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Abstract

The great scientific development and the great technology, which turned the globe as a whole into a small village, were not the product of a moment or a coincidence, and this great development did not come out of a empty, but was thanks to a considerable and difficult effort, and the enormous contributions of many scientists, inventors and researchers from various regions They have spent their lives studying, researching, contemplating, serving science and various sciences, with sincerity and dedication to advancing themselves and for all of humanity. Without these scientific revolutions and the great effort they have made, we would not have achieved this great scientific and technological progress which our current era is witnessing at all levels. In this article, using a database that includes 104 countries during the period 1996 -2018, we seek an answer to the following question: Do researchers stimulate economic growth?

Keywords: Researchers, Economic Growth, Global Evidence

JEL Classification: I21, I23, I25, I28, O47, O50.

1. Introduction

Scientists have been called "savants" for a long time. Today we are talking about "researchers". These two terms make it clear that these people move between what we know and what we might know within a day, or between knowledge boundaries that we will not know for a long time. In their activities, people sometimes feel very satisfied, for example, when a part of reality becomes understandable; in this way, the world seems more harmonious to us. These moments are the result of building instruments, making measurements, arguing the results against the knowledge already acquired, new measurements and the contributions of colleagues from four corners of the world.

Mastering this knowledge and sharing it with colleagues, students and the public will bring joy and satisfaction. Take the privileged astronomers in this field as an example. The image of the sky is beautiful, the public is very interested, and the sense of harmony in the universe is obvious. The life of a scientist is not a long romantic journey. To understand a reality that is more often hidden and defended, this is a sometimes long and monotonous, sometimes cruel and harmful, and sometimes an excellent struggle. It will not show up in the eyes of admirers.

The knowledge gained from this allows us to enter the wonders of the world, whether it is the beauty of the sky, the history of our planet, the structure of matter, the mechanism of life, the complexity of our bodies, and the process of human activities. For centuries, it has remained the mystery of our brain. This knowledge is also knowledge that enables us to control the environment and adapt it to a certain extent to our life and comfort needs. It allows us to live long, healthy, heated houses, various foods, and provides us with a comfortable environment, from a comfortable planetary movement to using a keyboard with these words written on it. .

The knowledge accumulated over the years has helped shape the world we live in. This gives scientists the responsibility and opportunity to help meet the challenges of our time. Human control on the planet requires us to take decisive action to feed about 800 to 10 billion people, to ensure the dignity of each of them, or to maintain an atmosphere such as evolution. The climate will not endanger the entire population. Solving current human problems requires a lot of knowledge.

Let us give an example: to understand the evolution of climate, it is necessary to know how the atmosphere absorbs and reabsorbs the energy of the sun, how the sun interacts with the ocean and the surface of the earth, and how heat is transmitted through the sun. Wind and ocean currents, how clouds form and how they affect the absorption and reflection of light, how living organisms, volcanoes and human activities change the chemical composition of the air. Although we know that there is an urgent need to reduce the amount of various gases emitted by our activities, we still need to understand the mechanisms of human society and how each of us responds to new needs.

All this requires physical, chemical, geological, geographic, social, historical, economic and psychological knowledge. It is one of the responsibilities of scientists to bring this knowledge to where it is needed for our societies to make the right decisions and carry out the resulting actions. This work is most often that of academies. They are the ones who are most able to synthesize knowledge and make it independently accessible to the circles on which society's decisions depend.

Many of our challenges are global. Our action here, industrialization for example, has effects elsewhere, rising sea levels among others. Knowledge is also universal: There is no science here or elsewhere. Yet most of our decision-making processes take place at the national level. We make decisions guided by local interests mediated by national powers. However, planet Earth is a spaceship whose governance must be informed about the best available science and be partially declined globally.

Considering the above motivations, the purpose of this research is to address these gaps and give empirical evidence on the role of researchers in making the country more sustainable. Therefore, it has made a basic contribution to the existing knowledge base. Specifically, we will study whether researchers can create economic growth. As far as we know, in the context of the determinant of economic growth and the area of research policy, there is no existing study that studies the relationship between researchers and economic growth. Second, our findings on the link between researchers and the economic growth also contribute to the existing literature. More precisely, they have strongly supported the research on determinants of economic growth literature, innovation policy; conditions of researchers and game theory by confirming that the economic growth challenges of in the world correspond to the prisoners' plight.

In this research, we start with an analysis of the concept of economic growth and scientific research and discuss the connection between researchers and economic growth. Then, we described the research methods and data used in this study. Then introduce the empirical results, and then discuss their contribution to the existing literature, their impact on the management and policy of researchers activities in economic growth, their limitations and future research directions. Finally, the main conclusions of the research are given.

2. Economic growth and scientific research - complex concepts

2.1.Economic growth

Economic growth refers to the increase in the production of goods and services in the economy over a period of time. Indeed, the indicator most commonly used to standardize economic growth is gross domestic product (GDP). Similarly, economic growth refers to the result of a country's increase in production and, in turn, normalizes the improvement of living standards, which are measured by per capita GDP.[1] In addition to the technological advancement accompanying scientific progress[2], economic growth is also legally linked to the reduction of material suffering and social inequality. In terms of growth rate, it is calculated by the rate of change of GDP from one period to another (see: Ménard (2004)). Finally, in order to compare the economic growth of several countries, we usually use parity. Approval of purchasing power to show purchasing power in reference currency [see: Krugman and Obstfeld (2009)].

2.2.Scientific research

According to the Canadian Social Sciences and Humanities Research Council (2010), research is usually defined as an effort to develop systematic inquiry or new knowledge through structured work. Similarly, the Ministry of Economic Development, Innovation and Export (2010) defined research as: "The process of combining human and material resources to increase knowledge (including human knowledge). Culture and society, and use this knowledge to create new applications program". There are two main types of research: basic research and applied research.

2.2.1. Fondamental research

The main purpose of basic research is to create new knowledge through structured research or systematic research, regardless of application prospects [see: Pavitt (1991)]. It usually involves the development of the problem, the realization of the research process and the delivery of the results. Usually, this type of research is conducted in universities, research

[1] The increase in production depends mainly on two factors: capital and labor.
[2] The notion of technical progress is the basis of many economic models, in particular that of Solow, for which economic growth results in the long term from technical progress.

centers, hospitals, and research institutes. Similarly, basic research can also eliminate certain uncertainties, correct social dysfunctions, and even improve social systems. In this sense, basic research has undoubtedly contributed to economic growth, but it has also contributed to broader development.

The main beneficiary of basic research is population. Scientific publications, such as scientific articles, collective works, working papers, monographs and conference proceedings, constitute the main contribution of basic research, which makes it possible to enrich the world heritage of scientific knowledge. The reason why this work is funded by public funds rather than private funds is because people believe that certain scientific disciplines will produce results of general interest and therefore have economic benefits. Therefore, it is necessary to invest in basic research to ensure such progress in the future. However, research is often not motivated by profit prospects. In this regard, the private sector is usually best suited for R&D work [see: Roehrig (2011)].

2.2.2. Applied research

The goals of applied research are practical goals, usually carried out by companies to support their innovative projects. Although this can also lead to the advancement of knowledge, the main motivation of people pursuing this goal is to increase sales, market share and profits due to productivity needs, rather than hope to improve the world around them.

With the prospect of tangible profits, the company will invest in research and development to meet the needs expressed by its customers, sometimes as a strategy to ensure its position in the market. To be sure, today's research has become the lifeblood of many companies (at least in developed countries) in order to survive in an increasingly competitive global market. All in all, research seems to be an important element of a country’s development because it has the potential to develop its knowledge base, strengthen its position in certain markets, improve efficiency and competitiveness, and solve problems and social dysfunction.

2.3.Invention

The term "invention" means any embodiment, any process that is innovative and useful, that is, the manufacture and manufacture of machines or the composition of materials, and any improvements to them. Inventions need to discover applications and should not be confused with innovations. Like discovery, an invention contributes to the growth of human knowledge, but if discovery reveals something unknown, an invention must involve proposing an action to be performed, which must lead to a new product or new process [See: Barrigar (2009)].

2.4. The discovery

The discovery improves the state of human knowledge by revealing something that has never been observed or found previously [see: Barrigar (2009)].

2.5. Innovation

In contrast to inventions aimed at creating new things, innovation is the constant search for improvements to existing things. In the economic field, innovation leads to the design of new products, services, manufacturing or organizational processes that can be implemented directly in production equipment and meet consumer needs. Therefore, the difference between it and invention or discovery is that it can be immediately implemented by the company to gain a competitive advantage. Due to the various standards used by different authors for designers, it is very difficult to define this concept. Indeed, one of the main difficulties we face when analyzing innovation is the lack of consensus on the meaning of the term.

However, many authors believe that innovation has a commercial purpose and is synonymous with modernity. For example, after analyzing the literature, Garcia and Calantone (2002) proposed the following definition from the research of technological innovation, which can understand the general concept of the concept of “innovation”: innovation is an iterative process begins with the design of new markets or innovative service opportunities that leads to development, production and marketing activities and aims to achieve the commercial success of the present invention.

The proposed definition mainly focuses on technological innovation. However, innovation may also be related to organization or marketing. Therefore, this definition is restricted. However, it reveals two important aspects of the innovative concept. First, implicitly, innovation must be realized or even commercialized. This distinguishes innovative concepts from inventive concepts that may not have practical applications. Invention is the production of new ideas (Bamberger, 1991; Osborn, 1988), and innovation includes the invention and commercialization of inventions (Osborn, 1988; Garcia and Calantone, 2002; Trott, 2005). Therefore, in order to make an invention an innovation, the invention must be implemented.

The second important aspect of the innovative concept involves the dynamic range of phenomena. In fact, innovation is caused by a structured interactive learning process, which leads to the first change, which often requires further changes to lead to other changes (Carrier and Julien, 2005).

According to Romon and Walsh (2006), the innovation is neither technical, organizational no commercial but multidimensional. They define it as "a deliberate process that leads to a proposal for a new product in the market or within the company." Innovation is also defined as "all scientific, technical, organizational, financial and business methods that lead to or should lead to the production of new or technologically improved products or processes." Based on these final definitions, we conclude that the concept of innovation is considered a process that can produce results. We propose this vision because it will enable us to define a series of dynamic, evolving and complex innovation processes.

2.6. Technology transfer

According to the United Nations (1999), “technology transfer” refers to the transfer of knowledge necessary for product manufacturing, process application or service provision, and does not include transactions involving simple sales or leasing of goods commodity.

In short, technology transfer is a series of activities whose purpose is to help companies or institutions acquire the skills and abilities needed to effectively use new technologies. Therefore, transferring technology is equivalent to enabling buyers to reproduce certain production processes, while at the same time interpreting and formalizing them. The latter involves mandatory transfer of knowledge and know-how. Technology transfer is a term used to describe the process of exchanging technology between organizations. The transferred technology can take many forms. Regarding the international transfer of technology, it refers to the way in which such transfers are carried out between countries. However, the concepts of technology interfere with each other, often causing confusion and even divergent interpretations (Barré and Papon, 1993).

2.7.Intellactual property

According to the World Intellectual Property Organization (WIPO), "intellectual property" (IP) refers to all exclusive rights granted to intellectual property. These rights can be divided into two categories: literary and artistic property rights, including copyright, copyright and related rights; industrial property rights, including patents, trademarks, designs, industrial models, and appellations of origin.

2.8.Researcher

Researcher refers to a person engaged in scientific research. Because the research fields are so diverse and there are significant differences in the practice of this work, it is difficult to clearly define the profession of the researcher. The Frascati Handbook published by the OECD in 2002 defines it as: "Experts engaged in designing or creating new knowledge, products, processes, methods and systems, and related project management."

However, despite the existence of multiple identities, the status of researchers around the world is usually still associated with university positions. Nowadays, researchers are more or less the owners of permanent jobs and are more or less inserted. In a research team or laboratory, research laboratories are more or less connected to the business world (in the R&D department), more or less evaluated by their peers, etc.

In modern scientific organizations, the status of researchers is firstly due to the recognition of other researchers in the field of scientific production, usually in the form of scientific publications (articles or books) or conferences through which researchers publish theories or observations, the result is the result of their own work.

The development of the research industry is based on the requirements of innovation, imagination and reflection, know-how, knowledge and technical capabilities. The latter situation only develops with personal experience and opposition to the questions raised by research. The "European Researchers Charter" stipulates the basic principles for the profession.

In order to prevent his work from being interfered with by specific interests, it is necessary to ensure the independence of researchers from political or economic pressure. Therefore, some researchers have introduced a guarantee of work stability.

The technical nature of the results and the nature of basic research make it difficult to assess their relevance and scope in the short term. This poses a problem for policymakers, who want to be able to monitor the appropriateness of research spending. In order to provide indicators of the work efficiency of researchers, different research evaluation techniques have been established, which may have adverse effects in some cases.

3. Literature survey

As we mentioned before, we did not find any work that empirically and theoretically addressed the link between researchers and economic growth. for this reason we will explore a little the relation between R&D and economic growth and the relation between innovations and economic growth which aim to inspire our empirical methodology and our economic interpretations concerning the nexus between researchers and economic growth.

3.1.R&D and economic growth

Research and development (R&D) is an important contribution to economic growth. R&D spending has a positive impact on innovation and total factor productivity (TFP), which drives growth (Romer 1990). In the long run, technological progress brought about by industrial innovation has been the driving force behind the inevitable improvement of living standards in developed countries (Grossman and Helpman 1994).

When a company invests in research and development, it can develop new ideas, intermediate products, cost-reducing methods and final consumer products, thereby making the company more efficient and profitable. In addition to the private benefits of R&D, there are also positive spillover effects within and between companies, industries, and geographic regions. The knowledge gained through R&D is not the same, so even if companies are located in different departments or regions, they may benefit from the R&D investment of other companies (Arrow 1962; Aghion and Howitt 1992).

Lichtenberg (1993) investigated the relationship between private and public sector R&D expenditures and economic growth during 1964-1989 by analyzing 74 countries. The conclusion drawn in the study is that although the private sector's R&D expenditure has a positive impact on growth, the public sector's R&D expenditure will not have any positive impact on economic growth, and sometimes even have a negative impact on this economic growth. Goel and Ram (1994) found a significant relationship between R&D expenditure and long-term economic growth in a study of 52 countries from 1960 to 1980. However, the direction of the causal relationship between variables cannot be determined. Park (1995) concluded that using data from 10 OECD countries from 1970 to 1987, R&D investment in the local private sector is an important determinant of local and foreign factor productivity increases. Slywester (2001) found that there is no relationship between R&D expenditure and growth in the countries concerned. When considering the G7 countries, the results indicate a positive correlation between R&D spending (especially industrial spending) and the growth of data from 20 OECD countries. Ülkü (2004) used various panel data programs in 30 countries (20 OECD and 10 non-OECD) to analyze the relationship between R&D, innovation and economic growth, and concluded: In the OECD and non-OECD countries, there is a positive correlation between innovation created by the R&D sector and GDP per capita; however, innovation will not lead to sustained economic growth. Yanyun and Mingqian (2004) used a partial least squares (PLS) regression model, using data from some Asian countries, and found that R&D spending has a positive impact on economic growth. Similarly, Falk (2007) analyzed the long-term relationship between R&D investment and economic growth from 1970 to 2004, and insisted that as the share of R&D investment in GDP increases, per capita GDP will also increase. Wang (2007) pointed out that, based on data from 30 countries, countries that actually use R&D expenditure will have better economic growth performance. Goel et al (2008) investigated the relationship between federal and non-federal R&D expenditures and economic growth during the period 1953-2000 in a study of American data, and concluded that economic growth and federal R&D expenditures are related The relationship between them is much stronger than others. Kue and Yang (2008) studied the impact of intellectual capital and technology diffusion on China's regional economic growth, and pointed out that R&D capital and technology imports have made a significant contribution to economic growth. Samimi and Alerasoul (2009) used the panel data method in a study of 30 developing countries during 2000-2006, and the results showed that because these countries have low R&D expenditures, there is no causality between economic growth and R&D expenditure.

On the other hand, Sandrouil and Zina (2009) used dynamic panel data to study 23 countries from 1992 to 2004 and found that there is a positive and significant relationship between R&D and economic growth. Saraç (2009) revealed that R&D spending had a positive impact on the economic growth of 10 OECD countries during 1983-2004. Korkmaz (2010) used the Johansen co-integration method to assess the relationship between R&D expenditure and Turkish economic growth from 1990 to 2008. They found that there is a long-term relationship between R&D and economic growth. Bravo-Ortega and Marin (2011) studied data from 1965 to 2005 in 65 countries. According to research conducted using the panel data program, in the long run, a 10% increase in per capita R&D expenditure will increase total factor productivity by about 1.6%. Eid (2012) used data from 17 high-income OECD countries between 1981 and 2006 to increase R&D expenditures in higher education by increasing productivity, thereby affecting growth. Gülmez and Yardımcıoğlu (2012) used panel causality and co-integration methods to analyze the relationship between R&D expenditure and economic growth in 21 OECD countries from 1990 to 2010. According to the results of the study, it can be found that there is a two-way causal relationship between R&D expenditure and long-term economic growth. An increase of R&D expenditure by 1% will increase economic growth at a rate of 0.77%. Wang et al. (2013) found that R&D expenditures in high-tech industries will use data from 23 OECD countries from 1991 to 2006 to affect the level of per capita GDP. These expenditures have a positive impact on per capita GDP. Amaghouss and Ibourk (2013) tested the relationship between entrepreneurship, innovation and economic growth through the OECD national panel data method (2001-2009). They use entrepreneurial activity and innovation to measure entrepreneurial ability and find that entrepreneurial activity and innovation have a significant and positive impact on economic growth. Inekwe (2014) divided 66 countries/regions into different income categories during 2000-2009. Inekwe said that the impact of R&D expenditure on economic growth is different in the short-term and long-term, as well as in high-income countries. Compared with low-income countries, its impact is much greater and significant. David (2000) studied economic data on the relationship between public and private R&D expenditures at different aggregation levels. They found that in many industries or national studies of the US economy, complementarity is more common than substitution. They recommend continuing work in this area based on the data of the international expert group, because many differences will affect the expected private R&D yield. Bassanini et al. (2001) estimated the impact of other determinants of public and private R&D on economic growth on OECD countries during 1980-1990, and found important coefficients of R&D activities. For the coefficient of public R&D, the author describes the negative impact of public R&D on growth. Their results indicate that public sector research expenditures crowd out resources that could otherwise be used by the private sector. Coccia (2012) found that when the R&D expenditure of the corporate sector exceeds that of the public sector, labor productivity in developed countries tends to increase. In addition, they show a strong positive link between public and private R&D spending.

3.2.Innovation and economic growth

There is a large amount of literature in development economists that proves that innovation is the seed of productivity growth and therefore transforms high levels of innovation participation into sustainable real GDP growth (Gill et al. Kharas, 2007; Pece et al. 2015;

Pradhan et al. 2018). The key role of innovation as a growth engine and the importance of achieving the best level of innovation and R&D to promote economic growth originated from Schumpeter (1939), Romer (1986 and 1990), Grossman and Helpman (1991), and got experience support by Aghion et al. (2005).

Lee and Kim (2009) used the latest data to re-examine this debate, and empirically found that factors such as technology, higher education, and systems are important determinants of economic growth. Interestingly, technology and higher education play a decisive role in the economic growth of high-middle-income countries and high-income countries, but have no effect on the economic growth of low-middle-income countries and low-income countries. Similarly, an economy characterized by high-quality secondary and tertiary education and a share of high-tech products in exports shows that economic growth is resistant to the effects of any downturn (Eichengree et al., 2013). This finding emphasizes the importance of improving technology and points out that a growth strategy that promotes innovation should be a priority. To further strengthen the role of innovation in economic growth, we should also consider the protection of new ideas by the innovation management system and the market. In this regard, Jalles (2010) found that countries with higher levels of intellectual property rights (IPR) (which reflect market protection of new ideas) generally have higher levels of per capita income. Wu et al. (2017) found that the National Innovation System (SNI) greatly encouraged social entrepreneurship and improved economic growth in rural China.

On the other hand, Hasan and Tucci (2010) emphasized the importance of quantity (measured by total R&D expenditure) and innovation quality (the ratio of patents granted in the United States to the total number of patents granted) on economic growth. The study analyzed a sample of 58 countries from 1980 to 2003, and the results showed that the quantity and quality of invention activities were related to economic growth. The results also show that the economic growth of countries with high-level patents has shown a coordinated increase. Bakari (2019) considered the importance of the Internet in 76 developing and developed countries from 1995 to 2016, and therefore sought the link between innovation and economic growth. Bakari (2019) used the ARDL group as an empirical technique, which found a causal relationship between two innovations and long-term economic growth. The empirical results also show that the Internet has a positive effect on long-term economic growth and innovation. Mabrouki (2018) studied the impact of innovation and human capital on Tunisia's economic growth from 1970 to 2015. He used the VAR model and Granger causality test and found that innovation and human capital are the root causes of economic growth. Yang (2006) studied the link between innovation and economic growth in Taiwan from 1951 to 2001. As an empirical model, he used the VECM model, and he found that innovation has a positive impact on long-term and short-term economic growth. Galindo and Mendez (2014) analyzed the relationship between entrepreneurship, innovation and economic growth in 13 developed countries (Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Italy, Netherlands, Norway, Sweden, United Kingdom, and Spain). They used panel data and fixed effects methods from 2002 to 2007. Empirical analysis shows that innovation and entrepreneurship have a positive impact on economic growth. Sohag et al. (2015) studied the link between technological innovation and economic growth in Malaysia from 1985 to 2012. They used the ARDL boundary test method to find that technological innovation can promote economic growth in the long and short term. Maradana et al. (2019) used the Panel VAR model to study the link between innovation and economic growth in EEA countries from 1989 to 2014. They found that there is a positive two-way causal relationship between innovation and economic growth in the short and long term. Qamruzzaman and Jianuo (2017) studied the impact of financial innovation on the financial system on Bangladesh's economic growth from 1980 to 2016. As a method, they applied the ARDL limit test method and error correction model to capture the financial impact. Economic innovation. increase. The empirical results show that financial innovation has a positive and static significant economic growth in the short and long term. Pece et al. (2015) studied the link between innovation and economic growth in Poland, the Czech Republic, and Hungary from 2000 to 2013. Based on multiple regression, empirical results show that there is a positive correlation between innovation and economic growth. Regarding the causal relationship between innovation and economic growth, Galindo and Méndez (2014) analyzed the feedback effect of entrepreneurship, the dynamic relationship between innovation and economic growth. They used entrepreneurial activities in 13 developed countries as a sample, and the time period was from 2002 to 2007. The empirical results based on panel data of fixed effects show that several factors including monetary policy and social climate have a positive impact on innovation and entrepreneurship. In addition, two-way feedback effects are observed between economic activities and entrepreneurial and innovative activities. This means that there is a two-way feedback effect between innovation and economic activity. For high-income OECD countries, Guloglu and Tekin (2012) studied the causal relationship between R&D expenditure, innovation and economic growth. Use GMM and panel autoregressive vector (VAR) model under the frame of panel fixed effects. The research supports the theory of endogenous growth, in which there is evidence of Granger causality, from R&D expenditure to innovation, and from technological innovation to economic growth. Interestingly, there is no evidence that there is a reverse causality from economic growth to innovation. In other words, the growth rate of Granger products leads to technological change. The multiple causality tests further confirms that both market size and Granger innovation rate can induce R&D activities. The increase in domestic production and R&D intensity is the cause of technological change. These empirical results show that technology-driven and demand-driven innovation models are equally feasible. Regarding the role of domestic and foreign innovation in accelerating economic growth, Yang (2006) found that both domestic patents and global thought discovery significantly promoted economic growth. The results in Taiwan confirm that domestic innovation and foreign innovation activities are equally important for promoting economic growth.

On the other hand, Schneider (2005) found that foreign technology has a greater impact on per capita gross domestic product (GDP) growth than domestic technology. Empirical analysis was carried out using panel data sets from 47 developed and developing countries. He believes that the role of innovation at home and abroad is unique to each country. In this country, time series analysis is more suitable for solving this problem than panel data analysis. Nevertheless, Cameron (1998) pointed out that active technology spillovers often benefit multinational companies more and limit local companies. The study shows that although technological advances among countries are focused on global productivity, the attachment process is considered slow and uncertain, requiring a lot of national innovation efforts.

4. Model specification

The mathematical equation estimated in this study, based on the Cobb-Douglas production function, is as follows:

$$\mathbf{Y_{it} = \beta_0 + \beta_1 K_{it} + \beta_2 L_{it} + \beta_3 FC_{it} + \beta_4 RD_{it} + \varepsilon_{it}} \qquad \{\mathbf{Eq(1)}\}$$

Where ‘Y’ is the logarithm of gross domestic product (2010 constant US $), ‘K’ is the logarithm of gross fixed capital formation (2010 constant US $), ‘L’ is the logarithm of the total labor force (in millions of inhabitants), ‘FC’ is the logarithm of Final consumption expenditure (constant 2010 US $), 'RD' is the logarithm of Researchers in R&D (per million people), ‘γ’ is a country-specific effect not observed, ‘ε’ is the term error, ‘i’ is the individual dimension of the panel (the country) and ‘t’ is the temporal dimension.

The main goal of this study is to investigate the effect of researchers in R&D on economic growth for 104 countries over the period 1996 - 2018. All data are obtained from the World Bank database.

5. Empirical analysis

Before presenting empirical results, some data pre-tests are usually carried out, which are very important to provide preconditions or information about the relevance of target variables. According to Table 1, the rejection probability of all variables is less than 5%, which indicates that they have all been taken into account during the study. Other statistics of skewness and kurtosis reflect whether the target variable follows a normal distribution. Asymmetry measures the strength of outliers separately. All given variables are positively biased. In terms of kurtosis, it measures the peak or flatness of the target variable compared to the normal distribution. The kurtosis coefficient values of all variables reflect the peak value. The overall asymmetry coefficient and kurtosis coefficient prove that the variables follow a normal distribution.

Table 1. Statistic descriptive

	Y	**K**	**L**	**CF**	**RD**
Mean	25.80046	24.25730	15.63301	25.52550	6.948201
Median	26.03112	24.45448	15.46075	25.66242	7.373544
Maximum	30.48453	28.92777	20.00505	30.30219	8.995399
Minimum	21.03525	18.80243	11.94262	21.05753	1.776955
Std. Dev.	1.880848	1.910331	1.518579	1.845758	1.542054
Skewness	0.006196	-0.032988	-0.028095	0.100307	-1.053544
Kurtosis	2.442207	2.455285	2.740071	2.493291	3.404832
Jarque-Bera	17.73035	17.14829	40.02811	16.91662	262.2197
Probability	0.000141	0.000189	0.013344	0.000212	0.000000
Sum	35269.24	33159.73	21370.33	34893.36	9498.191
Sum Sq. Dev.	4832.348	4985.032	3150.108	4653.722	3248.254
Observations	1367	1367	1367	1367	1367

Table 2 lists the Pearson correlation results between all series variables in the panel. The correlation coefficient shows that the extracted regression model will not be severely biased due to multi-collinearity. Table 2 shows that economic growth is correlates positively with researchers, gross fixed capital formation, labor force and final consumption expenditure.

Table 2. Correlation analysis

	Y	K	L	CF	RD
Y	1				
K	0.9930	1			
L	0.7708	0.7577	1		
CF	0.9958	0.9871	0.7875	1	
RD	0.5138	0.5245	-0.0106	0.4984	1

In Table 3, we commence by interpreting the findings of statics models (Pooled OLS Model and GMM Model) for the fixed effect estimator and random effect. Table 3 lists the regression results. We estimated the growth equation (Eq. (1)) by various estimation methods : (a) Pooled Ordinary Least for individual fixed effects, Pooled Ordinary Least for individual random effects, (c) Generalized Method of Moments (GMM) in individual fixed effect, and (d) Generalized Method of Moments for individual random effect. The results of all models indicate that the estimated coefficients of researchers range positively from 0.018316 to 0.025239 and are significant at 1% level as expected. This means that when researchers increase by 1% point, the economic growth increase by between 0,018316 % to 0,025239 % point. Also the estimated coefficients of fixed capital formation, labor force and final consumption expenditure are positive and significant at 1% level in models (a), (b), (c) and (d).

To sum up, the effect of researchers on economic growth is positive and significant across all the regressions. Furthermore the regression coefficients of fixed capital formation, labor force and final consumption expenditure are mostly consistent with the standard results in the literature. This means that the result is quite robust against different estimation methods.

Table 3. Researchers and economic growth

Dependent Variable: Y								
	Pooled OLS: Fixed Effect		***Pooled OLS: Random Effect***		***GMM: Fixed Effect***		***GMM: Random Effect***	
Variable	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.	Coefficient	Prob.
C	0.795925	0.0031	0.878719	0.0000	0.878719	0.0000	0.878719	0.0000
K	0.128941	0.0000	0.139535	0.0000	0.139535	0.0000	0.139535	0.0000
L	0.157315	0.0000	0.036518	0.0000	0.036518	0.0000	0.036518	0.0000
CF	0.755723	0.0000	0.814028	0.0000	0.814028	0.0000	0.814028	0.0000
RD	0.018316	0.0002	0.025239	0.0000	0.025239	0.0000	0.025239	0.0000
Diagnostics Tests	R-squared	0.999456	R-squared	0.972702	R-squared	0.972702	R-squared	0.972702
	Adjusted R-squared	0.999410	Adjusted R-squared	0.972622	Adjusted R-squared	0.972622	Adjusted R-squared	0.972622
	S.E. of regression	0.045680	S.E. of regression	0.051347	S.E. of regression	0.051347	S.E. of regression	0.051347
	Sum squared resid	2.627078	F-statistic	12133.02	Durbin-Watson stat	0.203220	Durbin-Watson stat	0.203220
	Log likelihood	2335.263	Prob(F-statistic)	0.000000	Instrument rank	6 Variables	Instrument rank	6 Variables
	F-statistic	21631.72	Mean dependent var	3.013350	Mean dependent var	3.013350	Mean dependent var	3.013350
	Prob(F-statistic)	0.000000	S.D. dependent var	0.935984	S.D. dependent var	0.935984	S.D. dependent var	0.935984
	Mean dependent var	25.80046	Sum squared resid	3.590880	Sum squared resid	3.590880	Sum squared resid	3.590880
	S.D. dependent var	1.880848	Durbin-Watson stat	0.203220	J-statistic	1362.000	J-statistic	1362.000
	Akaike info criterion	-3.258614			Prob(J-statistic)	0.000000	Prob(J-statistic)	0.000000
	Schwarz criterion	-2.846178						
	Hannan-Quinn criter.	-3.104253						
	Durbin-Watson stat	0.249340						

Conclusion

Overall, our research results confirm that researchers are linked to economic growth for 104 countries over the period 1996 - 2018. Our results contribute to the literature on the economics of innovation by proposing an empirical method that not only demonstrates the contribution of researchers to economic growth, but also confirms the hypothesis of the importance of research and innovations in the entire economic system. This method not only contributes to the existing literature, but also has an impact on policy and management, and provides future research directions.

Despite the debate surrounding economic growth, it has become an increasingly influential concept in academia and management. In this case, researchers' activities are considered an important channel for sustainable products and processes. In fact, researchers' activities are a panacea for solving many economic, social and environmental problems. Industrial policies, taxation, investment, agriculture, natural resources, and competitive advantages enhance economic growth. Therefore, from the perspective of researchers' activities, especially in leading practitioner magazines, there are very few studies to solve the problem of economic growth.

Starting from these considerations, our humble contribution in this research is to demonstrate the impact of researchers on economic growth and to study the ability of researchers' activities to make countries more growth. As far as we know, there is no existing study that studies the impact of researchers on economic growth. In addition, our findings on the impact of researchers on economic growth also contribute to the existing literature.

This study supports the idea of the role of researchers in improving economic growth. Our empirical findings show that researchers positively contribute to economic growth. Accordingly, some important implications for managers and policy makers regarding the sustainability process are given below.

- Make the research profession attractive and attract young talents
- Establish a researcher status for people who carry out a research activity in research establishments, without being teacher-researchers
- Provide more remunerative open-ended and fixed-term contracts that would offer more open professional prospects, greater mobility in the course, as well as an opportunity for those who work more to earn more;

- Establish at the level of the bodies responsible for designing, implementing and ensuring the monitoring and evaluation of research, an entity that will be dedicated to them. Such representation must exist and be operational in the Ministries of the countries and in the national research system for each country.
- Make the necessary resources available to make research structures sustainable;
- Systematize evaluations and index their career to scientific production, with the aim of developing current structures that meet international standards;
- Encourage the pooling of resources (Pooling and synergy) and the development of multidisciplinary collaborations;
- Intensify, diversify, facilitate scientific exchanges and strengthen existing scientific networks;
- Strengthen the logistics and human resources necessary for the proper functioning of research structures (technicians and qualified IT specialists);
- Create technological platforms bringing together heavy measurement and analysis equipment and provide them with the conditions for proper operation;
- Develop specific research capacities in all research fields and especially in the research field of human and social sciences.
- Ensure the establishment of libraries and central theses, written and electronic documentary sources, accessible to all researchers, with access to databases of ministerial departments (statistics, interior, etc.),
- Organize and promote scientific publication by grouping publications by major families of disciplines at the university level in order to remedy the current dispersion of efforts.
- Develop a methodically forward-looking recruitment policy to prevent the aging of the population of national research and innovation systems;
- Provide for an increase in the share of GDP devoted to research and innovation.
- Set up mechanisms allowing the mobility of research actors (teacher-researchers, researchers, engineers, doctors, executives, etc.) between universities, institutes and the socio-economic world;
- Establish greater interaction between national research and the socioeconomic world.
- Develop a culture of communication and information by putting an end to practices that limit the dissemination of information.
- Develop a culture of recognition of the research function and the work accomplished by the researcher, manager, technician, administrative agent, etc. ;

- Lighten and make the procedures for financial management of research budgets more flexible;
- Increase the financial resources allocated to research and ensure a more balanced distribution between disciplinary fields, particularly for the human and social sciences.
- Ensure that the nature of the process of financing national research and innovation systems necessarily goes beyond the public / private dichotomy and mobilizes other sources for this financing such as Para-fiscal taxes, research tax credits and co-financing, however prerequisites: (i) a clear choice of priority research axes to be promoted, (ii) structuring of the offer in relation to the objectives pursued, and (iii) structuring of the evaluation system in relation to efficiency aimed;
- Support programs with greater involvement of economic and social actors in the analysis of demand, the management of systems and control and evaluation actions;
- Modernize the current financial instruments to combine flexibility and efficiency so that they can pass through a gradual and continuous development of co-financing of research, based on the strategic role of the State as a force for investment, incentive and support, and direct or shared contribution from companies, as well as a call for voluntary contributions from individuals and groups (University foundations, sponsorship).
- Find the forms of organization and the methods of enlarging the current area of cooperation so as to maximize and strengthen national potential and involve as many national actors as possible.
- Give importance to the means and methods allowing to conquer new areas of cooperation through the development of joint research, exchanges of teacher-researchers and students, joint supervision of theses, the joint organization of scientific events and cultural;
- The promotion of training through and in research by setting up joint research programs, exchange of publications and scientific and educational documentation, training courses, etc. ;
- Improving the performance of research and innovation systems through the development of research development structures equipped with services helping to set up research projects and their management.
- The development of applied research programs likely to allow the development of a hard core around a national technology able to catalyze the economic activities of the country and increase their share of added value;

- The development of an entrepreneurial culture in academic circles to allow certain elements of this population to play an active role in the creation of innovative businesses based on the exploitation of research results.
- Build research systems with the necessary capacities to generate valuable research results;
- Transform these into inventions or any other intellectual works through R&D processes;
- Promote these inventions and intellectual works, previously protected by intellectual property rights, into innovations through mechanisms for incubating innovative projects and businesses;
- Disseminate these innovations in the socio-economic fabric via technology transfer operations.

In addition to the insights and enlightenment provided by this research report, it also proposes some important limitations Therefore, future research can extend this research by adopting mediation or moderation models in order to study the conditions under which researchers can achieve economic growth' goals. They can also examine entrepreneurship, domestic investment, foreign direct investment, the Internet, business alliances and partnerships, research and development expenditures, favorable research conditions for scientific researchers, institutional quality, good governance, country size, corruption, and the role of natural resources, poverty, unemployment, teaching quality, important research areas, good supervision of civil organizations and networks to promote the link between researchers and sustainable development.

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