this particular topic. Then, we switch emphasis to the determinants of GDP growth, with a particular accent on the role of public investment as a potential growth-enhancing policy measure in light of various theoretical contributions and empirical evidence. The downstream aim is to assess the significance of public capital in influencing growth and to come up with general rules-of-thumb that, put together, could help explain any economy's likelihood of public investment macroeconomic returns.

II. THE MAIN CONTRIBUTIONS OF THE GROWTH THEORY

One of the most influential contemporaneous schools that tackled the question of the ins and outs of economic growth and helped switch the research paradigm regarding this matter is, without a doubt, the Growth Theory. According to the literature at this regard, growth theorists make the difference between *proximate* sources of growth and *deep* ones. The main variables that have been examined in the first category are capital and labor, as well as their accumulation and the degrees of their respective productivity, while the second category is mainly focused on the macroeconomic impact of technology, knowledge and innovation. In this framework, Rodrik (2003) argues that, when analyzing the accumulation of the aforementioned production factors in different countries, one cannot miss the significant disparities between the said countries regarding the amount of success in adopting new

[3] According to economic history literature, the intensive growth pattern could have been triggered by the industrial revolution. The period of time (several decades) is considered however to be quite small, compared to centuries of extensive growth paradigm.

technologies, or simply in producing and accumulating the said production factors. Obviously, some economies have more advanced paces than others at this particular level[4].

In order to find explanation to these disparities, several growth theorists went beyond the *proximate* determinants. Economists like Rodrik (2003) and Temple (1999) focused on the *deep* (also said *fundamental*) causes of economic growth, which relate to those variables that lay influence on an economy's capacity to accumulate human and physical capital and to invest in the production of knowledge and innovation[5]. In this context, Temple (*ibid.*) argues that population growth, income distribution, trade regimes, the size of the government, but also the overall macroeconomic, political and social environments have a tangible impact. Analyzing the *fundamental* determinants of economic growth helped shift emphasis to the institutional aspects of a given economy. According to several World Bank reports, good governance and institutions represent a "crucial precondition for successful growth and development". Moreover, Abramovitz (1986) drew attention to the determinant role of an economy's *social capability* when it comes to economic growth[6].

Some of these hypotheses, among other assumptions, were encompassed in integrated workhorse models in order to facilitate their assessment when it comes to economic implications. According to the literature, there are three main patterns of economic growth theory models. The first one to be ever created was the New Keynesian Harrod-Domar model, developed by the year 1948 by Roy Harrod and Evsey Domar. The emphasis was then significantly shifted toward the neoclassical framework in 1956, with the development of the Solow-Swan growth model. As a response to the theoretical and empirical insufficiencies observed in the neoclassical model, a type of models initially developed by Paul Romer and Robert Lucas, led the way toward the *endogenous* growth theory.

2.1 The New Keynesian Harrod-Domar model

The theories behind this model were separately developed by Harrod (1948) and Domar (1947). Their respective works aimed to assess the long-term dynamics of capitalist market economies, thus transcending the initial static Keynesian short-run paradigm. In his research, John Maynard Keynes argues that investment drives a significant impact on aggregate demand. Harrod and Domar, however, shed the light on the supply-side effect, namely how investment spending helps enhance the productive capacity of a given economy.

The model is based on the assumption that the labor force growth rate is exogenous, and the capital-output ratio has an unchanged value (the technology is assumed to be fixed). Given an

[4] Rodrik, D. (2003), 'In Search of Prosperity: Analytic Narratives on Economic Growth', Princeton University Press, chap. 1

[5] The logic is explained in Temple, J. (1999), 'The New Growth Evidence', Journal of Economic Literature, Vol. 37 (March), PP. 141-144

[6] Abramovitz M. (1986), "Catching Up, Forging Ahead, and Falling Behind", Journal of Economic History, June, P. 389

economy that encompasses only firms and households, and since national income (Y_t) would in this case equal consumption (C_t) and saving (S_t), we write:

$$Y_t = C_t + S_t$$

In order for the economy to reach equilibrium, all saving must be invested. We write:

$$I_t = S_t$$

As a consequence, it would be possible to say that the national income (which represents also the GDP) equals consumption and investment:

$$Y_t = C_t + I_t$$

Also, given that the capital stock is subject to a persistent depreciation (δ), while investment helps push it upward, it can be written as follows:

$$K_{t+1} = K_t - \delta . K_t + I_t$$
$$\text{Or} \quad K_{t+1} = (1-\delta)K_t + I_t$$

As mentioned above, the capital-output ratio ($\frac{K_t}{Y_t}$) is supposed to be fixed. This implies that the variations in these two variables are proportional, hence $\frac{\Delta K_t}{\Delta Y_t}$ is also fixed. We write:

$$\varphi = \frac{K_t}{Y_t} = \frac{\Delta K_t}{\Delta Y_t} \text{ Therefore } K_t = \varphi . Y_t$$

It is possible to say that total saving is a certain proportion (τ) of national income:

$$S_t = \tau . Y_t$$

If we take into account the aforementioned equilibrium condition, in which investment is strictly determined by saving:

$$K_{t+1} = (1-\delta)K_t + \boldsymbol{S_t}$$

After replacing K_t and S_t: $\boldsymbol{\varphi . Y_{t+1}} = (1-\delta)\boldsymbol{\varphi . Y_t} + \boldsymbol{\tau . Y_t} = \varphi . Y_t - \delta . \varphi . Y_t + \tau . Y_t$

When dividing both sides of this equation by φ then moving Y_t to the left side:

$$Y_{t+1} - Y_t = [(\tau/\varphi) - \delta] . Y_t$$

Dividing by Y_t gives us:

$$[Y_{t+1} - Y_t]/Y_t = (\tau/\varphi) - \delta$$

The left side of this final equation represents evidently the growth rate, which can be replaced for the sake of simplification by the letter *G* per example. Thus, according to the Harrod-Domar model, economic growth rate is tributary to the saving ratio τ divided by the capital-output ratio φ, minus the capital stock depreciation rate δ. In other words, the more important the saving ratio and the lower is the depreciation rate and the proportion of capital compared to output, the higher is the growth rate. As for the depreciation rate, it was considered by both authors to be of no tangible influence on the economic growth and was not taken into account in several arguments after that.

More saving implies more investment. The mainstay of the Harrod-Domar model is quite simple: more investment and relatively less capital accumulation in order to support GDP growth. Used in development economics research areas, the solution to underdevelopment would be to simply increase resources dedicated to investment. And as the growth rate is positively correlated to the savings ratio in this model, several economists, such as Lewis (1954) and Rostow (1960), focused their research on the means of raising private savings ratios with the purpose of enabling underdeveloped countries to converge toward self-sustained growth. Following this paradigm, public fiscal policy was considered as a prominent tool according to development economics theorists during the 1950s, especially that a budgetary surplus can hypothetically substitute for private domestic savings. Some works also took into account the significant role of foreign aid when reducing the savings gap in developing countries.

However, the main downside of the Harrod-Domar model is the fixity of the capital-output ratio, to which we refer above as φ. In principle, $\frac{1}{\varphi}$ represents the *productivity* of investment; a fundamental concept when it comes to analyzing the effectiveness and efficiency of the investment policy. Since the capital stock depreciation ratio influence on growth could be neglected, it is possible to state that GDP growth is tributary to the savings ratio multiplied by the productivity rate of investment. The latter variable should not be given. Moreover, according to Griffin (1970), the propitious effect of aid on investment was overrated; as a matter of fact, foreign inflows often led to a decrease in domestic savings alongside a decline in the productivity of investment. Nonetheless, this observation could not be assessed in the Harrod-Domar framework.

Another shortcoming of this model is the hypothesis of zero substitutability between capital and labor, which can be deduced from the abovementioned exogenous aspect of the labor force growth rate and the fixed factor proportions production function. The latter reflects a rigid technology, and strictly limits the margin of fluctuation and evolution regarding this particular aspect, thereby making it quite difficult for the economy to reach equilibrium with full employment of both capital and labor. As mentioned before, the capital-output ratio φ is assumed to be fixed, which implies that capital and output are bound to progress at the same pace in order to maintain equilibrium. It is worth noticing that Harrod and Domar also put forward the constancy of the capital-labor ratio $\frac{K}{L}$. This means that capital and labor must also increase at the same rate. Thus, if labor is supposed to follow the same rhythm of expansion

as the population growth ΔN_t, then the sole way to maintain the economy at equilibrium is for the population growth rate to be the same as the economic growth rate:

$$\Delta N_t = {}^{[Y_{t+1} - Y_t]}/_{Y_t} = {}^{\tau}/_{\varphi}$$

(Here we neglect the impact of capital depreciation, as mentioned above)

If population growth rate exceeds GDP's variation, unemployment would persistently increase, thereby generating disequilibrium in the labor market and, by extension, in the economy. And if it is underneath the economic growth rate, the capital stock would progressively decrease -in order to match the relative decline in labor, and the growth rate with it until $\Delta N_t = \Delta Y_t$. Otherwise, if labor and capital do not grow at the same pace, the economy would lose its frail equilibrium. This element do not meet empirical evidence, which suggests that production factors progress in different rates and that technology changes can shift the economy into different settings of both factors without necessarily generating disequilibrium and confusion.

In order to respond to the deficiencies of Harrod-Domar model regarding technology and the respective contribution of labor and capital to economic growth, we discuss below some models that tackled these very questions in a more elaborate way.

2.2 The Neoclassical Solow-Swan model

Initially developed in the works of Solow (1956) and Swan (1956), this model, best known as the Solow neoclassical model of economic growth, assesses the effect of saving, demographic growth and technology on GDP growth. It is based on several main assumptions, particularly the hypothesis that factor prices are flexible in the long term and respond to excess demand, which allows factor substitution by firms in response to changes in relative factor prices. Aggregating this response by firms across the economy would lead to changes in the factor proportions utilized in order to generate output[7].

So, in response to the deficiencies observed in the Harrod-Domar subsection, the neoclassical model considers the capital-output ratio $\frac{K}{Y}$ and the capital-labor ratio $\frac{K}{L}$ to be flexible. And all the proportion of output that goes to saving is totally invested. It also considers the assumptions of full price flexibility and monetary neutrality, and GDP is supposed to be persistently at its potential level. Unlike the Harrod-Domar model, the Solow model is based on the existence of technological progress; its rate, as well as the capital stock depreciation's and the population growth are determined exogenously. And in order to simplify, the model takes into account an economy made of one sector and one type of product that can be used for both investment and consumption.

[7] Levacic & Rebmann (1982), P. 272

According to Mankiw (1995), one of the strengths of Solow's version of the neoclassical growth model is that, despite its simplicity, it has many predictions. In evaluating the usefulness of the model in explaining growth experiences, it is worth stating namely: 1. In the long run, the economy approaches a steady state that is independent of initial conditions. 2. The steady-state level of income depends on the rates of saving and population growth. The higher is the rate of saving, the higher is the steady-state level of income per person; the higher the rate of population growth, the lower the steady-state level of income per person. 3. The steady-state rate of growth of income per person depends only on the rate of technological progress; it does not depend on the rates of saving and population growth. 4. In the steady state, the capital stock grows at the same rate as income, so the capital-output ratio is constant. 5. In the steady state, the marginal product of capital is constant, whereas the marginal product of labor grows at the rate of technological progress. These predictions are broadly consistent with experience[8]. Moreover, the simplicity of the neoclassical model, together with its ability to yield substantive and seemingly reasonable predictions, has given it a prominent place in the macroeconomist's toolbox[9].

The model tackles the *proximate* sources of growth and is built around three main functions, i.e. the production function, the consumption function and the capital accumulation process. The first one, based on the neoclassical aggregate production function, is written initially as follows:

$$Y = f(K; L)$$

One of the key hypotheses here is that when capital and/or labor increase, the marginal returns generated by this variation would be positive, but progressively diminishing. Besides, it is assumed that the higher is the capital-labor ratio $\frac{K}{L}$, the smaller becomes the marginal product of capital, and vice-versa. This finds explanation in the fact that, in an economy with a given level of technology, the capital-labor ratio would increase if there were, per se, more machines per worker. Subsequently, the output per worker/capita $\frac{Y}{L}$ (i.e. labor productivity) would reach a higher level. On the other hand, as (marginal) returns tend to diminish, the effect driven by this capital accumulation per worker (per capita) on output would become thinner as $\frac{K}{L}$ keeps going upward. Accordingly, the impact of a certain progression in $\frac{K}{L}$ on $\frac{Y}{L}$ is likely to be more important if capital is not relatively abundant. This observation led the proponents of the Solow model to defend that capital accumulation would have a larger impact on labor productivity in developing countries, as opposed to developed ones. Following this logic, in an open economy framework with no rigidities on capital mobility, capital is supposed to flow from developed countries to developing ones *ceteris paribus*.

Expressed in a more elaborate way, income can be expressed as in:

$$Y = A_t f(K; L)$$

[8] Mankiw, N.G. (1995), 'The Growth of Nations', Brookings Papers on Economic Activity. P. 277
[9] *Idem*, P. 278

This could be written as follows, in the Cobb-Douglas version:

$$Y = A_t . K^{\propto} . L^{\beta}$$

Where $\propto$ and b are weigh parameters, reflecting the proportion of capital and labor in income; their sum usually equals 1[10]. This function, best known as the aggregate production function, is assumed to exhibit constant returns to scale, i.e. if capital and labor are raised by a certain rate, output would increase according to the same exact rate. The main hypothesis of constant returns to scale implies that the economy is advanced enough that there are no more possible *Smithian* gains from additional division of labor and specialization; hence, output per worker cannot be influenced by the size of the economy in terms of the labor force. As for A_t, it represents technology, i.e. the way production factors are used in order to generate output. This variable is considered to be exogenous, depending basically on time. As defended by Solow (1956) and Mankiw (1995), among other neoclassical growth theorists, technology follows the same logic as a –free from charges- public good. If we consider the world economy, this would imply that all countries, despite their different levels of development, are allowed access to the same technology, ergo they are likely to follow the same production function. In other words, the neoclassical model of economic growth predicts that, in the long run, output per capita in all countries will grow at the same exogenously determined rate of technological progress.

Several economists disagree with this assumption and insist that there are severe technology gaps between countries. Fagerberg (1994) argues that the only factor left within Solow's framework that can explain differences in per capita growth across countries is the "transitional dynamics". Since initial conditions are generally different, economies may grow at different rates in the process towards long-term equilibrium. By the time said economies will reach this long-run equilibrium, disparities in terms of income would have narrowed down and eventually disappeared. This could be demonstrated through the abovementioned tendency for capital to flow from developed countries –where capital is abundant and its profitability is low, to developing ones –where the capital-labor ratio is low and capital profitability is at its best. This would result in a higher rate of capital accumulation and in a faster growth pace in the poor countries, as opposed to developed economies. However, Solow's model seems to have overlooked the interaction between capital accumulation and technological progress: according to several theorists, new technology is usually embodied in new capital goods[11].

The second key component of Solow's model is the consumption function. As mentioned earlier, it is assumed that output per worker/capita $\frac{Y}{L}$ is positively tributary to capital per

[10] In the literature and based on the fact that the sum of both parameters equal unity; β would logically equal 1-α

[11] Fagerberg, J. (1994), 'Technology and International Differences in Growth Rates', Journal of Economic Literature, September. P. 1149 / See also Johansen (1959) and Nelson (1964).

worker/capita $\frac{K}{L}$. Based on this hypothesis, it is important to understand how the latter evolves over time, i.e. capital accumulation, which is largely determined by saving. As mentioned earlier in section 2.1, income –which equals output-, encompasses consumption and investment:

$$Y_t = C_t + I_t$$

And since $I_t = S_t$ and $S_t = \tau . Y_t$, it is possible to write:

$$Y_t = C_t + \tau . Y_t$$

$$\text{Thus } C_t = (1 - \tau) . Y_t$$

Capital accumulation plays an important role in the neoclassical framework of growth analysis. It constitutes the 3rd key component of Solow's model, and is initially based on the hypothesis that capital stock is subject to a persistent depreciation (δ), while investment helps push it upward. As written in the previous section and in light of the other elements presented here:

$$K_{t+1} = (1 - \delta)K_t + \boldsymbol{I_t} = (1 - \delta)K_t + \boldsymbol{\tau . Y_t} = K_t - \delta . K_t + \tau . Y_t$$
$$K_{t+1} - K_t = \tau . Y_t - \delta . K_t$$

In order to study capital accumulation in relation with labor, we subdivide both sides of the equation by *L*:

$$\frac{K_{t+1}}{L} - \frac{K_t}{L} = \frac{\tau . Y_t}{L} - \frac{\delta . K_t}{L}$$

This last equation illustrates the principle according to which capital accumulation evolves through time. According to the literature, the fundamental differential equation of the Solow model in this framework is usually written as follows[12]:

$$\dot{k} = \tau f(k) - \delta . k$$

Where $\dot{k} = \frac{K_{t+1}}{L} - \frac{K_t}{L}$ is the variation of capital input per worker, and $\tau f(k) = \frac{\tau . Y_t}{L}$ represents saving (investment) per worker. As for $\delta . k = \frac{\delta . K_t}{L}$, it represents the level of investment required in order for the capital-labor ratio to stay invariable. Solow's model takes into account the assumption that the labor force grows proportionally to the population growth rate n. Since $k = \frac{K_t}{L}$ an increase in the labor (e.g. due to a demographic expansion Δn) would

[12] In a more elaborate way, the equation also takes into account the technology growth rate (g) such as $\dot{k} = [sf(k) - (n + g + \delta) . k]$. However, all these rates are assumed to be exogenous. In the present paper, we chose not to further analyze g since its underlying philosophy has already been discussed and its implications are not significantly related to the elements developed in the sections below. See Mankiw (1995), PP. 276, 282 and 309. See also Snowdon & Vane (2005), P. 607.

drive a downward influence on k, just like capital depreciation do. Ergo, the equation can simply become:

$$\dot{k} = \tau f(k) - (n + \delta).k$$

The steady state, which has been discussed above, can then be expressed as:

$$\tau f(k^*) - (n + \delta).k^* = 0$$

$$\text{Thus:} \quad \tau f(k^*) = (n + \delta).k^*$$

In a nutshell, the steady state is where saving (investment) can only cover the combined effect of population growth and capital depreciation per worker/capita, in a way that the capital-labor ratio stays unchanged. According to the literature, when $\tau f(k)$ is larger than $(n + \delta).k$, the capital-labor ratio progresses, and vice versa. It is worth noticing that public finance could play a prominent role in influencing the course of capital accumulation, through the strengthening of $\tau f(k)$ in this particular framework.

If we apply the same logic here to the income equation $Y = A_t.K^{\propto}.L^{\beta}$, we can write the equation below. Provided the hypothesis that returns to scale do not change, output per worker $\frac{Y}{L}$ is not likely to be influenced by the scale level of output. In the Solow model, it is also assumed that for a given technology A_0, the output-labor ratio $\frac{Y}{L}$ is positively correlated to capital per worker $\frac{K}{L}$.

$$\frac{Y}{L} = A_0(K^{\propto}.\frac{L^{1-\alpha}}{L}) = A_0(K^{\propto}.L^{\mathbf{1}-\alpha}.L^{-\mathbf{1}}) \qquad \text{As} \quad \beta = 1 - \alpha$$

$$\text{Then} \quad \frac{Y}{L} = A_0(\frac{K}{L})^{\propto}$$

If we take $y = \frac{Y}{L}$ and $k = \frac{K}{L}$, the intensive form of the aggregate production function can be written as follows:

$$y = A_0(k^{\propto})$$

According to this equation, the higher is the capital per worker the more important is output growth per worker, provided that the economy remains at an exogenously determined level of technology. This finding, among other aspects mentioned above, suggests that capital-increasing fiscal policy is likely to improve GDP growth, on condition that demographic growth stays stable (*ceteris paribus*). However, this observation does not apply to long-run output growth. On the other hand, it is worth noticing that this equation exhibits diminishing returns on capital, i.e. the more important is capital accumulation the less marginal returns it generates.

The Solow model gave a tremendous importance to technology as an explanatory variable that allows stronger output growth, by making it possible for a given economy to enhance its efficiency through different input combinations. Nevertheless, the fact that this key

component of the neoclassical model of growth (i.e. technological progress) could not actually be explained by the model raised a significant wave of criticism. In an attempt to develop the model's structure, Arrow (1962) incorporated the "learning by doing" concept, which is supposedly at the origin of technological progress and productivity improvement. According to Arrow, experience uplifts labor's productivity; he argues that "technical change in general can be ascribed to experience, that it is the very activity of production which gives rise to problems for which favorable responses are selected over time"[13]. In a nutshell, experience is tributary to cumulative investment expenditures that have an effect on the work environment.

As a whole, the Solow model has shown several deficiencies. One major shortcoming is the fact that long-run economic growth does not find satisfactory explanation in this model. As mentioned above, public economic policy can influence the level of output per capita/worker, whereas it has no effect on long-run GDP growth. Moreover, growth rate can only gather (or lose) pace temporarily during the aforementioned "transitional dynamics" toward a new steady state. However, sustained growth is still possible according to Solow's model, but only when there is technological progress. Then again, the only variable that could explain why there has been economic growth in world economies, i.e. technology, is left outside the model as it was demonstrated in this section. This also narrows the interest toward this model regarding public long-run economic growth policy in general, and public investment in particular.

To sum up, in the Solow neoclassical model of economic growth, capital accumulation is far from accounting for either continuous growth of output per capita in the long-run, or the tremendous gaps that can be noticed empirically between countries and geographical regions (even within the same country) in terms of welfare and living standards.

Starting from the strengths of this model and as a response to its deficiencies, Romer (1986) and Lucas (1988), followed by other growth theorists, developed an alternative model with a competitive framework where long-run economic growth is tributary to investment decisions rather than exogenously determined technological progress. The next section discusses the different findings in this framework.

2.3 The Romer-Lucas endogenous growth model

According to the aforementioned work of Arrow (1962), capital accumulation -which is translated into technical changes that touch the work environment, generates positive externalities on knowledge and learning among the labor force. The endogenous growth model, as introduced by Paul Romer (1986) and completed by Lucas (1988), started from this finding and expanded the notion of capital to include research and development spending (R&D) and human capital formation, besides from the obvious physical capital. In this

[13]Arrow, K.J. (1962), 'The Economic Implications of Learning By Doing', Review of Economic Studies, June. P. 156

framework, capital accumulation has a significantly more important role in the economic growth process, as opposed to the neoclassical model.

Here, knowledge is considered to have the characteristics of a public good since what the labor force learns in one firm is assumed to have a positive external effect on the production possibilities of other firms, because "knowledge cannot be perfectly patented or kept secret"[14]. Therefore, no firm can actually entirely internalize the propitious impact driven by their investment in physical and human capital on the stock of knowledge in the economy as a whole.

Following this logic, technology is included in the production function as an endogenous variable:

$$Y = f(K, L, A)$$

Unlike the neoclassical Solow model, this aggregate production function is assumed to exhibit increasing returns to scale, rather than constant ones. Another noteworthy difference is that Solow (1956) and Swan (1956) argue that returns to capital tend to progressively diminish, while the endogenous growth model does not. Moreover, the Romer-Lucas model supports the hypothesis that technology -or knowledge in general- is tributary to the growth of capital, since positive technological externalities are strengthened when there is an increase in the capital per worker ratio $\frac{K}{L}$ (capital *deepening*). Consequently, when K increases, it drives an upward influence on A, thereby uplifting the productivity of the economy as a whole according to the "learning by doing" logic as presented by the end of the previous subsection. In simpler words, economic growth is driven by investment, and the hypothesis of the nonexistence of diminishing returns to capital makes it possible for economic growth to sustain its pace as capital deepening takes place. In this case, the economy would fit in the *Promethian* type of growth, and would permanently increase its growth after each raise in the investment per GDP ratio.

However, several economists criticized the model's findings based on the so-called historical inconsistency of its core hypothesis, i.e. technology and knowledge as a free-from-charges public good. Empirical evidence shows that one of the most important problems that underdeveloped countries come up against is usually technology gaps. As a response to this wave of criticism, Romer (1990) enhanced his initial model based on three main premises. First, at the image of Solow's (1956) neoclassical model, it is assumed that technological progress (improvement in the production instructions for "mixing together raw materials") lies at the heart of economic growth[15]. Technological progress motivates economic agents into continuous capital accumulation which, combined with technological progress itself, account for much of the increase in output per hour worked. The second premise is that technological progress is an endogenous variable since it is assumed to arise in large part as a consequence of intentional actions taken by people (e.g. economic agents, scientific researchers…) who

[14] Romer P.M. (1986), 'Increasing Returns and Long-Run Growth', Journal of Political Economy, October, P. 3
[15] Romer, P.M. (1990), 'Endogenous Technological Change', Journal of Political Economy, October P. S72

respond to market incentives[16]. The third and most important premise is that once the cost of creating a new technology –and a new set of production instructions with it- has been incurred, the said technology can be put to use over and over again without any additional cost. Romer compares the development of new production instructions to incurring a fixed cost, which makes technology "inherently different" from other economic goods. In this framework, Romer admits that the benefits of knowledge/technology have to be at least partially excludable, in order to encourage the investment that is supposed to trigger such technological progress. Since the second premise states that technological progress arises in principle as a consequence of purposeful actions taken by economic agents who are self-interested, the said progress must at least generate benefits that are motivating enough to these agents and which are supposed to be higher than what other people would generate afterward. Unlike public goods, which are non-rival and non-excludable, knowledge is assumed to be only non-rival[17]. In other words, its use by a given firm does not technically stop others from using it, but said firm can prevent them via legislation and patent restrictions.

Following this logic, the endogenous model of growth rejects the neoclassical hypothesis that considers technology to be a pure public good, hence accessible by everyone across the world without restrictions. Differences in incomes at the international level could be explained by differences in productivity, the latter being tributary to technology gaps, which are also known as "idea gaps". This finding was confirmed by several economists, particularly Parente & Prescott (1999), who affirm that productivity gaps are due to the existence of barriers in the form of lobby-based high costs of entry which prevent economic agents in many developing economies from improving their respective technology and production process[18]. Subsequently, if the developing world's problem is rather *idea* gaps than *object* gaps (i.e. physical capital gaps), then it would be possible to stem the tide of income disparities and poverty in several countries simply via technological catch-up, which would come at a relatively low cost. This perspective implies that economies that are isolated in terms of foreign economic exchanges are in effect raising barriers to the adoption of new technologies, thereby increasing their probability of having a lethargic GDP growth rate. A clear silver lining of economic openness is foreign direct investment (FDI), which can significantly facilitate the transmission of innovation and know-how, thereby boosting income growth. As a consequence, technological catch-ups can be made possible if developing countries at least encourage inward FDI flows and invest in human capital, in order for the workforce to be able to acquire and assimilate technological progress itself.

In support to the importance of human capital, recent studies came up with the conclusion that investment in physical capital and in education play roughly similar roles in the

[16] Here, Romer (*ibid.*) accepts that, per example, an academic scientist who is supported by government grants would not be motivated by market profit in order to seek new technologies. The idea is that profit starts playing a crucial role only once new technologies are translated into goods with market value.

[17] Rivalry is a purely technological attribute, in the sense that a purely rival good has the property that its use by one firm or person precludes its use by another, while excludability includes a legal aspect, i.e. a good is excludable if the owner can make use of the legal system in order to prevent others from using it. See Romer (*ibid.*) P. S74

[18] Parente, S.L. and Prescott, E.C. (1999), 'Monopoly Rights: A Barrier to Riches', The American Economic Review, Vol. 89, No 5, P. 1231

determination of output, which implies that economic growth depends roughly equally on the amount of physical capital and the amount of human capital in the economy[19]. Blanchard and Johnson (2013) say in this framework that countries that save more and spend more on education are likely to reach significantly higher steady-state rates of output per worker/capita. They explain that both forms of capital can be accumulated, the former through private and public physical investment, and the latter via education and training. According to these authors, there is a consensus among endogenous growth proponents regarding the fact that increasing either the saving rate or the fraction of output spent on education might lead to much higher levels of output per worker/capita in the long run. Nonetheless, seen the rate of technological progress, increasing education expenditures would not lead to a sustainably higher growth rate.

From the elements developed in the three growth models, it is possible to read the importance of investment and capital accumulation in the improvement of economic growth, whether directly or through the facilitation of technological progress. In this context, it is most valuable to bear in mind that reducing restrictions to international trade is not enough to boost FDI flows and GDP growth; it could even generate reversed effects when the ground for such investments and the technology that comes along with them, are not satisfactory. Private investment in general, whether at the national scale or through FDI, is usually motivated by a ripple effect as regards to fiscal policy, particularly public investment. The latter provides in principle the required infrastructures regarding logistics, transport infrastructures, education and public health services, which are considered as *sine qua non* preliminary conditions for any investment in human or physical capital, hence for any progress in terms of economic growth and development.

In order to deepen the discussion regarding the relation between growth and its determinants, we take this issue into an empirically founded level with practical cases of developed and developing countries in the sections below. But before doing so, we first make a swift emphasis on some further elements that could bring additional explanatory power over growth.

2.4 Further determinants of economic growth

According to the discussion above, three main growth factors can be identified, namely capital accumulation, human capital formation and technology/innovation. All three involve investment, respectively in physical capital, in education and knowledge, and in research and development (R&D).

Stern (1991) goes beyond these elements and adds three other potential determinants of growth, i.e. organizational management, infrastructure and allocation of output across directly productive sectors[20]. According to the author, infrastructure deficits, together with a non-

[19]Blanchard O. and Johnson R.D. (2013), "Macroeconomics", sixth edition, London: Pearson Education, United Kingdom. P. 264

[20] Stern, N. (1991), 'The determinants of growth', The Economic Journal, Vol. 101, No. 404, p. 128

optimal management and economic organization, are likely to account for a significant part of low factor productivity in developing countries. He illustrates with the example of a private factory that works in an environment characterized by weak water and electricity supplies, unreliable transport infrastructures and expensive access to other logistics. It is important to note in this framework that, infrastructure spending constitutes the buckle of public investment. In this perspective, public infrastructure investment plays a crucial role in economic growth and development. Based on several studies laid by the World Bank, it is broadly accepted that infrastructure and GDP growth are linked by a more or less one-to-one correlation in developing countries, i.e. a 1 percent rise in the infrastructure stock would lead to a 1 percent progression in output growth.

As regards to the organizational factor of economic growth, well managed firms are supposedly likely to improve output by working with efficiency, and even in the case of a small capital-labor ratio -and thus allegedly strong incomes[21], capital can squarely be unproductive if combined with a weak organization. Moreover, Stern (*ibid.*) argues that a system where individuals behave dishonestly, where bureaucracy is obstructive, or where property rights are unclear may lead to a very wasteful allocation of resources in insuring against dishonesty, circumventing bureaucracy or enforcing property rights. The costs involved and the distortion of incentives in this framework might critically clog GDP growth[22].

Empirical studies provided evidence on the importance of the three factors Stern (*ibid.*) defends, besides from the ones presented by Solow (1956), Romer (1986) and Lucas (1988). A strong role in stimulating the growth process was assigned to both competition and government action by offering, for example, education and infrastructure[23]. Barro (1997) led a study in order to classify growth determinants in over 100 countries, which backed up and extended the broad lines of Stern's stipulations. Besides from the latter's three additional factors, Barro includes levels of education, fertility, inflation, government consumption, the rule-of-law, life expectancy and the terms of trade as factors that have a noticeable impact on GDP growth over "fairly long intervals" of time[24].

Furthermore, Abramovitz (1996) largely accepts technological progress as an eminent factor of growth, but partially links it to societal determinants, that he calls "social capability". He argues that technological backwardness is not usually a "mere accident". Tenacious societal characteristics normally account for an important portion of a country's past failure in achieving a level of productivity that is more or less equal to advanced economies', which could explain the persistent disparities in terms of output worldwide. The same deficiencies

[21] The underlying mechanism of this phenomenon has been explained previously in section 2.2. This mechanism fits into Robert Solow's "convergence" framework, which is determined by the diminishing returns hypothesis, also discussed in said section.

[22] Robert Barro takes as a prototype Sierra Leone which is poor and yet generating low economic growth, which is in contradiction with the convergence hypothesis. He justifies this by the fact that said country has "weak enforcement of property rights, low school attainment, high fertility, low life expectancy, no political freedom, high government consumption, moderately high inflation, and virtually no investment". See Barro (1997), 'Determinants of economic growth: a cross-country empirical study', MIT Press, Massachusetts. P.30

[23] Stern (1991), P. 131

[24] For more details regarding the empirical methodology of this study, see Barro (*ibid.*), P. 13 henceforth.

may also prevent developing countries from succeeding in the technological catch-up that is predicted in the Romer-Lucas framework. In a nutshell, Abramovitz defends that "a country's potential for rapid growth is strong not when it is backward without qualification, but rather when it is technologically backward but socially advanced"[25]. Education and economic organization play a crucial role in this context, as a trade-off between specialization and adaptability becomes decisive. The notion of adaptability suggests that there is an interaction between social capability and technological opportunity. The state of education embodied in a nation's population and its existing institutional arrangements has the tendency to hold back the economic agents in their choices of technology. It is, however, technological opportunity that encourages said economic agents to do additional –adaptation- efforts in order to enable the transition toward a new technology. Here, technological opportunity is usually materialized into a stronger income growth, whether as the consequence of a direct impact or via the increase of competitiveness at the international scale.

In effect, Abramovitz (*ibid*.) argues that an economy's "potentiality" for productivity advance through catch-up is actually defined by the combination of technological gap and social capability. Economies that are technologically backward have a potentiality for generating faster economic growth rates than more advanced ones, but only provided their social capabilities are sufficiently developed to enable successful exploitation of cutting edge technologies that are already in use in developed countries. The rhythm at which potential for technological catch-up is actually realized in a given period of time is tributary to factors limiting (or promoting) the diffusion of knowledge, the rate of structural change, capital accumulation and the expansion of the demand for new technology-based products. And as discussed in section 2.3, investment plays an important role, especially FDI which can significantly facilitate the transmission of innovation and knowledge, thereby boosting GDP growth. As a consequence, technological catch-up can be made possible if developing economies at least encourage inward FDI flows and invest in human capital, in order for the workforce to be able to acquire and assimilate technological progress itself. In this framework, needless to remind ourselves that FDI is usually driven by public economic policy, mostly through the existence of satisfactory social and physical infrastructures regarding logistics, transport infrastructures, education and public health services etc., besides from fiscal and tax incitements. Institutional infrastructures are also noteworthy (i.e. democracy, human rights and a relatively impartial justice system); they provide the country with political and social stability.

The free flow of FDI –and technology along with it, from advanced to developing countries can be highly dissuaded by the risk involved in investing in economies that suffer from macroeconomic volatility, trade barriers, insufficient infrastructure, weak level of education, social and political instability, and corruption. This having been said, theorists defend that *proximate* causes of growth are not enough to deepen the analysis and that one should also look into the larger *fundamental* determinants. Explaining growth "miracles" and "disasters"

[25] Abramovitz, M. (1986), "Catching Up, Forging Ahead, and Falling Behind", Journal of Economic History, June, P. 388

requires an understanding of the history of the economies being investigated as well as how policy choices are made within an institutional structure involving political distortions[26].

As a response to this necessity, the next section provides a discussion of several empirical studies regarding the very cases of some advanced and developing countries. The emphasis is laid in general on the empirically founded determinants of output growth; but out of relevance to the present paper, the choice of giving most attention to the influence of public investment was made. The analysis aims to assess the significance of the latter and to come up with transversal characteristics and rules-of-thumb that, put together, could help explain any economy's likelihood of –public- investment macroeconomic returns.

III. AN ANALYSIS OF THE EMPIRICAL STUDIES

This section reviews the main findings of empirical studies that had tackled the question of economic growth, its determinants and the role of public investment as a potential growth-enhancing policy measure. The analysis starts with general cases, mostly in advanced countries, before narrowing down the focus to discuss the case of middle-income countries.

As discussed in subsection 1.1.2, investment plays a decisive role in the sense that it enhances the capacity of production factors' inputs, particularly by driving an upward influence on technology and education, among other physical and societal variables. It is placed as a transversal determinant of growth. Even in the *learning by doing* process introduced by Arrow (1962), what is described as *experience* is tributary to *investment* expenditures that have an effect on the work environment. However, it is important to make allowances between private and public investment. Based on empirical studies, several eminent economists argue that the latter should be included in a production function as a separate variable from the overall investment, since private investment is not likely to be a substitute of public capital, particularly when it comes to providing public goods and services. Public investment is even considered to be an input to private production[27]. This argument is endorsed by the literature, where it is largely accepted that public investment is predominant when it comes to infrastructure expenditures and projects, as opposed to private capital. Hirschman (1958) and Biehl (1991) define infrastructure itself as the part of the overall investment that provides public services. Furthermore, the government's role in public investment is not limited to its own budgetary spending. The case of public-private partnerships (PPP) is a striking example of infrastructure projects where the biggest part of investment spending is supposed to be made by private companies. Yet the purpose of these expenditures would be to provide goods or services for which there is justified public involvement. And the government's role in relation to the PPP arrangement, e.g. monitoring, regulation and risk bearing, remains quite important. Similarly, in cases where the private sector invests in the production of goods characterized by natural monopoly conditions,

[26] Snowdon & Vane (2005), P. 633
[27] See for example Barro (1990), "Government spending in a simple model of endogenous growth", Journal of Political Economy, Vol.98, No.5, P. 106

government regulatory involvement is called for. In other spheres of private investment, a government regulatory or planning role may also be fundamental in order to take account of public policy objectives (in the case of externalities), though such investments would still be recognized as private[28].

Beyond the canonical crowding in/crowding out effects of government spending, the debate regarding the impact of public investment on economic growth was revived by an empirical research led by Aschauer (1989), where the emphasis was laid on the productivity growth generated by non-military public investment in the United States. He came up with the conclusion that investment in infrastructure has a really strong positive influence on private firms' productivity, as the post-1970 productivity decrease was found to be the result of the drop in public investment in the US. This finding was remotely supported by the high growth rates in Asian economies during the 1990s, which were linked to their tremendous public investment rates. Nevertheless, the causality here –and even the correlation sign in some studies- remained subject to controversy, as explored below in this section. Besides from divergences between researchers regarding the econometrical aspects and their outcome, it is possible to say that the persistent debate might also be explained by the fact that a considerable part of public investment is spent on the government's transversal functions, e.g. law and order enforcement, provision of social and public services, administration etc. Therefore, it is difficult to assess its impact on productivity and economic growth, since it would only indirectly affect them. This difficulty exists even when it comes to infrastructure investment expenditures, because the latter's impact on productivity takes a long time to be recognizable and the risk of losing track becomes quite important, which complicates the data assessment even more.

Usually, available data for this purpose consists of both national-level evidence and investment-specific evidence. The former consists in time series data on public investment expenditures while the latter tackles the economic impact of each specific investment project. Lack of coverage has always been a major difficulty in this framework, besides from the fact that developing countries –and even some developed ones- rarely keep track of the economic performances of their investment expenditures over time. Warner (2014) sums up this particular situation as follows: "Research in this area is bedeviled by the fact that governments that implement major public investment drives frequently leave no hard data behind on the impact of their investments; and governments that collect good data frequently do not attempt major investment drives"[29]. Subsequently, researchers are obliged to use estimates and, in most cases, to go along with how the national authorities differentiate public investment expenditure from public consumption spending. The difference between both types could be hazy, to some extent. For example, education expenditures are usually not considered to be public investment. Yet, even though the definitions are not unanimous across countries, there is a large consensus regarding expenditures that touch logistics, roads and power infrastructure which are treated as capital goods.

[28] UNCTAD (2009), 'Public Investment: Vital for Growth and Renewal, but should it be a Countercyclical Weapon?', United Nations Background Report, Geneva/New York, P. 5

[29] Warner, A.M. (2014), 'Public Investment as an Engine of Growth', International Monetary Fund working paper No 14/148, August, P. 6

In order to discuss these elements, among other significant findings, section 3.1 starts by reviewing the empirical debate regarding public investment among the determinants of economic growth in advanced countries. Then, in section 3.2 the light is shed on this question, but in the very case of developing countries in order to set a relevant benchmark and to come up with a sound rule-of-thumb that, put together, could help explain any economy's likelihood of –public- investment macroeconomic returns.

3.1 The case of developed countries

As briefly underlined above, one of the most influential research papers regarding the determinants of growth and the macroeconomic impact of public investment is Aschauer's (1989), in a sense that it revived the research in this area, in particular regarding developed countries. At the moment when economists were attempting to explain why productivity dropped in the United States, Aschauer provided based on a Cobb-Douglas econometrical model, a seemingly logical explanation, i.e. the decline of private and public investments[30]. Nevertheless, the findings were taken with much caution after acerbic criticisms regarding the modeling methodology. As a matter of fact, the non-stationarity of the data used in Aschauer's work was undoubtedly a significant problem, but also the assumption that production factors are purely exogenous, which implies that there would be no room whatsoever for a potential influence of output itself on private and public capital. However, empirical evidence visibly suggests that there is a back and forth connection between GDP growth and investment.

Sturn and De Haan (1995) revisited the results found by Aschauer (*ibid.*) and ended up with a different conclusion using the same data but more modern econometrical techniques. Based on their assessment of the data, it turned out that the variables in the production function were supposed to be estimated in first differences, as opposed to in levels regression used by Aschauer. One of their main conclusions is that the positive relation between public investment and GDP discovered by Aschauer had been overvalued[31]. A research paper made by Barth and Bradley (1987) -and which had not caught as much attention as Aschauer's even though it was prior to it- found, for the case of 16 OECD countries, that the share of investment in GDP had a statistically insignificant effect on growth, although the sign of the correlation was positive.

Also based on a Cobb-Douglas production function, Barro (1990) formally considered government (consumption and investment) expenditures to be endogenous, and provided an insight on the potential relation between the size of the government and the economic growth rate. He concluded that the share of productive government spending (e.g. public investment expenditures) that maximizes GDP growth is smaller if the government is also using the income tax to finance other less productive types of spending. In other words, an increase in

[30] Ashauer, D.A. (1989), 'Is Public Expenditure Productive?', Journal of Monetary Economics, No 23, North-Holland, PP. 177-197

[31] Sturm, J. E. and De Haan, J. (1995), 'Is public expenditure really productive? New evidence for the USA and the Netherlands', Economic Modeling, No 12, PP. 63-70

resources dedicated to non-productive government services is likely to generate lower per capita growth[32]. Therefore, Barro (*ibid.*) partially joined the conclusions of the former work of Kormendi and Meguire (1985) who found, based on a sample of 47 countries in the post WW II period, that there is no significant relation between average real GDP growth rates and average government consumption. This last paper did not, however, tackle government spending from a productivity-enhancing public investment perspective. As for Mankiw (1995), he sums up the buckle of empirical studies, stating that the share of output allocated to investment is positively associated with growth, as well as a certain number of measures concerning human capital, such as enrollment rates in primary and secondary schools. Milbourne *et al*. (2003) investigates whether there is a distinct role for public investment as a determinant of GDP growth. In order to neutralize the potential effect of demographic growth, they consider output per capita. The latter does not seem to be influenced in a noticeable way by public investment in the steady state equilibrium. However, the impact is found to be substantial during the periods of transition toward steady state[33].

Whereas, the models based on the production function or the cost function, were proven to have a noteworthy drawback, i.e. they can only analyze the effects of public spending that "transit" through private sector production. However, many government consumption or transfer items can have important macroeconomic effects even if they have no noticeable impact on private sector production or cost functions[34].

With the aim of addressing such particular issues, the introduction of the VAR approach by Sims (1980) enabled economists to empirically assess the influence of public and private investment on output growth without any pre-established theoretical restrictions. One of the most valuable contributions of Sims is the possibility to examine causality directions between all variables. This contribution largely responds to the abovementioned criticism regarding Aschauer's (1989) one-way-causality econometrical methodology. However, VAR's perks are limited by some deficiencies, particularly the fact that it demands larger data samples in order to apply lag lengths. This often narrows the possibilities for researchers due to the lack of long series data, especially regarding variables that only have annual frequency, e.g. public capital stock.

Using VAR methodology, Mittnik and Neumann (2001) analyzed the interactions between GDP, private investment and public (investment and consumption) expenditures in the case of six advanced economies. Their conclusion corroborated some of Aschauer's findings as regards to the significant positive effect of public investment as a determinant of GDP growth in the short run with a smaller influence in the long run, except for Germany where the effect remains significant. Furthermore, Mittnik and Neumann's (*ibid.*) results dismissed the

[32] Barro, R.J. (1990), 'Government spending in a simple model of endogenous growth', Journal of Political Economy, Vol. 98, No. 5, P. 117

[33] In the assessment of the impact of public investment on growth during transition toward equilibrium, the authors first use the Ordinary Least Squares method (OLD), then switch to instrumental variables econometrical techniques. More details about the methodology are explained in Milbourne R., Otto G. and Voss G. (2003), 'Public Investment and Economic Growth', Applied Economics No 35, PP. 530–535

[34] Perotti, R. (2004), 'Public investment: another (different) look', IGIER, Working Paper No 277, P. 4

existence of public investment crowding out effects. This last conclusion was contested by Voss (2002), who argues that innovations to public investment crowd out private investment, based on a VAR model that encompasses GDP, private investment, public investments, and the real interest rate for the cases of Canada and the United States from 1947 to 1996.

As for Perotti (2004), he led a study based on a quarterly VAR model with a sample that includes the United States, the United Kingdom, Australia, Canada and Germany. In order to improve the accuracy of his model, Perotti subtracted government investment for defense purposes from public investment and added it to government consumption, since defense machinery and equipment do not touch the conventional structures of the economy and are not likely to drive a ripple effect on private sector investment. However, the paper's result is quite difficult to reconcile with the studies mentioned above, among many others. Output and private investment were found to react more significantly to government consumption shocks, than to public investment. Perotti explains this puzzle by the fact that the aforementioned advanced countries might have too much public capital relative to their optimal level, so that public investment could have a very low, or even negative, marginal product. There is also a plausible hypothesis, i.e. public investment might be particularly prone to political pressure, and loaded with pork-barrel projects with no economic rationale; if it crowds out more productive private investment, it can show up as having a negative multiplier after the general equilibrium effects are played out[35]. Besides, Perotti argues that some types of transfers and government consumption also have important, if less obvious, positive externalities in the long run; for instance, some models of growth imply that under some conditions, transfers might release credit constraints and therefore promote investment in education and growth. Bottom line is: the paper provided evidence suggesting that the reputation given to public investment as a determinant of GDP growth is "probably undeserved".

The first explanation given by Perotti (*ibid.*) was corroborated by Kamps (2004) for the case of Japan, where public investment shocks seem to drive a downward influence on economic growth. Among the 22 OECD countries examined by Kamps, Japan is the country that exhibits by far the most important public capital to output ratio, which makes plausible the assumption that the said ratio in Japan is beyond its optimal level so any further public capital would have an unfavorable effect on GDP, hence the negative marginal productivity of public investment. However, Kamps' model contradicts itself if one follows only this particular logic. Portugal, which shows the lowest public capital to output ratio, also exhibits a negative marginal productivity of public capital, while the other countries in the sample have a larger ratio but still a positive macroeconomic effect of public investment[36]. As a response to this contradiction, the author brings up another possible explanation, i.e. public capital could simply crowd out private capital and employment[37].

[35] Perotti (2004), P. 39

[36] Kamps (2004) uses 1960-2001 annual data (private and public net capital stocks, employed population and real GDP). He considers the following countries: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom and the United States.

[37] Kamps (*ibid.*), P. 13

On a remotely different register, Gonand (2007) links the extent of public investment's impact on the economy to the existence of qualified labor force. Gonand focuses mainly on public investment in human capital, and underlines the substantial long-term impact on GDP of efficiency gains in public spending in education. According to his study, a 10 percent increase on educational output might raise GDP by an estimated 3 to 6 percent in the long run in most OECD countries. Following this logic, the public budget spent on education in the 25 EU members jumped from 4.7 percent to 5.2 percent in the 2000-2003 period, according to Eurostat data.

When analyzing the efficiency of public investment spending as regards to both its required financial resources and its economic impact, Afonso *et al* (2005) built a public sector efficiency composite indicator for 23 advanced OECD economies, which includes information on administration, education, health (life expectancy, infant mortality), income distribution, economic stability and economic performance outcomes. The latter is assessed through the variations among a 10 year average unemployment rate. Their main conclusion is that higher public investment expenditures are associated with diminishing marginal returns, which is in line with the elements discussed above in section 2.2. Furthermore, the authors here argue that countries with "small" public sectors (i.e. with public spending that is below 40 percent of GDP) *on average* have a more efficient provision of public services and a therefore a stronger macroeconomic impact[38].

Following the discussion in this section as a whole, it is possible to presume that an important part of the empirical literature tends to corroborate the existence of an upward effect of public investment when it comes to economic growth, in developed countries in this case. Nonetheless, research papers such as Perotti's (2004), Kamps' (2004) or Barro's (1990) question the effectiveness of public capital as a potential determinant of GDP growth. They generally support -based on empirical evidence- that an insignificant or negative multiplier of government investment goes alongside the existence of a large public capital per capita. Subsequently, some of the findings could probably not be extended to developing countries, which are characterized by low GDP and allegedly low public capital per capita.

The next section reviews some of the empirical studies that tackled the very question of public investment as a determinant of GDP growth in developing countries. The objective is to assess the validity of the aforementioned hypothesis, as low and middle income economies often have a low capital to GDP ratio.

3.2 Case of small and middle income countries

In the case of developing countries, where the infrastructure level is usually suboptimal and –in some sectors- nonexistent, the necessity for substantial public investment expenditures in order to promote both economic growth and development would merely be common sense.

[38] The countries studied in Afonso et al. (2005) are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, UK, and the US.

However, even among this category of countries, the significance of the impact of public capital on the economic activity is subject to a large empirical debate, since it remains tributary to several factors (e.g. governance, political stability, the relative dynamism of private investment…), as some concepts such as efficiency and optimality start to play a decisive role in the process.

One of the research papers that examined the largest samples of developing countries is Khan's (1996), which explored the relative importance of public and private investment in promoting economic growth for 95 developing countries using two stage least squares (TSLS) and panel data methods. The author found out that private and public investments have a differential impact on economic growth, with private investment having a much more significant macroeconomic influence than public investment. Nevertheless, Khan argues that the government can play a critical part in the process by identifying much more rigorously the types of investment that have positive net returns and are likely to be complementary to the private sector. In other words, this research subtly calls for the implementation of concepts such as efficiency and selectivity based on the size of investment and its expected returns. Public investments that do not meet these criteria would most likely appear to have a downward influence on GDP growth and factor productivity, and thus should be cut or not undertaken[39]. Khan's main finding was roughly corroborated by Ghani and Din (2006) who concluded, based on an analysis of the Pakistani framework, that growth is largely driven by private investment and that no strong inference can be made about the effects of public investment and public consumption on economic growth. However, they found that public investment has a negative -though insignificant- impact on output, which "raises some concern about the efficiency of public investment" in Pakistan[40]. Based on these two different research papers, it is possible to connect the dots and think of a plausible explanation for the relatively weak macroeconomic effect of public investment, i.e. when further public spending do not follow efficiency and profitability-based selectivity, its marginal productivity is likely to shrink as the crowding-out effect stays at a certain level. By the end of the process, the allegedly positive effect of public investment on output would have been partially or totally neutralized by the negative macroeconomic impact of crowding-out.

The assumption of the existence of crowding out effect in developing countries was challenged by a book published the same year as Khan's (*ibid.*) paper, i.e. Agénor and Montiel (1996). The latter authors argue that in the case of small and middle income countries, government budget deficits tend to have a negligible influence on interest rates; hence the crowding out effect would be of an insignificant magnitude. Moreover, public investment is supposed to provide developing countries with the lacking infrastructures regarding logistics, transportation, education and public health services, which are considered as *sine qua non* preliminary conditions for any private investment in human or physical capital, hence it is supposed to be non-substitutable and to uplift economic growth and development. In other words, public investment is likely to have a larger macroeconomic

[39] Khan, M. S. (1996), 'Government Investment and Economic Growth in the Developing World', the Pakistan Development Review, No 35, December, P. 434

[40] Ghani, E. and Din, M. (2006), 'The Impact of Public Investment on Economic Growth in Pakistan', the Pakistan Development Review, No 45, March, P. 96

effect in the developing world compared to advanced economies, since there is a more important margin of improvement at the infrastructure level, among other development and economic variables. In this context, the public investment multiplier effect is found to go up to 1.4 in middle income countries while it is weak –and even negative in some cases- in advanced economies, according to an empirical survey made by Hemming *et al* (2002). They explain this finding by the fact that crowding out is strong when government spending substitutes for private spending or when the interest rate and the exchange rate rise in response to fiscal expansion. This generally does not apply to developing countries, since most of them have fixed exchange rate and public spending, particularly public investment, tackles essentially the existing infrastructure issues, hence its non-substitutability as regards to private investment. The paper also links crowding out to the predominance of Ricardian households in the economy, in which case a permanent fiscal expansion would reduce the demand, particularly consumption[41].

Based on these elements, among others, Hemming et al (*ibid*.) conclude that crowding out is more likely to take place in developed economies, not in developing ones. In a more recent study, Swaby (2007) contested this finding in a research paper that discusses the interaction of public investment and GDP growth in Jamaica using a VECM method, based on 1994-2006 data. The paper's results show that public investment considerably crowds out net private investment, while only a weak relationship between output and public investment has been detected. Furthermore, the Granger causality result suggests that public investment does not cause GDP growth; however, reverse causality could not be convincingly rejected. Swaby's VECM results join Khan's (1996) when it comes to the importance of private investment as a determinant of economic growth: it was found that domestic private sector investment and FDI have a positive direct impact on the level of GDP in the long-run[42].

China, during its development phases, also constitutes an interesting case to investigate. An empirical research led by Chow (1993) tackled the role of capital stock variations in determining the Chinese GDP growth. Besides from the fact that it enables to discover China's investment policy by the time it upgraded to the status of emergent economy, the particularity of this study lies in the disaggregated analysis regarding agriculture, industry, services and construction. The sectors where public and private investment had been the most productive were construction (a 26 percent rate of return to capital), agriculture (20 percent) and industry (17 percent). Moreover, Chow (*ibid*.) discovered that in the period from 1952 to 1985, the Chinese average income growth rate went alongside the capital growth rate, respectively 6 percent and 7.6 percent.

The concept of public investment optimality was motivated by Fosu *et al* (2011), who used a panel data from 33 Sub-Saharan African countries during the period from 1967 to 2008 in order to assess the relationship between public investment, private investment and economic growth. The results indicated that not only does public investment play a crucial role in

[41] For further explanations regarding this aspect, see Hemming R., Kell M. and Mahfouz S. (2002). 'The effectiveness of Fiscal Policy in stimulating Activity – a review of the literature', IMF Working Paper 02/208, PP. 35-36

[42] Swaby, R. (2007), 'Public Investment and Growth in Jamaica', Bank of Jamaica Working Paper, P. 22

determining economic growth, but also that its current level in Sub-Saharan economies is, on average, sub-optimal[43]. The paper went further and tried to identify the growth-maximizing level of public investment. The latter level was found to fluctuate between 8.4 percent and 11 percent of GDP depending on the country, but also on the econometric technique used. This finding does not diverge quite much from a study made before by Miller and Stoukis (2001) and in which the results exhibit a public investment "optimal" level of 18 percent of GDP, for a different set of low and middle income economies[44].

A certain number of research papers investigated the relationship between public –and private- investment and economic performances, but for specific Sub-Saharan African countries using different econometrical methods. Their findings, however, do converge considerably. For example, Bédia (2007) examined the case of Ivory Coast during the period from 1969 to 2001, using an error correction model and an autoregressive-distributed lag methodology. The paper shows that in the short run, a 100 percent increase in public investment leads to a 7 percent rise in real GDP. The impact is even larger in the long run, going up to a 37 percent increase in real output. This finding diverges from Khan's (1996) and Ghani and Din's (2006) in their respective samples, especially that public investment is found to have a larger effect on economic growth compared to private capital shocks. On the other hand, Bédia (*ibid*.) raises the question of public investment inefficiency in Ivory Coast in the short run; however, one should bear in mind that public investment usually generates returns only after a relatively long period of time, since it generally handles long term structural issues, as opposed to private investment.

In Northern Africa, the Tunisian case regarding the particular contribution of private and public investment to economic growth has been subject to several studies. Casero and Varoudakis (2004) examined the significance of each factor's contribution to average GDP growth in Tunisia from 1970 to 1999, in comparison to five fast growing countries, i.e. Chile, Korea, Malaysia, Mauritius and Thailand. The study takes into consideration public investment, private investment, the macroeconomic stability, the structural reform in trade and finance, the human capital, and the convergence effect[45]. The results indicate that as opposed to the five aforementioned fast growing economies, Tunisia's GDP growth relied more on public investment, and less on private investment and human capital. The authors defend that it would be unrealistic to assume that public investment will continue to be a main driver of growth in Tunisia in the near future. They explain this predictive hypothesis by the fact that the margin for maneuver to raise public investment is narrowing down, as the size of

[43] Fosu A.K., Getachew Y.Y. and Ziesemer T. (2011), 'Optimal Public Investment, Growth, and Consumption: Evidence from African Countries', UNU-MERIT, Working paper No. 51, P. 25

[44] Both Miller and Tsoukis (2001) and Fosu *et al* (2011) use the same definition of public investment optimality, where the issue is to drive a maximal upward macroeconomic influence under the constraint of keeping down crowding out effects.

[45] As implicitly explained previously in the section about the Neoclassical Solow-Swan model, the convergence effect is driven by the initial conditions regarding the level of income and implies, based on the hypothesis of diminishing returns to capital, that countries with high capital per GDP ratio tend to have a low marginal productivity of public and private investment, and vice versa. The concept was first introduced by Solow (1956), and emphasized later by Fagerberg (1994) under the name of "transitional dynamics".

non-discretionary public expenditures is growing bigger and given the need to consolidate and rationalize Tunisian fiscal policy[46].

These arguments are endorsed by Achy (2011), who laid emphasis on the fact that Tunisia's excessive level of public debt is likely to only weaken investors' confidence and trim down growth prospects. Subsequently, it would be capital to promote the private sector development, particularly by removing inefficient regulations and fighting corruption[47]. Nevertheless, a study made by Boughzala *et al* (2007) regarding regional economic growth and development in Tunisia had reached the conclusion that public capital is an essential determinant of economic growth and that it plays a crucial role in the reduction of poverty, therefore it should not be cut down. Based on a dynamic and regionalized computable general equilibrium model (CEGM), the authors discovered that the Tunisian regions and areas where there is the least public investment spending have substantial development deficiencies and show a distorted income distribution and high rates of poverty, as opposed to regions where the state invests more. One should bear in mind that based on the literature we have been discussing so far, public investment (among other instruments of fiscal policy) is hypothetically supposed to help drain private investment to a given region or country by providing infrastructures etc., provided that the public-private investment complementariness is ascertained. In this framework, IMF (2014a) recommends for Tunisia a gradual replacement of generalized subsidies with a better-targeted compensation system, and the control of the wage bill, which would free up budget resources for higher social expenditures and growth-supporting public investments over the medium term[48]. These recommendations are quite similar to the reforms suggested by the IMF for the cases of other MENA countries, such as Morocco.

Following IMF's doctrine and based on several other reports regarding middle and low revenue countries, public investment and social programs are in principle seen to be important to promote growth. The issue is in defining which sectors are the most economically reactive to public investment, and the extent to which certain types of public project management are best in order to improve efficiency regarding some specific public investment expenditures, but also the public projects that are likely to encourage and drive further private capital. On the other hand, fiscal policy makers would usually face a tradeoff between investing and maintaining debt in a sustainable level.

Several studies concerning the Turkish economy discuss this very issue. As opposed to the predictions and recommendations made by Casero and Varoudakis (2004) regarding the Tunisian public investment trends, the case of Turkey exhibits a squarely detrimental impact of the retrenchment of public capital. Ismihan *et al* (2002) argue that when the government cuts down public investment –especially infrastructural expenditures- instead of current and "populist" spending, capital accumulation, economic growth and development suffer from a

[46] Casero, P. A. and Varoudakis A. (2004), 'Growth, Private Investment, and the Cost of Doing Business in Tunisia: A comparative perspective', World Bank working paper series No 34, PP. 8-9
[47] Achy L. (2011), 'Tunisia's Economic Challenges', The Carnegie papers, December, P. 22
[48] IMF (2014), 'Tunisia: First and Second Reviews under the Stand-By Arrangement', IMF Country Report No. 14/50, February, P. 63

severe regression in Turkey. Hence, in order to satisfy the public finance stability constraint, fiscal decision makers have to choose carefully which components of public expenditures should bear the burden of fiscal adjustments such as the ones motivated above by the IMF[49]. Their study indicates that capital accumulation is the main factor behind Turkey's growth performance, and that private investment's response to public investment shocks is quite large, which gives even further importance to public capital from a macroeconomic point of view. And as the post-1980 macroeconomic instability in Turkey resulted in the reduction of public investment, particularly in infrastructure projects, the relative proportion dedicated to current public spending increased which reversed the complementariness between public investment and private investment. The existence of a relatively significant long-run crowding out effect of the overall public investment on private investment is most probably tributary to the waning of this very complementariness, as even post-2002 data exhibits no long-run correlation between the two.

Arslan and Saglam (2011) went further in their analysis of the Turkish framework by introducing corruption. They basically argue that corruption affects investment, and particularly public investment, which is reflected on the economic performances. The authors explain this chain of causality based on the fact that corruption supposedly distorts the decision making process regarding public investment projects and is likely to influence both the size and the composition of the overall public investment. In other words, corruption would increase the number of projects carried out by the government and alter the design of said projects, mostly by extending their sizes and their complexity. Subsequently, the part of public investment in GDP would increase as its marginal productivity would drop, which would trim down the output growth[50]. Despite the fact that their empirical results do not fully support their thesis, as they turned out to be insignificant, the study led by Arslan and Saglam (*ibid*.) can fit in the line of several research papers regarding this very issue in different countries, such as Bardhan (1997) and Mauro (1996, 2004). And the analysis carried by these authors motivates the notion of efficiency through the reduction of corruption.

IV. CONCLUDING REMARKS

In this paper, the light was shed on economic growth as a core variable of the economic activity, its determinants and the role of investment, and particularly public investment, as a potential contributor. Growth theorists agree in principle that public and private investment plays a decisive role in the sense that it enhances the economy's productivity, particularly by driving an upward influence on technology and education, among other physical and societal variables. Public investment's particularity lays in the fact that it is sought to provide key infrastructural components, which theoretically constitute the fundamental basis for any economic activity. Regardless of the specific magnitude of its impact on GDP and

[49] Ismihan, M., Metin-Özcan K. and Tansel A. (2002), 'Macroeconomic Instability, Capital Accumulation and Growth: The Case of Turkey, 1963-1999', Bilkent University Working Paper, P. 14

[50] Arslan, Ü. and Saglam, Y. (2011), 'The relationship between corruption and public investment: the case of turkey', Sosyal Bilimler Enstitüsü Dergisi, Vol. 20, No 2, P. 369

productivity according to different empirical studies, a large part of the theoretical and empirical literature recognizes public investment to be a superior determinant of economic growth. As an example, in the well-known Baxter and King's (1993) neoclassical model, public capital is typically modeled as an unpaid factor with a significant marginal product in the private sector production function. This implies that, besides from its "ordinary" effects like any economic agent's consumption, government can also provide a positive externality on the private inputs' productivity through public investment.

However, the approach that one should adopt in order to produce a precise assessment of this externality remains blurry, as public investment offers goods and services that cannot be directly connected to private sector output. In other words, it is difficult to assess public capital's impact on productivity and output growth, since it would only indirectly affect them. This difficulty exists even when it comes to infrastructure investment expenditures, because the latter's impact on productivity takes a long time to be recognizable and the risk of losing track becomes quite important, which complicates the data assessment even more.

The debate remains unfasten, starting from the Keynesian-Classical controversies, down to the divergent empirical findings regarding the very impact of public spending, particularly government investment, on GDP growth. Based on the different works reviewed in this paper, it would be difficult to definitely ascertain the extent of relationship between fiscal policy/public investment expenditures and the economic activity. A large number of empirical studies confirmed the existence of a significant upward influence of public investment on economic growth and, in some cases, on private investment. However, several authors found public capital to be of no avail when it comes to promoting output growth, and some even came up with the conclusion that public spending has a detrimental macroeconomic effect.

Nevertheless, it is possible to draw a certain number of rules-of-thumb that could help guide a country in the shaping of an effective public investment policy. Authors like Easterly and Rebelo (1993) and Warner (2014) defend that the differences in estimates of the extent of public investment's influence on output growth are most likely due to uncertainties around fiscal multipliers on the demand side and inefficiencies on the supply side[51]. Another strand of research papers sort-of combines the different visions by linking the significance of public investment's impact on GDP growth, to various notions of efficiency. As a matter of fact, efficiency stands out as a transversal concept, whether through the reduction of corruption or investment projects selectivity –based on costs and macroeconomic reactivity, among other forms efficiency incarnates. Several of the papers discussed above present it as a decisive determinant of the significance of the influence of public investment on the economic activity. The overwhelming result is that relationships between investment (both private and public) and GDP growth are stronger in countries where public investment is more efficient. Gupta *et al* (2014) support this conclusion in the case of 52 developing and provide evidence that when public capital is adjusted for efficiency, i.e. the adequacy of projects selection and implementation, its impact as a contributor to growth increases in a statistically significant

[51] Regarding the uncertainties on the demand side of the economy, see Easterly and Rebelo (1993), PP. 13-14. As for the supply side deficiencies, they are explained further in Warner (2014), P. 62

way, especially in low-income countries[52]. On the other hand, other economists, at the image of Berg *et al* (2015), take this question from a "transitional dynamics" perspective and argue that economies with sub-efficient public capital usually also have a rather small quantity of capital; therefore, it can still benefit from substantial returns to public and private investment compared to more efficient countries, which often happen to also have an abundant capital stock.

As a consequence, public investment is likely to be more efficient in small and middle income countries where the capital to GDP ratio is usually the lowest. This could be explained by the fact that public investment supposedly provides developing countries with the lacking infrastructures regarding logistics, transportation, education and public health services, which are considered as *sine qua non* preliminary conditions for any private investment in human or physical capital, hence it is generally non-substitutable and helps uplift economic growth and development. In other words, public investment could have a larger macroeconomic effect in the developing world compared to advanced economies, since there is a more important margin of improvement at the infrastructure level, among other development and economic variables, hence a low likelihood of public-private capital substitutability. The public-private investment substitutability plays a determinant role in this framework since it exacerbates the crowding out effect. The substitutability is more present in advanced economies than in developing ones, which could explain why the public investment multiplier effect is found to go up to 1.4 in middle income countries while it is weak –and even negative in some cases- in advanced economies [see Hemming *et al* (2002)].

Based on these different elements of analysis, it is possible to connect the dots and think of a plausible explanation for the relatively weak macroeconomic effect of public investment, i.e. when further public spending do not follow efficiency and profitability-based selectivity, its marginal productivity is likely to shrink as the crowding-out effect stays at a certain level. By the end of the process, the allegedly positive effect of public investment on output would have been partially or totally neutralized by the negative macroeconomic impact of crowding-out. The same effect is to be expected in the case where capital stock is very high compared to GDP, as returns generated by further investment would progressively diminish. In other words, public investment could be a significant determinant of economic growth, provided that governments take the aforementioned constraints into account.

[52] Gupta S., Kangur A., Papageorgiou C., and Wane A. (2014), 'Efficiency-Adjusted Public Capital and Growth', World Economic Development, Vol. 57, Issue No C, PP. 171-174

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