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Economic growth at the expense of technology

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Abstract. *In this article the authors aim to emphasize the effect that improving technology has in ensuring the conditions of economic growth. It is known that in Clark-Douglas' production function we encounter the three factors, namely capital, labor and resources. Of course, economic growth can be achieved by improving labor productivity, increasing the efficiency of the use of capital and using resource efficiency. However, among all countries that have approximately equal conditions, growth is somewhat differentiated. This is primarily due to the quality of the technology used. In the current conditions, we can no longer talk about the industrial revolution but about the development of industry on a modern basis, as a result of research, innovation and inventions. The version launched by the Solow model expresses views on the role that technology plays in the economic growth of an area of activity, of a country or, if we want to think about the European Union, of this economic community as a whole. Addressing these issues one by one, it follows that indeed the technology, explained in theoretical and even concrete terms, has a particular effect on economic growth. The authors used an appropriate technology, namely the interpretation of the data and indicators that the National Institute of Statistics, Eurostat or the European Union provide. The analysis is also a logical one in the sense that, by the way in which this data is expressed, it is ensured that the possibility of using technology in increasing economic growth is ensured.*

Keywords: economic models, research, development, innovation, technology, economic growth.

JEL Classification: C10, F40.

Introduction

In the article *Economic growth at the expense of technology*, the authors started from the fact that technology is an important factor of economic growth. Countries that use this advanced technological process also have better results generated by the efficiency and efficiency given by these technological machines. Of course, there are a number of theories such as the starting version of the Solow model, which start from the idea that, in general, work and technology are the determining factors of the production of goods and services of a nation.

The Solow model shows how capital changes through savings and investments, what are the changes that are taking place, and also expresses how to correlate these factors that it considers. In Solow's conception, technological progress is one of the ways of improving the production framework and, consequently, increasing the results, with an effect on economic growth.

In order to incorporate technological progress, we must return to the fact that this capital cannot become profitable without the use of a workforce that is well-skilled, specialized and in full accordance with the features of the technology used.

A simple assumption about technological progress is that it provides growth with a steady rate of productivity of work and quality of products.

Technological progress does not necessarily make it necessary for the number of workers to increase or decrease, but it is about the adequacy of the number of workers in full accordance with the quality of the technology used.

It is clear that the effects of technological progress are absolutely special and necessary in the concern of modernizing the industry and putting it on other bases, which will ensure a substantial increase in production, that is, as a consequence, in economic growth.

The introduction of technological progress also changes the criterion for the golden rule. The capital level of the golden rule is now defined as the steady state, which maximizes consumption per worker.

Following the same argumentation that we use in many analyses, it follows that this consumption will be dependent on the quality of the equipment, eliminating as much as possible the scraps and products that do not comply with the criteria for increasing production.

Economic growth according to Solow's model must be balanced, in the sense that technological progress causes the values of many variables to increase, which, however, must be in a state of equilibrium in order not to arrive at the lack of correlation between the quantitative and qualitative level of the factors of production involved in economic activity.

In a positive sense, technological progress also affects factor prices, in other words, ensuring value growth and maintaining a match between the costs of production and the prices of the finished product, which satisfies market conditions, both for individual and industrial consumption.

In the article we also referred to convergence in the sense that we will see that there are a number of variations in the industrial, economic standards used by the countries of the world. Poor countries have at most an average level of per capita income, which takes into account the conditions of production activity. The economies of poor countries tend to catch up with the economies of the rich countries of the world, but this process, as Solow explains in his model, cannot be achieved in the short term, at most it can be a goal that can be achieved in future periods.

In the article we explain some elements on technology and economy in the interwar period, then in the period after the Second World War to reach the conclusion of our days that involves re-technology and development of the economy on modern bases.

The Solow model raises a particular question between the idea of accumulating capital, including human, and the differences that exist in countries around the globe that want to do so. That is why we have dealt with issues in relation to the accumulation of factors and the efficiency of production. Accumulation means increasing the factors in the results of the activity and this must be done in full concordance, so that the correlation is one of growth, one of positive.

There are a number of policies to bring about economic growth. The Solow model discovered the theoretical relationships between the different sources of economic growth and discussed several aspects that this concordance raises, which must be achieved in the vision of real economic growth.

According to the Solow growth model, when you save and invest is a determining factor in the level of production quality and, ultimately, in the standard of living of the population in that country.

Solow made an analysis based on the Model of the United States, in which he showed that the golden rule provides the reference point with which to compare any other country with the level of technological evolution of the United States. I gave some examples in the sense of understanding this situation, this perspective of growth at the expense of technology.

Literature review

The economic recovery of a nation can be achieved based on technology, following a sustained research and development strategy. A number of researchers have turned their attention in this direction. Thus, I remember significant works such as that of Anghelache, C., Anghel, M.G., Dumbravă, G.Ş. (2019) who paid attention to the investment fund of financial portfolios, which represent an important step on the path of innovation and at the same time represent an undeniable step on the growth of production in the field of industry, the emergence of new industries that will benefit greatly from robotization and the introduction of the most advanced techniques. Anghelache, C., Anghel, M.G., Dumitrescu, D., Avram, D. (2018) in their paper refers to the role of the science of technology and innovation in the economic evolution of each state in the European Union, and as a consequence of Romania in terms of the perspective of economic growth. Barbosa, N., Faria, A.P. (2011) emphasizes that innovation is an important element of supporting the development of a country's economy through the results resulting from research and development with immediate application in the business environment. Buesaa, M., Heijsa, J., Baumert, T. (2010) mention that national and regional innovation must ensure a perspective of factoring influence on the growth of each country's economy and the economy of the European Union as a whole. Charron, N., Lapuente, V. (2018) gives an overview of spatial and temporal analysis of the quality of governance activity in the various regions of the European Union. Farole, T., Rodríguez-Pose, A. and Storper, M. (2011) refers to the need for political cohesion in the European Union, so that regional development is a priority objective, by implementing projects that ensure that the differences that exist between Member States are reduced. Lane, P.R. (2006) addresses the problem of the effects of the European Monetary Union that create advantages for some Member States and puts other Member States in some difficulty somewhat, there being from this point of view some difficulties for the participation of states with limited financial resources or low technological potential in large European projects. Onetti, A. et al. (2012) emphasize that business must be based on certain and future results of research and innovation, and Pinto, H. (2009) refers to the fact that the diversity of innovation must be an important factor in the evolution of the European Union. Srholec, M. (2009) highlights that cooperation in the field of innovation is beneficial for project participants and gives meaning to the future evolution of the proposed activities regardless of the branch to which they refer. Tosun, J. (2014) and Voigt, P. and Moncada-Paternò-Castello, P. (2012) address issues related to the importance of absorption of regional funds by Member States, as well as to the prospect of intensive growth of the economies of the Member States of the European Union.

Methodology, data, results and discussions

Technology is an important driver of economic growth. In the case of her Indi, we find that it has grown rapidly, a phenomenon that has saved millions of people from extreme poverty. At the same time, other poor nations are, including many countries in sub-Saharan Africa, have seen little growth and their citizens continue to live in poverty. It's the idea of growing theory and explaining such results. The reasons why some nations fail, while the tele manage to promote long-term economic growth, the disastrous consequences for human well-being are indeed astounding.

Starting with the basic version of the Solow model, we will consider four aspects. The first is to adapt the Solow model more general and realistic. We know that technology is important for increasing production alongside capital and labor. So, we can add the third source of growth, the technology.

The second aspect is to move from theory to empirical. That is, to apply the Solow model to a concrete case. In recent decades, the literature has examined the predictions of the Solow model and other economic models of growth and the Solow model can clarify the experiences of international growth, the wave of technology.

The third aspect is to examine how a nation's public policies can influence the rise of the population's standard of living. In particular, the following issues arise:

- Should society save more or less? How can the policy influence the savings rate?
- Are there certain types of investments that should be encouraged?
- Do the institutions have to make sure that the resources of the economy are used as well as possible?
- How can political strategies increase the rate of technological progress?

The Solow growth model provides the theoretical framework within which we can consider these political issues.

The fourth aspect is to consider what the Solow model omits. As we have indicated, models help us understand the world they simplify. Once an analysis of a model has been completed, it is important to consider whether we have simplified the situation properly. It is necessary to examine a set of theories, called endogenous growth theories, that help explain the technological progress that the Solow model considers exogenous.

There mention of the Solow model assumed an existing relationship between capital inflows, labor, and the production of goods and services. However, the model can be modified to include exogenous technological progress, which over time expands the production capacities of the company.

To incorporate technological progress, we need to return to the production function that reports total capital K and total labor L with total output Y. F the production was given by the relationship:

$Y = F(K, L)$

Now we write the production function as:

$Y = F(K, L \times E)$,

where E is a new (and somewhat abstract) variable called work efficiency.

Work efficiency is meant to reflect society's knowledge of production: as the available technology improves, work efficiency increases and every hour of work contributes more to the production of goods and services. De example, labor efficiency increased when production on the assembly line transformed and increased again when computerization was introduced in the late twentieth century. Work efficiency also increases when there are improvements in the health, education or employment skills.

The term $L \times E$ can be interpreted as measuring the enjoyment of the actual number of workers.

The number of actual workers L and the efficiency E of each of them shall be taken into account. In other words, L measures the number of workers in the workforce, since $L \times E$ measures both the workers and the technology used. This new production function states that the total outflow *of Y* depends on the contribution of K capital and the number of actual L x E workers.

The essence of this approach to shaping technological progress is that increases in the efficiency of *E* work are analogous to increases in labor *force L*. For example, a breakthrough in production methods causes work efficiency *E* to double between 1990 and 2021 This means that a single worker in 2021 is, in fact, as productive as two workers in 1990. That is to say, even if the actual number of *L* workers remains the same from19 90 to 2021, the actual number of *L* x *E* workers is doubling and the economy is benefiting from an increase in the production of goods and services.

The simplest assumption about technological progress is that it influences the efficiency of E's work to increase at a constant rate *g*. Thus, if $g = 0.02$, then each unit of labor becomes 2% more efficient every year: production increases as if the labor force had grown by 2% more than it really grew.

This form of technological progress is called workforce growth, and *g* is called the rate of technological progress that increases the workforce. As the workforce *L* increases at the n rate, and the efficiency of each unit of work *E* increases at the rate *g*, the actual number of L x *E* workers increases at the rate $n + g$.

Since technological progress is modeled here as an increase in the workforce, one can use the model in almost the same way as in population growth. Technological progress does not make the actual number of workers increase, but because each worker actually comes with more units of work over time, the effect of technological progress causes the actual number of workers to increase. The analytical tools we used to study the Solow model with population growth are easy to adapt to the study of the Solow model with technological progress that increases the workforce.

Before adding technological progress, we looked at the economy in terms of quantities per worker. How can we generalize that approach lies by looking at the economy in terms of quantities per actual employee.

We consider that $k + K/(L \text{ x } E)$ represents capital per actual worker and $y = Y/(L \text{ x } E)$ represents the output per actual employee. With these clarifications we can write again $y = f(k)$.

The analysis of the economy continues as it did when we examined population growth. The equation showing the evolution of *k* over time becomes:

$\Delta k = sf(k) - (\delta + n + g)k$

Modification of the capital stock is equal to the investment $\Delta ksf(k)$ minus the investment break-even $(\delta + n + g)k$. Now because $k + K/(L \text{ x } E)$, the investment in the break-even point includes three terms: to maintain *k* constant, it is necessary δk to replace the capital that depreciates, *nk* is necessary to provide capital for new employees, and *gk* it is necessary to provide capital for efficient new *workers* created by technological progress.

The inclusion of technological progress does not substantially alter the equilibrium state analysis. There is a level of *k*, denoted k^*, at which the capital per actual employee and the output per actual employee are constant. This equilibrium is the long-term balance of the economy.

We will consider the technological focus and the Solow growth model. Technological progress that increases the workforce at the g-rate enters our analysis of the Solow growth model in the same way as population growth at the n-rate. Now that k is defined as the amount of capital per actual worker, increases in the actual number of workers due to technological progress tend to decrease k. In the steady state, the $sf(k)$ investment compensates precisely for the reductions in k attributable to depreciation, population growth and technological progress.

The effects of technological progress, in the way in which four key variables behave in the state of equilibrium with technological progress. As we have seen, the capital per actual worker k is constantly in a steady state. Under these conditions $y = f(k)$, the output per actual worker is also constant. These quantities per actual worker are constant in the steady state. From this information, we can deduce what happens to variables that are not expressed in units per actual worker. For example, if we consider the output per actual worker $Y/L = y \times E$, because y is constant in the stationary state and E increases at the rate g, the output per worker must increase by the rate g constantly state.

Similarly, the total output of the economy is $Y = y \times (E \times L)$. Because y is constant in the steady state, E increases at the rate g, and L increases at the n rate, and the total output increases at a rate $n + g$ in the steady state.

With the addition of technological progress, the model can finally highlight sustained increases in the standard of living. The technological focus can lead to a sustained increase in production per worker and, in contrast, a high rate of saving leads to a high rate of growth only until the state of equilibrium is reached. Once the economy is in a state of equilibrium, the rate of increase in production per worker depends only on the pace of technological progress. According to the Solow model, only technological progress can explain the sustained growth and steady increase in living standards.

The capital level of the golden rule is now defined as the steady state that maximizes consumption per actual worker. Following the same arguments that we have used; we can show that the consumption at the steady state per actual worker is given by the relationship:

$c^* = f(k^*) - (\delta + n + g)k^*$

Steady-state consumption is maximized if:

$MPK = \delta + n + g$,

or

$MPK - \delta = n + g$.

La level of the golden rule of capital, the net marginal product of capital, $MPK - \delta$, is equal to the growth rate of total production, $n + g$. Because economies experience both population growth and technological progress, this criterion must be used to assess whether they have more or less capital than they should in the golden rule of equilibrium.

Up to this point we have introduced exogenous technological progress into the Solow model to explain the sustained increase in the standard of living. We will further analyze what happens when this theory is applied in practice.

According to the Solow model, technological progress causes the values of some variables to grow together in the steady state. This property, called balanced growth, influences the evolution of the economy in the long run.

We will consider productions per employee Y/L and capital stock per employee K/L.

According to the Solow model, in the steady state both variables increase by g, the rate of technological progress. In the American economy over the past half-century, output per employee and stock of capital per worker have increased at about the same rate (2% per year). We can appreciate that the capital-production ratio has remained approximately constant over time.

Technological progress also affects the prices of factors. From the study of data on the U.S. economy, we find that in the last 50 years, the real salary has increased by about 2% per year. Around this rate, the real GDP per worker has also increased.

The Solow model's prediction of factor prices is noteworthy, especially when contrasted with Karl Marx's theory of the development of its capitalist economists. Economic history did not support Marx's prediction, which only partly explains why we are now studying Solow's growth theory rather than Marx's.

Countries individually have a different standard of living, which depends on the level of development of each. The poor countries of the world have low or average levels of income per person, which are less than one-tenth of the level medium of the developed countries of the world.

These differences in income are reflected in the quality of life. Much research has been devoted to the question of whether economies are moving towards convergence over time. Poor economies should grow faster than developed economies. If this progress takes place, then the developing economies of the world will tend to catch up with the developed economies. This process of catching up is called convergence.

The Solow model makes clear predictions about when convergence should occur. According to the model, it depends on whether two economies will converge and why they differ in the first place. On the one hand, let's assume that two economies, it happens by a historic accident, start with different stocks of capital, but they have the same state of equilibrium, as determined by their saving rates, population, growth rates and labor efficiency. In this case, we should expect the two economies to converge. It’s poorer economic with smaller capital will naturally grow faster to reach equilibrium. On the other hand, if two economies have different stability, perhaps because economies have different savings rates, then we should not expect convergence. Instead, each economy will approach its own balanced state.

Experience is consistent with this analysis. In the analysis of economies with similar cultures and policies, studies show that economies converge at a rate of about 2% per annual gap between rich and poor, economies close by about 2% each year. Convergent can be analyzed with the Solow model under the assumption that those state economies had different starting points, but approaching the state of balanced.

When researchers only examine income data per person, they find little evidence of convergence. Poor countries don't grow faster on average than rich countries. This finding suggests that different countries have different states of equilibrium. If statistical techniques are used to analyze some of the determinants of equilibrium status, such as savings rates, population growth rates and the accumulation of human capital (education), it is found that the convergence data have a rate of about 2% per annum. in other words, the economies of the states show conditional convergence. They seem to converge towards their own states of equilibrium, which in turn are determined by variables such as saving, population growth or human capital.

From an accounting point of view, international differences in income per person can be attributed either to differences in factors of production, such as quantities of physical and human capital, or to differences in efficiency with which economies use factors of production. Aworker in a poor country can be poor because he lacks the tools and skills or because the tools and abilities are not used to the fullest. To present this problem in terms of the Solow Model, the question is whether the large gap between rich and poor is explained by differences in the accumulation of capital (including human capital) or differences in production function.

A lot of research has been aimed at estimating the relative importance of these two sources, namely income gaps. The precise response varies from study to study, but both the accumulation of factors and the efficiency of production are important. A common finding is that they are positively correlated in the sense that nations with high levels of physical and human capital tend to make effective use of these factors.

There are several ways to interpret this positive correlation. One hypothesis is that an efficient economy can ensure the accumulation of capital. Thus, a person in a well-functioning economy may have greater resources and incentives to accumulate human capital. Another hypothesis is that aggregating capital can ensure greater efficiency. If there are positive externalities towards physical and human capital, then countries will emerge that save and invest more by increasing their productive functions. A higher efficiency of production can cause greater accumulation of factors or vice versa.

A final assumption is that both the accumulation of factors and the efficiency of production are influenced by a third common variable. The third common variable is the result of government policy-making.

According to the Solow growth model, how much a nation saves and invests is a determining factor in the standard of living of its citizens.

As we have seen, the savings rate determines the equilibrium levels of capital and output. A certain rate of saving produces the steady state of the golden rule, which maximizes the consumption per worker and highlights economic well-being. The Golden Rule provides the reference point with which we can make comparisons.

To decide whether the economy of a country is above or below the equilibrium level of the Golden Rule, we must compare the marginal product of net depreciation capital (MPK - δ) with the growth rate of total production ($n + g$), respectively the steady state of the Golden Rule, $MPK - \delta = n + n + g$. If the economy operates with less capital than in the steady state of the golden rule, the marginally decreasing product highlights us that $MPK - \delta < n + g$. In this case, the increase in the savings rate will cause capital accumulation and economic growth. In the end, it will lead to a state of equilibrium with a higher consumption.

On the other hand, if the economy is capitalized higher, compared to the constant golden rule in the state, respectively $MPK - \delta = n + g$. In this case, the accumulation of capital is excessive, and the reduction of the savings rate will lead to higher consumption in the short or long term.

To make this comparison in a real economy, an estimate of the rate of growth of production ($n + g$) and the net marginal product of capital (MPK - δ) is required. We can estimate the net marginal product of capital from the following three situations:
a) The share capital is about 2.5 times the GDP of a year.
b) The depreciation of capital is about 10% of GDP.
c) Capital income is about 30% of GDP.

Using the notation of the model we can write these situations as:
a) $k = 2.5 and$
b) $\delta k = 0.1 and$
c) MPK x $k = 0{,}3y$

We solve the depreciation rate δ dividing equation two by equation one, respectively:

$\delta k/k$ = (0,1 ani)/(2,5 ani) => $\delta = 0{,}04$

Rwe solve the marginal product of MPK capital by dividing equation three by equation one, resulting in:

(MPK x k)/ k = (0.3 ani)/(2.5 ani) => $MPK = 0.12$

Thus, about 4% of the share capital depreciates every year, and the marginal product of the capital is about 12% per year δ.

We find that the return on capital ($MPK - \delta = 8\%$ per year) is well above the average growth rate of the economy ($n + g = 3\%$ per year). This indicates that the capital stock is well below the Golden Rule level. In other words, if the state in question were to save and invest a greater part of the income, it would impose a greater increase and would eventually end up with a state of equilibrium with a higher consumption.

Calculations show that in order to lead an economy towards a state of equilibrium, policymakers should adopt policies to encourage national savings.

The most direct way the government influences national saving is through public savings, the difference between what the government receives in tax revenues and what they spend.

When its spending exceeds revenues, the government has a budget deficit, which represents negative public savings. Conversely, if it spends less than it earns, then the Government has a budget surplus, which it can use to stimulate investment.

The government influences national savings by influencing private savings by households and businesses. How much people decide to save depends on the incentives they receive, and these incentives are the result of a public policy. Many economists argue that high tax rates on capital, including income tax, property tax, and many state taxes on income and property, discourage private saving by reducing the rate of return. Some economists have proposed increasing their incentives to save by replacing the system of taxing their income with a system of taxing it consumption. Many disagreements about public policies are present in different opinions about how effective private saving is depending on the incentives.

The Solow model acknowledges the simplifying hypothesis that there is only one type of capital, but in reality, there is a diversity of types. Private businesses invest in traditional types of capital or newer types of capital. The government invests in public capital in various forms, usually infrastructure.

It's about human capital, the knowledge and skills acquired by workers through education and training. Although the capital variable in the Solow model is usually interpreted as including only physical capital, in many instances human capital is analogous to physical capital. Ca and physical capital, human capital increases the ability to produce goods and services. Raising the level of human capital requires specific investment in education and research. Research on economic growth has highlighted that human capital is as important as physical capital, which is the motivation for international differences in living standards. One way to shape this aspect is to include both human and physical capital in the overall capital.

Political factors that try to influence economic growth face this problem, namely the correlation of the structure of capital. In this regard, policymakers must rely on the market to allocate the savings fund to alternative types of investment. The industries with the largest marginal capital ratios will naturally be the most targeted and pre-borrowing on the market to finance new investment. Many economists argue that policymakers should create *a level playing field* for different types of capital.

Other economists have suggested that the authorities should actively encourage certain forms of capital. Suppose that technological progress appears as a byproduct of certain economic activities. This would happen if the production processes improve and are correlated with the capital allocation process. This by-product is called technological externality. In the presence of such externalities, the return on capital exceeds private profits and the benefits of increased capital as suggested by the Solow model.

The expansion of robots produces greater technological externalities than building a new factory, and then perhaps the government should use tax breaks to encourage investment in robots. The success of such an industrial policy requires the government to accurately measure the externalities of the various economic activities so that it can provide the right incentive to each activity. Many economists are skeptical about industrial policies for two reasons. First, measuring externalities in different sectors is very difficult. If the policy is based on inconclusive measurements, its effects can be random. Secondly, it is known that the political process is far from perfect. The government can reward certain industries with subsidies and tax breaks, with the rewards being able to influence the extent of the externalities.

Local governments decide if and when they should borrow to finance infrastructure works. Among economists, this subsidy policy has both defenders and critics, but they all agree that measuring the marginal product of public capital is important but difficult. Private capital generates an easily measurable rate of profit for the firm that owns the capital, while the benefits of public capital are more diffuse. While private equity investments are made by investors who spend their own revenues, allocating resources to public capital involves the political process and financing of taxpayers.

It’s the economists who study international differences in living standards attribute some of these differences to the growth of human capital, as well as to the productivity with which these allocations are used.

Another important institutional difference between countries is the quality of the executive and the honesty of government officials. Ideally, governments should lend *a helping hand* to the market system by protecting property rights, executing contracts, promoting competition, prosecuting and sanctioning fraud. The governments depart from this ideal and acts by using the authority of the state to enrich a few powerful individuals at the expense of the wider community. Empirical studies have shown that the scale of corruption in a nation is decisive in determining economic growth.

As early as the eighteenth century, the great economist Adam Smith was aware of the role of institutions in economic growth. He said that something else is needed to lead a state to the highest degree of opulence in the lowest barbarism, that is, a tolerable administration of justice, all the others being determined by the natural course of things. Unfortunately, many nations do not enjoy these three advantages. Regarding the encouragement of technological progress, the Solow Model shows that it must result in an increase in the income per worker from technological progress. The Solow model takes technological progress as an exogenous. don't explain it.

Many public policies are designed to stimulate technological progress. These policies encourage technological innovation in the private sector, which will allocate necessary resource. Industrial policymakers say the government needs to take a more active role in promoting their specific industries, which are the key to rapid technological progress.

In recent years, encouraging technological progress it has an international dimension. Many of the companies that engage in research to advance technology are located in developed countries. If intellectual property rights were respected around the world, firms would become more motivated to engage in research, and this would promote technological progress worldwide.

The Solow growth model shows that such economic growth must result from technological progress. To fully understand the process of economic growth, we need to study beyond the Solow model and develop models that are based on technological progress. The models that do this go under the label of endogenous growth theory because they reject the Solow model hypothesis of exogenous technological change.

To illustrate the idea on which the theorists of endogenous growth are based, let's consider a function of production, of the form:

$Y = AK$,

where: Y is the output; K is the stock of capital and A is a constant that measures the amount of production produced for each unit of capital.

We note that the function does not have the property of returning capital. This absence of diminishing returns to capital is the key difference between the endogenous growth model and the Solow model.

Now let's see what this production function is about economic growth. We believe that part of the income is saved and invested. We will describe the accumulation of capital with an equation similar to those we used previously:

$\Delta K= sY - \delta K$

This equation shows that the change in the stock of capital (ΔK) is equal to investment (sY) less depreciation (δK). Combining this equation with the production function $Y = AK$, we obtain:

$\Delta Y/Y = \Delta K/K = sA - \delta$

This equation shows what determines the growth rate of production of ΔY/Y. Notice that as long as *it has* > δ, the income of the economy increases forever, even without the assumption of exogenous technological progress.

A simple change in the production function may change the forecast of economic growth. In the Solow model, temporary saving leads to growth, but falling capital returns eventually forces the economy to approach a steady state in which growth depends only on exogenous technological progress. In contrast, in this model of endogenous growth, saving and investing pot leads to an accumulated growth.

But is it reasonable to abandon the hypothesis of declining capital income? The answer depends on how we interpret the variable K in the production function $Y = AK$. If we take the traditional view, according to which K includes only the stock of plants and equipment of the economy, then it is natural to assume decreasing profits. Giving 10 computers to a worker does not make that worker 10 times as productive as when operating a single computer.

Proponents of the theory of endogenous growth, however, argue that the hypothesis of constant returns on capital are more acceptable if K is interpreted more broadly. Perhaps the best case may be for the endogenous growth model. Clearly, knowledge is a key element in the production of goods and services. Indeed, the increasing pace of scientific and technological innovation over the past several centuries has led some economists to argue that there are increasing returns to knowledge. If we accept the view that knowledge is a type of capital, then this model of endogenous growth with its hypothesis of constant profitability becomes a more plausible solution to long-term economic growth.

Although the $Y = AK$ model is the simplest example of endogenous growth, the theory has gone beyond this stage. Research has attempted to develop models with more than one manufacturing sector to provide a better description of the forces that govern technological progress.

The economy has two sectors, which we can call manufacturing firms and research centers. Firms produce goods and services, which are used for consumption and investment in physical capital. The centers produce a factor of production called *knowledge*, which is then freely used in both sectors. The economy is described by the production function for firms, and the production function for the centers and the equation of capital accumulation becomes:

$Y = F[K, (1- u)LE]$ (production function in manufacturing firms),

$\Delta E = g(u)E$ (production function in research universities),

$\Delta K = sY - \delta K$ (capital accumulation),

where u is the fraction de labor force in the centers ($1 - u$ is the fraction of production), E is the stock of knowledge (which, in turn, determines the efficiency of work), and g is a function that shows how the increase in knowledge depends on the fraction of the labor force in the centers. The rest of the notation is standard.

The production process for production assumes that firms have constant returns at scale: if we double both amounts of physical capital (K) and the actual number of productive workers $[(1 - u)LE]$, we double the production of goods and services (Y).

This model is associated with the model $Y = AK$. It is important that this economy exhibits constant (rather than decreasing) returns of capital, as long as capital is widely defined to include knowledge as well. That we double the physical capital K and knowledge E, then we double the production of both sectors of the economy. As a result, just like the $Y=AK$ model, this model can generate persistent sharp growth without assuming its exogenous changes in production function. Here the sharp growth occurs endogenously due to knowledge, which never slows down.

At the same time, however, this model is also close to the Solow growth model. If u, the fraction of the labor force in the centers, is kept constant, then the efficiency of the E work increases at a constant rate $g(u)$. This result of the steady increase in labor efficiency at the g-rate is precisely the hypothesis established in the Technologically Advanced Model Solow. Moreover, the rest of the model, the production function and the capital accumulation equation, resemble the rest of the Solow model. As a result, for any given value of u, this endogenous growth pattern works just like the Solow model.

There are two key decision variables in this model. As in the Solow model, the production fraction used for saving and investing, s, determines the stock of physical capital in a steady state. In addition, the fraction of work in centers, *u*, causes the inventory of knowledge to increase. Both *s* and *u* influence the level of income, although only *it* leads you to increase to the equilibrium state of income. This model of endogenous growth takes a small step in the direction of showing which decisions determine the rate of technological change.

Conclusions

From those set out in that article, a number of theoretical and practical conclusions emerge in relation to the use of technology and the assurance of economic growth in this way. It is obvious that the level of technological endowment of an economy is the essential element on which economic development strategies must be based.

Improving the factorial structure of states in terms of economic organization is also very important from the point of view of the evolution of a country. The economic development strategy must be based on an appropriate model, a model that meets the correlative aspects that the national economy entails.

Another conclusion is that at the moment there is no longer a question of re-industrialization, but of the development of industry and the economy as a whole at the expense of the latest conquests of research and development, robotization, digitalization and other concrete methods and possibilities of superior use of resources through the use of appropriate technologies. Economic growth must also be based on research to ensure the qualitative growth of the technology used in economic projects.

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