The creative intelligence

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Abstract:

The creative intelligence lies in the framework of the "intelligent" way which must be used to assure creativity and, thus, innovation. As its name suggests, the creative intelligence excludes imitation. Therefore, firstly, it requires an important R&D investment that manifests itself in the developed countries. The resulting technological change seems to be a necessary but insufficient condition to assure innovation. Indeed, two other factors are necessary for that: the patent, as a form of protection of the rights of intellectual property, and the human capital (and thus education).

The resulting innovation can be of two forms: either horizontal or vertical, though more interest should be given to vertical innovations since there is a priority of households for quality.

Key words: R&D, horizontal innovation, vertical innovation, technological obsolescence, creative destruction.

JEL Classification : D23, D24, I2, J24, O3, O31, O32, O33, P14.

INTRODUCTION

At the macro-economic level, an increased use of inputs, especially the capital and the manpower explains fairly well the growth of a national economy.

On the other hand, the effectiveness of institutions associated with technology (public laboratories, universities that support innovations through conducting researches and governmental programs) also plays a vital role in the social potential of enterprises to engender and exploit the technology, consequently with an increase in the total factor productivity (TFP), which is another explanatory factor to the development of a national economy. Indeed, the total factor productivity is but "the residual value of the economic growth that one cannot explain in terms of an increase of inputs of basis that are manpower and capital, therefore we need to attribute it to the progress of technology"[1].

Thus, the theorist of growth need not choose between models which focus on the accumulation of capital and those which focus on the technology. Even in a world in which the technological progress is the engine of growth in the long run, the accumulation of capital will play an independent role at this level.

As the source of technological progress is research and development (R&D), supported mainly by the endogenous theory of growth, so we will, in what follows, dwell on this last point, while trying to demonstrate to what extent a developed country, which invests more in R&D, may benefit from spillovers of the R&D it leads, beginning at the outset by defining the R&D. Then, it is important to focus on the relationship between the R&D and the

[1] OECD (1992).

level of development of the country. After that, the relationship between the R&D and innovation will be examined. Finally, a fourth part will be devoted to sectors of R&D.

I. Definition of R&D:

In the contemporary world, both nations and enterprises devote more and more resources to research and development. So, what is exactly meant by this term?

The term "research and development" can be divided into two[2]:

- **Research:** With its two possible extensions:
  - Pure or basic research: is an experimental or theoretical work mainly carried out to acquire new knowledge in principles governing the remarkable phenomena, without considering the specific applications or current and potential uses; and
  - Applied research: is an original research conducted with a view to extend knowledge, but mainly articulated on the realisation of a precise practical objective.

- **Development:** is a "systematic work undertaken on the basis of knowledge acquired from research and the practical experience, but geared to the material production, goods and services, the implantation of new processes or on systems and processes already in use"[3].

[2] UNESCO Statiscal Yearbook (1980), p.742. The definitions of R&D are common in the OECD, in RICYT (Red Iberoamericana de Indicadores de Ciencia Y Tecnologia) and in the World Bank, all of them are based on the definition of Frascatti Manual.
[3] Frascatti Manual, OECD 1993, pp. 19-45.

If they differ in their nature, both the pure or basic research and the applied one contribute to advance the techniques. Their first result is to produce a set of intangible goods[4], either of the knowledge of the expertise and new concepts for goods and equipment that is usually realized in the form of new and enhanced products or improved techniques to deal with process.

Thus, research and development is a creative work, continued methodically to increase cultural backgrounds, including improvement of human knowledge, culture and society, as well as the use of new knowledge to find new applications.

I.1. The R&D is an investment:

Economists have long been interested in the response to the investment in the firm-level to changes in the macro-economic environment. In the recent past, the studies linking the investment to such variables such as the early production or the desired production or the market value of the firm, have been put into practice by several researchers[5]. Almost all of these studies have focused on only one type of investment, usually the overall expenditure in equipment and material.

Although the stock of physical capital of the firm can be the most important generator of cash-flows nets, and therefore of the profits or incomes, other forms of capital are also able to generate these incomes and can be more likely to generate very high incomes: It is the capital

[4] According of Romer (1990), and Grossman and Helpman (1991a, ch.3), taking into consideration the process of R&D, certain theorists of the recent growth have treated the R&D as any activity of production, converting the principal inputs automatically (Personnel specialized in R&D,…) in output, which is in this case technology.
[5] See Chirinko (1986) for a study of the models of investment.

of R&D. Consequently, Hall and Hayashi (1989) assumed a firm with two types of capital: physical capital and the capital of R&D which are used to produce profits.

There is a possibility for interaction between these two types of investment; investment in the physical capital and investment in R&D[6], since the possibilities of substitution exist for the firm engaged in the maximization of incomes generated by the two types of capital.

By comparing these two types of investment, Hall and Hayashi (1989) suggested that like investment in physical capital, R&D also meets future prospects of the firm such as profitability, technological opportunities or changes in the prices of factor.
However, a significant difference arises is that, in principle, only the stock of physical capital is observable independently of the history of investment. In addition, the shares of physical capital and of the capital of R&D devoted to the production differ permanently. In general, the R&D has a number of characteristics which distinguish it from an ordinary investment. First, in practice, 50% or more of the expenditure in R&D are salaries for highly educated scientists and engineers, that is to say for the personnel specialized in R&D.
The second important characteristic of the investment in R&D is the degree of uncertainty associated with its production. This uncertainty tends to be greater at the beginning of the program or of the research project.

I.2. The R&D is a program or project:

G.M. Grossman and C. Shapiro (1986) studied an optimal model of expenditure in

[6] Lach and Schankerman (1988) studied some of the interactions between the two types of investment.

R&D for only one firm pursuing a program of R&D over time. The two authors complemented the work of Roberts and Weitzman (1981) who had examined the discreet decision of the firm to continue or abandon the research project as the progress is made and the information about future steps of this program of research is acquired. In this context, the firm would vary its expenditures in R&D directly with the current value (expected) of the project. More precisely, it is about a simple and positive relation between the optimal level of the expenditure in R&D at any point in time and the value (expected) at this time of the research project. In many circumstances, this value will increase as the firm achieves progress.

Consequently, Grossman and Shapiro (1986) found that, as supplementary progress is achieved and the research project approaches completion, it is optimal for a firm to increase its research effort (or its spending on research) on time.

If, however, the firm learns that the research project is more difficult to realize than it was previously grown, then it may be optimal to reduce the weight of its program of R&D or even abandon it entirely.

On the other hand, Grossman and Shapiro (1986) also studied the effects of the uncertainty on the expenses of the optimal research. They found that a risky research project is always preferred to a project that is completely without risk. This implies that more resources will be devoted to the risky effort. However, more risk is not necessarily beneficial to the firm. The reason is that certain information is obtained as well earlier as later under the less risky mode, and in certain circumstances, that can make it possible for the firm to readjust its program of R&D to preserve the expenditure substantially. That’s why Grossman and Shapiro (1986) assumed that the firm is neutral to the risk.

Ultimately, it is possible to describe the properties of an optimal dynamic project of R&D. First, if it is optimal to begin research, then the research project will be carried towards completion in all contingencies, insofar as the prospects for success are at least as important at every moment as they were not to it the moment before beginning this project.
Then, as more stages of research are completed, it is optimal to increase the research effort through expenditure in R&D increasing over time.

The previous analysis has been restricted to a single company, whether it is a monopoly or a perfect competitor. In other words, Grossman and Shapiro (1986) neglected, in this analysis, the aspects of the competition, which were the centre of interest of a large part of the literature of recent R&D. It was later that this point has been studied. Thus, the two authors explored the dynamics of competition in R&D, which occur when two firms engage in a "race" to patent. In particular, they focused on how a firm engaged in the "race" to patent will change its behaviour over the time if it takes the head or is left behind by its rival in this "race", recognizing that each firm is fully informed of the state of the progress of its rival.
In this respect, Grossman and Shapiro (1986) concluded that a firm in head (or the leader) intensifies its research effort, i.e. increases its expenditure in R&D, when it advances towards the final stage of the research project, while the next reduces the scope of its activity of research, that is to say reduces its expenditure in R&D.

In other words, the leader devotes always more resources to the R&D than the following. However, if the latter happens to catch up the leader, then the competition becomes more and more intense, and the two competitors will end up by increasing their efforts of research.

On the other hand, Grossman and Shapiro (1986) highlighted the different forms of cooperation: the desire to license agreements after one of the firms has accomplished some progress, a public policy that grants patents to an intermediate stage in the process of innovation or of the research partnership allowing firms to coordinate their research activities at the initial stage of a program of R&D. This latter form of cooperation is in general more likely to increase the common expected profits, when the competition which occurs would be quite intense.

Of another side, Lederman and Maloney (2003) are interested in the evolution of R&D, or more precisely of the expenditure in R&D, along the development process of a country.

II. R&D and the level of development of the country:

There are three remarkable conclusions which are central to understanding the links between R&D and the level of development of a country.

First, Lederman and Maloney (2003) modelled the evolution of expenditure in R&D based on the level of development of a country, using a panel data set constructed by Lederman and Saenz (2003)**.** The evidence showed that the effort of R&D, measured as a part of GDP, increased at a growing rate with the level of development of a country measured by GDP per capita.

Then, both authors suggested that the countries in the process of development (or the developing countries) need to improve their efforts of R&D**.** In fact, the incomes in R&D in the developing countries are above those of the industrialized countries: just like the incomes in physical capital, the incomes in R&D are decreasing with development. However, some authors[7] have questioned the suggestions made by Lederman and Maloney (2003), arguing that the countries in the process of development have low expenditure in R&D. Therefore, they can be ignored.

After all, if incomes in R&D are thus high in the poor countries (or in the process of development), then why they invest less in R&D than rich (or industrialized) countries?

To answer this question, Lederman and Maloney (2003) have explored potential determinants of R&D across countries and over time, knowing that there are very few studies at this level. Two of these studies[8] already suffer from small samples and, as a result, inconsistent estimates owed to the inability to treat the specific effects of the country and the endogeneity of explanatory variables.

II.1. Determinants of R&D:

Lederman and Maloney (2003) concluded that the level of development of a country is positively correlated with the effort to R&D, mainly because the rich countries tend to have:

- Credit markets more in-depth;
- A better protection of the rights of the intellectual property;
- A higher government's ability to mobilize the resources (that is to say the public expenditure in R&D) ; and
- In all likelihood, a better quality of research institutions (universities, public research centres ...).

[7] Coe, Helpman & Hoffmaister (1997), and Keller (2001).
[8] Varsakelis (2001) and Bebczuk (2002).

Thus, according to David et al. (2000), the deepening of the credit market is measured by the ratio of credit of private sector relative to GDP. The expected positive sign associated with the private sector credit indicates that the markets of capital facilitate the investments in R&D**.**

The rights of the intellectual property affect the expected quasi-rents from the innovation. Indeed, although the impact of intellectual property rights is theoretically ambiguous[9], Arora, Ceccagnoli and Cohen (2003), using data from a study of U.S. manufacturing, found that the protection of intellectual property rights by the patent stimulate R&D across almost all industries.

The government's ability to mobilize the resources is measured by the total expenditure of the government relative to the GDP. A greater ability to mobilize the resources makes account one half of the impact of the variable "GDP per head of population" on the effort of R&D in a large sample, and a quarter of this impact in a small sample.

Note that in a large sample, besides the expenditure of the government, the private sector credit and the intellectual property maintain their positive and significant effects on expenditure in R&D.

Finally, the mediocrity of the quality of the research institutions makes it possible to explain why the projects of R&D, with very highly expected incomes, become unexploited in the developing countries.

[9] Hörstmann & al. (1985).

Therefore, it is clear that the ratio "Expenditure in R&D/GDP" increases with the level of development of a country. As examples, the United States and Japan, the most two developed countries in the world, invest very high shares of GDP in the R&D.

On the other hand, a question immediately comes to mind, is whether the low expenditure on R&D in developing countries is to some degree the result of the specialization of these countries in intensive products in natural resources.

II.2. Abundance in natural resources of the developing countries:

There are some doubts about a link between natural resources and R&D. Despite these doubts, we can say that R&D and natural resources are complementary. Indeed, incomes in R&D increase with net exports of natural resources and vice versa. In other words, the incomes on R&D are high in countries abundant in natural resources.

However, many authors have argued that prospects for growth of total factor productivity are inherently lower in natural resource sectors than in industry.

However, many authors[10] have argued that the prospects for the growth for the total factor productivity are intrinsically weaker in the sectors of the natural resources than in industry. The lower potential for the growth of the productivity would imply weaker incomes in R&D, and then a weaker investment in R&D. Moreover, the weak investment in R&D in natural resources in the abundant countries occurs because the revenues associated with the exploitation of the natural resource allow these economies to function properly without a great effort of innovation[11].

[10] Matusyama (1991), and Sachs & Warner (2001).
[11] Landes (1998).

Thus, although the Netherlands, Finland and Sweden have chosen a path of strong innovation, the Latin America, Indonesia and Thailand are more representative of the economies rich in natural resources than the first countries, insofar as they followed a path of low innovation.

In sum, a significant negative relationship emerges between the abundance of natural resources and the expenditure on R&D.

It follows from the above that countries differ largely in the expenditure on R&D, or that spending on R&D is distributed unequally across the countries, and these differences are particularly striking when one compares developed countries with developing countries, mainly for reasons mentioned above knowing the determinants of R&D and the abundance in natural resources of developing countries. This is what is entirely justified by Coe, Helpman and Hoffmaister (1997), whereby 96% of world R&D is represented in a handful of industrialized countries against only 4% in many developing countries (among them 15 only making a significant R&D). Consequently, within the same developed country, it is necessary to be interested as well in the relation between R&D and the innovation as with the sectors of R&D.

III. R&D and innovation:

According to the endogenous growth model [P. Romer (1986, 1989, 1990), Lucas (1988),…], and more precisely according to the approach of human capital, investment in R&D consists in the investment in the human capital (Education and training), in the use of specialized staff (Staff R&D) and the equipment and materials**.** It is at the origin of new knowledge or new technologies.

Subsequently, referring to J. Schumpeter (1943), the application of this technology to the process of production[12] leads to a change called the technological change or more precisely the technical progress, this application allows to improve the performance, thus to produce the desired output, that is to say to produce new or improved products or innovate, with less resources**.** Hence, there will be an increase in the total factor productivity. Thus, technological change is endogenous rather than exogenous[13]. Indeed, as indicated by the name of their new theory, the theory of endogenous growth, P. Romer and others recognize that technological change is endogenous, in short constitutes a by-product of economic activity and figures among the basic sources of growth**.** The fact of being endogenous means that the process of innovation is rooted in each country or area. The companies play a big role in the genesis of new technologies and their behaviour varies, on the one hand with the national socio-economic climate, and on the other hand with the intensification of competition in the world.

III.1. The importance of the role of patents:

Contrary to the neoclassical growth hypothesis according to which technology is a public good, the endogenous growth model takes into account the fact that technology is far from being a public good. Thus, the modern definition of a public good identifies two distinct qualities of this property: non-rivalry and non-exclusivity[14]. These qualities are usually applied to property of consumption, but they are also important for inputs in production, particularly for an input such as technology.

[12] The application of information does not mean necessarily the use of new information. Indeed, a good part of the growth derives from the diffusion from existing information, not of the genesis of new knowledge.
[13] According to the neo-classic model of growth [Solow (1956),…].
[14] Cornes and Sandler (1986).

The technology is non-rivalled in the sense that its use by a person or firm does not prevent its use by another. In other words, the technology is freely and universally accessible. It is a free good, which everyone can access without charge. In addition, technology is non-exclusive. It should be noted that exclusiveness needs either technological means to prevent access to the good (i.e. encryption) or of a legal system which dissuades indeed the others from the use of the input (i.e. patents for example). In our case, the producer of technology can not prevent others from being able to take advantage of the property without consent. Patents and other forms of protection of intellectual property rights (trademarks, copyrights) would be abolished. Therefore, many users can use the technology simultaneously. In other words, improvements in technology can be used simultaneously by all firms. The neoclassical model assumes then the same rate of technological change in all countries. Thus, as the Solow model shows, there should be a convergence of growth rates: growth in industrialized countries is expected to slow down and that of developing countries should accelerate.

As the public goods are not-rivalled and not-exclusive, the endogenous model of growth suggests whereas the technology, which is not a public property, is not rivalled but exclusive or at least partially exclusive. At this level, the scientific discoveries and information are goods with the exclusive use, of which many users cannot make use of it simultaneously. In other words, improvements in technology can not be exploited simultaneously by all firms. As a result, only the endogenous growth model takes into account the role of such patents. Indeed, the patent system as a form of protection of the rights of intellectual property may be a solution to the non-exclusivity. In this context, according to Jean-Marc Bascans (2000): "The patent is a system of legal protection. It imposes an exclusive right of publication. It is a national public title of industrial property by which the inventor of a product or a manufacturing process receives an exclusive right to manufacture, to use and to sell the patented product or, when it is about a process, to adopt this process, to control the production and the use of the products obtained by this process". In other words, the largely recognized role of the patent is precisely to protect the innovator, and thus to encourage to innovate, because it makes it possible to the innovator to make profitable his investment by granting him an exclusive right of exploitation of his innovation. However, the important role of the patent is certainly to provide a monopoly on the use of technology, and consequently on the design of the new property, but only for a certain period of time. Indeed, in the industrialized countries, the duration of protection of the rights of the intellectual property conferred by a patent varies from 17 to 20 years. In other words, the inventor keeps the control of his invention only for a certain number of years. Consequently, improvements in technology must confer benefits that are at least partially exclusive, since the owner of the technology can not prevent others from using that only to some extent.

In this framework, to support their earlier view, supporters of the endogenous growth model showed that the United States, exasperated to see that they lost their technological lead, have tried to prevent their competitors, particularly Japan and the newly industrialized countries (NICs) from rapid growth and free access to American technology. At this level, the U.S. government has obtained in the Uruguay Round of GATT trade negotiations, the adoption of rules protecting intellectual property. It is about an important reversal in the economic policy, reversal which one owes with the fact that one starts to seize the importance of technology as a fundamental source of the prosperity of a country.

Consequently, a second major step was made towards an analysis closer to reality, in abandoning the unrealistic hypothesis that the knowledge and technology are free and universally available. In this context, important innovations match of an exclusive use, even if it is only temporary. The patents and the trademarks constitute the most current means to prevent others from using the new process or product, and ensure that the inventor benefits from the fruits of his invention. In this case, the owner of knowledge or exclusive technology equally enjoys a competitive advantage that can benefit him thanks to higher prices and monopolistic profits, which will be more important than the marginal costs of production of new goods, and therefore provide a way to compensate for the costs of production of technology, that is to say the costs of R&D.

III.2. The importance of the role of human capital:

The most recent models of endogenous growth also stressed the human capital as an important input in the invention, mainly if it is a complement of the use of new technologies and production. In this context, it is vital for a country to develop a qualified workforce and competent manpower, capable of assimilate the technology, to develop and improve for productive purposes. At this level, literacy is the only measure of human capital. More precisely, according to Romer (1989b), the human capital combines three types of knowledge:

- The physical skills such as force (labor force);
- Knowledge acquired in elementary and secondary: The primary role of education in elementary and secondary school is to produce basic knowledge such as the ability to read or solve an equation; and

- Scientific knowledge acquired in post-secondary education. This knowledge is mainly in mathematics and science. According to Romer (1990), the concentration on these two fields corresponds to the importance of the activities of R&D as a source of growth.

For these different types of knowledge to be clearly printed in human capital, the country must have powerful educational systems, evidenced by a school quantity (measured by the average number of years of study and length of the school year) and quality (measured by student-teacher ratio, class size, teacher characteristics, the resources available or dedicated to the educational institutions and the organizational structure of these institutions).

The basic conclusion remains that education, or more precisely the fact of having powerful educational systems, is in favour of a significant level of literacy, which is, in turn, regarded as a measure of a significant improvement in human capital. Thus, it is possible to define the overall production of consumer goods in an economy as a function not only of work, physical capital and experience, but also of education. In this case, the production increases more than proportionately with increases in these inputs.

IV. Sectors of R&D:

Within the framework of an endogenous growth model based on innovation, there are two sectors of research and development: horizontal innovation and vertical innovation. Koléda (2004) justified this dichotomy of research and development by its ease of modelling and the opportunity it offers to describe the developments within the sector of research. So, it is first of all advisable to define the term "innovation".

IV.1. Definition of innovation:

Morck and Yeung (2001) proposed three definitions of innovation. First of all, they are based on the definition proposed by "OED"[15], according to which there was the progressive evolution of a negative connotation to a positive connotation of the term "innovation". Indeed, innovation firstly had a strong negative connotation between the 16th century and the 19th century, that of rebellious, disturbing and useless operation going against the established good practices. Later, the economist Joseph Schumpeter (1939) had the first use of the term "innovation" in its positive and modern sense, that of a creative and useful change.

Then, as the innovation is associated with scientific, economic and social progress, it was defined by Freeman and coll (1982) as being "the introduction of a new product, process or system in the marketing activities or usual social of a country".

Finally, contrary to neoclassical economic theory that all economic activity is devoted to the manufacture of existing products using existing technology, current economic theory suggests that innovation is manufacturing a new product using a new technology, or manufacturing a new product using existing technology or manufacturing an existing product using a new technology.

On the other hand, in recent models of growth, there are several representations of innovation and technological progress. At this level, it is the representation of technical progress distinguishing between two areas of research as two directions can be followed, horizontal or vertical, which has been privileged for the opportunity of answer that it can provide to the paradox of scale effect, highlighted by Jones (1995).

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[15] Oxford English Dictionary.

IV.2. Horizontal and vertical innovations :

The horizontal innovations are innovations of enlargement, in the sense that new industries were created to produce new goods. They correspond to the creations of a certain number of goods at every moment. Therefore, they are related to the model of variety, and are consequently in relation with the quantitative growth of households utility and thus of the economy.

By cons, vertical innovations are innovations of deepening in the sense that they allow existing property to incorporate quality advanced economy**.** They are therefore relating to the model of scale of quality, and, as a result, are in relation with the qualitative growth of the usefulness of households and thus of the economy. Consequently, research intended to innovate vertically is targeted, in the sense that a firm chooses the good of which she wants to develop a higher version.

In addition, for a firm, vertical innovation is a lot more in terms of profits like horizontal innovation. Indeed, the higher the consumption good produced is of quality, the more the profits made by a firm are important, because of the preference of households for the quality. However, because of the effects of market share, the profits are reduced as the number of current varieties is important.

However, the consumption goods may become obsolete regardless of their level of quality. As suggested by Koléda (2004), the process of obsolescence is not directed towards the goods of inferior quality, it is all the more important than the rate of growth in the level of the quality of point is high. This is explained by the phenomenon of technological obsolescence.

IV.3. Technological obsolescence and creative destruction:

The technological obsolescence means that the more technology at the basis of an industry of consumption goods was invented a long time ago, the less it is integrated in the current technological paradigm, even if it has been repeatedly improved by vertical innovations. Consequently, a part of technological knowledge at the basis of this industry is tacit, and thus can disappear. Therefore, the technological obsolescence is a phenomenon which restricts the duration of life of a given version of consumption goods. As a result, whole pieces of industries of consumption goods will be destroyed. From where, the duration of life of an industry of consumption goods or its sustainability is limited, due to the existence of a process of technological obsolescence which leads to the destruction of a certain number of industries at each period. These are the consequences of the evolution of technological paradigm.

Consequently, it appears that the process of creative destruction defined, according to J. Schumpeter (1943, 1950), like: "… process of change which constantly revolutionizes the economic structures of the interior by destroying its out-of-date elements unceasingly and by creating new elements continuously. This process of creative destruction constitutes the fundamental data of capitalism". As creative destruction lies in improving the quality of goods and is, therefore, related to the vertical innovation, an approximation can be made between the creative destruction, as Schumpeterian technological regime of type I, and qualitative growth of households utility. Similarly, another comparison is possible between the creative accumulation, as Schumpeterian technological regime of type II, and the quantitative growth of households utility. Generally, and within the framework of this endogenous growth, reconciliation between technological regimes, which are distinguished by the evolutionary approach, and qualitative and quantitative components of the growth can be carried out.

In sum, it is clear that technological obsolescence allows to determine the nature of the technological regime, that of creative destruction, and thus the type of growth of the economy, that the qualitative growth.

CONCLUSION

Despite the apparent importance of the activity of R&D, few attempts were made to give this variable a real role in a growth model. However, the endogenous growth model has taken account of the role of the R&D, stipulating that a developed country can improve its TFP, and therefore the overall effectiveness of its economy, enjoying the benefits of the R&D it leads. At this level, many economists have believed that the expenditure on R&D is an important determinant of long run growth. The funds which one continues to inject into R&D[16] and the flow of innovations which results in from it is reflected by a constant improvement in the quality of the products. As a result, goods with high costs of R&D play an important role in the promotion of the growth.

Within the framework of this direct contribution of R&D in the growth of productivity

[16] P. Romer recognizes that these funds are about 2% to 3% of the Gross Domestic Product (GDP) in the industrialized countries.

lies the creative intelligence, which is cyclical and characterized by successive and repetitive activities according to the following sequence: current R&D → technical progress → innovation (especially vertical) → technological obsolescence → creative destruction[17] → future R&D → ….

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