Global Scientific JOURNALS

GSJ: Volume 11, Issue 2, February 2023, Online: ISSN 2320-9186
www.globalscientificjournal.com

南京信息工程大学

Nanjing University of Information Science & Technology

《Management of technology innovation》 course work the second semester, 2021-2022 school year

Paper title： **Factor of R&D in Colombia**

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GSJ: Volume 11, Issue 2, February 2023
ISSN 2320-9186

Factor of R&D in Colombia

Huang Hak Tang Zhu

Abstract

Colombia has historically been a country with economic difficulties, having seen the concepts that led China to become the industrial and economic power that it is today, it is convenient to ask what are the ways and what factors are important when talking about a change in R&D for Colombia? It could be an increase in state spending on education, perhaps on infrastructure, or perhaps the truth is that it is not a single factor that determines the generation of R&D in a country, and on the contrary, the solution is more like a group of solutions, comprising a strategy, holistically focused on the development of trained professionals or skilled labor, as well as capital for investment in R&D projects, and a legal basis that allows the protection and generation of patents, finally the implementation of proposals that expand trade with other technological countries.

Keywords Latin America, Research, Development,

1. Introduction

The world is advancing by leaps and bounds, scientific and engineering achievements are increasingly visible in the great world powers, and the race to have scientific advances in the world is getting stronger, thirty years ago I saw how great powers monopolized the knowledge and progress. Today, thanks to a more globalized world, we have opened the possibility for developing countries to have access to this stream of advances, however, the acquisition of knowledge and new technologies is not easy and often unattainable for some countries. Colombia is part of the group of developing countries, and like many countries in the region they seek to gain access to knowledge, and the latest advances in technology, hoping perhaps one day to be able to produce their advances. It is therefore important for Colombia to review cases such as China, a country that 50 years ago maintained an economic profile very similar to Latin American countries, today they are the great axes of knowledge and technology.

The monopoly of technology has always been an interest of all societies throughout history, very early to 1421 date the first patent laws mostly sought to control commercial monopolies. It is not until the Industrial Revolution with the arrival of the modern economic model that it becomes relevant to patent knowledge, new technologies, machinery, and products. At the end of the 20th century, 95% of patents were produced jointly between North Atlantic and East Asian nations; It is common when reviewing the literature to find detailed information on the technological change of these nations, however, this is not the case for nations located in Latin America. The studies in Latin America reflect the prematureness of the study of the effects of technological transformation in the countries, quite the contrary, most studies are focused on the development of the effects of economic changes, leaving the development of technology as a residue of the economic management process. Certainly, it is not to be expected less, the history in Latin America is relatively young, and historically they are countries that have imported many of the technologies that are used today, it is also worth mentioning the lack of legal criteria on patents, trademarks, and copyrights, since many times they are the product of the adaptation of new companies when they arrive in these countries.

There is abundant literature that shows the benefits of investment in R&D, even in recent years after the pandemic, the benefits that investment in this area brings have been insisted on. Some of them are mitigating carbon emissions, the use of renewable energies, job creation, greater efficiency in production as well as improving the trade balance since it diversifies the portfolio of products and services that a country can offer. Likewise, the effects on migration to more sustainable economies are mentioned, a goal that is part of the international agenda as one of the objectives to be achieved by 2030 by the UN.

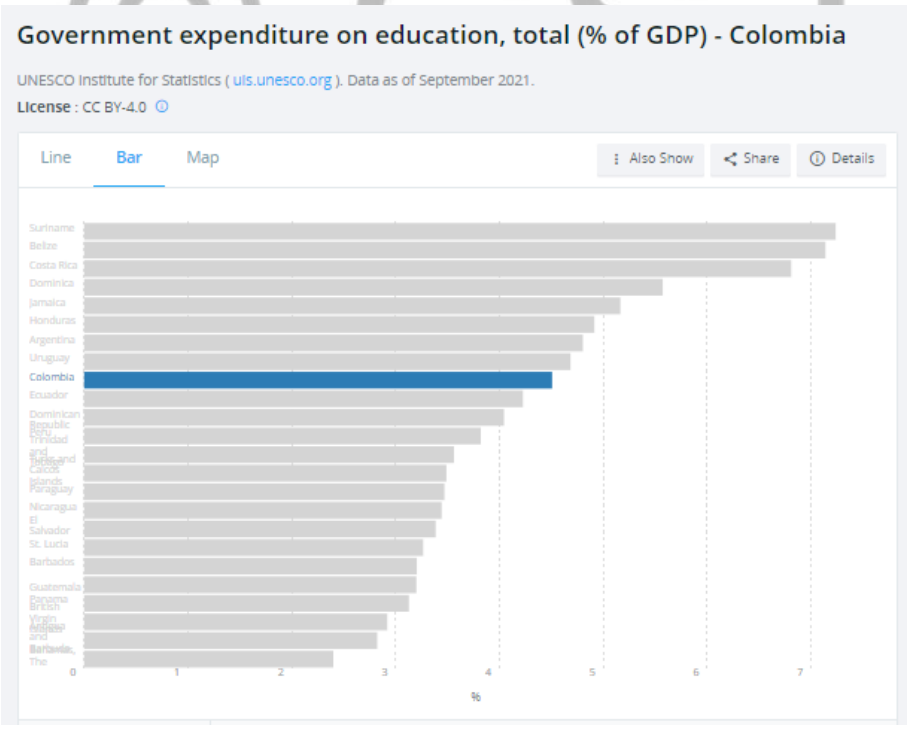
Finally, mention that in Latin America a change in the understanding of the use of research and development is necessary, many of the countries do not use research as a way of solving the problems that each nation has, this implies that many of the policymakers are focused on economic development, ignoring the advantages of a more comprehensive approach that leads to research and development as the engine of social transformation. Many of the investigations or developments carried out in Latin America have the generation of economic benefit as their first objective, leaving aside the importance of many technological advances for the benefit of society without receiving income. The foregoing generates a bias towards

research and development that are leveraged by strong economic sectors such as the pharmaceutical or chemical industries, leaving aside other sectors with fewer resources.

The present work aims to find the importation of certain macroeconomic indicators at the Colombian level that affect or have an impact on investment in R&D in the country, according to the above, a model will be developed where they interact, direct foreign investment, investment in education and military spending to find the relationship to an increase or decrease in R&D.

1.1 Socioeconomic limitations.

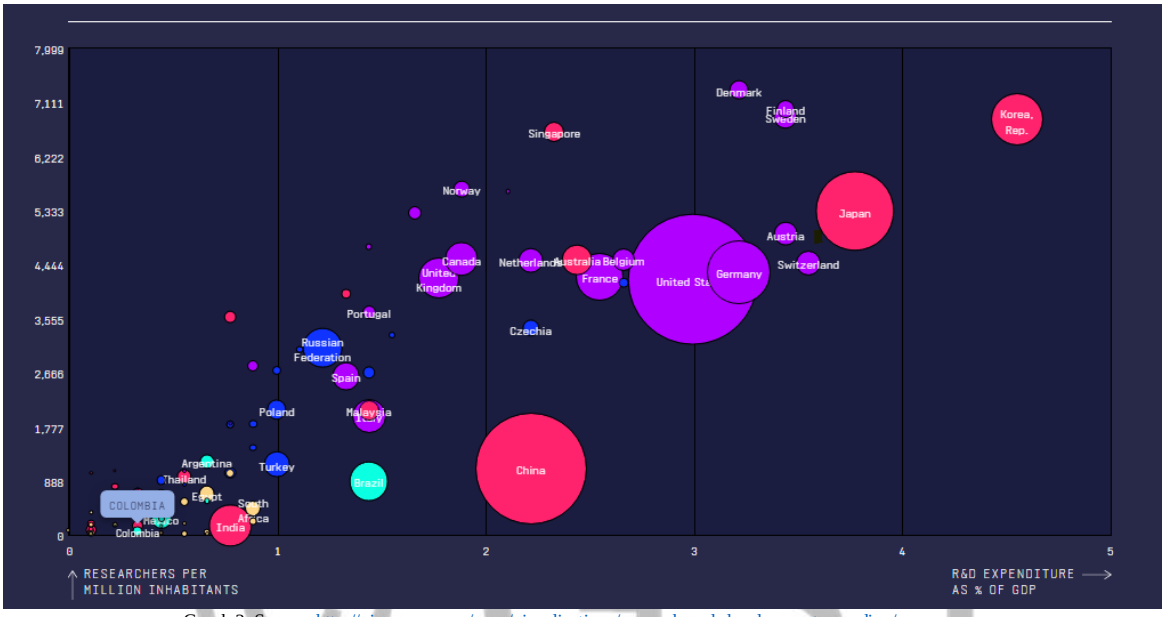
However, much of the discussion on the development of technologies in Latin America is centered on the role of the government and its influence in creating environments conducive to development. Even though the governments of Latin American countries are aware of the importance of investment in R&D, many studies highlight the little commitment, the lack of support for students, and researchers, and in general the lack of promotion of suitable environments. for R&D development. There is also a need to internationalize students, although Latin America has worked to extend education to more vulnerable sectors of the population until a few years ago it was not a priority for students to have access to a foreign language. The foregoing is a clear disadvantage not only within the educational field but also due to the poor accessibility that the country must build bridges with other markets and other societies in the world.



Graph 1. Source: https://data.worldbank.org/indicator/SE.XPD.TERT.ZS?end=2018&locations=CO&start=1979&view=chart

Latin America also lacks to be competitive in the development of new technologies, it is not precisely due to the lack of researchers, the problem of brain drain moving to other more

developed countries is very well known. Given the foregoing, mention several specific details for the Colombian case, first of all, it is worth highlighting the average state investment for the total education in the country is on average 4% of GDP as can be seen in graph 1, of which 77% is invested in first and second level students, only 23% is invested in third level students and without counting the direct investment for research projects or researchers. Second, according to graph 2 developed by UNESCO, the number of researchers per million inhabitants is only 58, added to the fact that only 0.3% of GDP is invested in R&D.



Graph 2. Source: http://uis.unesco.org/apps/visualisations/research-and-development-spending/

On the other hand, existing studies on socioeconomic factors that affect investment in R&D in developing countries, of which many countries in Latin America are part, suggest a direct correlation between foreign investment and increases in the R&D category. The foregoing is a clear example of the effects of having open policies and reducing the obstacles surrounding the free trade of new technologies, not only concerning its import but also its export. In this way, the role of the government would not just be associated with an investment in infrastructure or labor that encourages spending on R&D; It is also responsible for allowing foreign investment to flow directly into the country and positively impact those projects.

1.2 Conceptual limitations.

Another big problem regarding the development of R&D is directly related to two aspects, on the one hand, the legal field and, on the other, a conceptual field on the study of patents.

On the legal side, countries belatedly adapted their laws regarding the protection and development of patents. Colombia only developed its patent law until 1902. In the world, there were laws developed since 1870. In addition to the above, there is a difficulty in finding a rigorous way to historical patent files, this is large since information on patents in Latin America is not indexed or is fragmented, which makes its study and analysis impossible. Recent studies by Edward et al (2017) explain these difficulties very well.

On the conceptual side, many of the studies address the review of the number of patents produced by the country, leaving out the understanding that the patent is, as mentioned by Edward et al (2017), only a photograph of an instant that summarizes a whole moment of creation, work and many trials and errors [**1**]. The foregoing certainly demonstrates the lack of detail in many of the studies on the activities that make up innovation, leaving aside the improvement of production techniques, changes in machinery, ideas lost along the way before the publication of the patent, etc. Understanding these delimitations could show a new path for the conceptualization of R&D in countries beyond economic work and more centralized in research and creative action.

2. Literature Review

There is extensive literature on factors involved in R&D, however, most of these document's date from the development of developed or fully industrialized countries, when it comes to looking for information related to Latin America, the information is biased, incomplete, or related to the management economy of the countries. However, at the time of carrying out this work, different aspects were addressed to find the right information that could support the ideas evaluated here.

The first work Beatty Edward et al (2017), gives us a general vision of technology in Latin America, the emergence of the first patent laws, and its difficulty in finding information. He also mentions how marginal the researchers' interest in documenting the development of technologies in Latin America has been, mainly due to the low contribution of patents to the world. The disinterest of researchers in delving into the technological development of the region stands out since historically Latin America has been an importer of technology; and many changes have occurred hand in hand with changes in the economy, leaving aside the social and cultural aspects of many of the Latin American societies. Agriculture, mining, manufacturing, and transportation have been the main economic sectors that have caused the technological change, the author also highlights specific cases such as the sugar industry. In the same way, the author mentions in the document the importance of keeping a database on the activity around R&D, patent registration, research activity, registered trademarks, and industrial designs, as the beginning that allows new researchers to achieve a better understanding of the factors that are relevant in Latin America for R&D.

Ciocca et al (2017) explore the needs of researchers in Latin America, mentioning the various problems they face, socioeconomic disparities, the problem of brain drain, deficits in financing scientific programs, and especially the bureaucratic problems that are found in the region. He mentions that despite the great effort to delay that the route of investment in R&D can be a solution for many of the socioeconomic problems that the region carries, the governments have taken another route, ignoring the benefits that a longer-term vision brings about the importance in R&D. He ends by concluding the imperative need for governments to take as an example more developed countries where the central axis of social change is research and development.
Regarding the problems in education, Berry C. et al (2014) raises the great shortcomings of Latin American educational systems, specifically analyzing the Colombian case and the Mexican case. The author finds sufficient basis to affirm the commitment of governments to

build bridges with more industrialized countries, however, it is very common to see that they are promises that remain on paper; he mentions that, unlike regions such as Europe or Asia, the internalization of education in Latin America is not at the peak of needs. In the same way, he shows the dichotomy of many of the institutions between supporting strong socioeconomic changes and dealing with the strong external competitiveness due to increasingly strong globalization.

In Sameti (2010) we analyze in his study the factors that the OECD countries have in common concerning investment in R&D, approaching their influence on the development of new technologies from a perspective of free trade agreements, he finds that one of the main drivers for the technological development of nations is foreign direct investment, but there is even an important statistical base where less developed countries are impacted to a greater extent than countries already considered developing. It concludes in the need for more governments to allow and encourage free trade between nations, this contributes to the free passage of technology between countries with more development to others with less, in principle privately and then from public policies to promote it more widely.

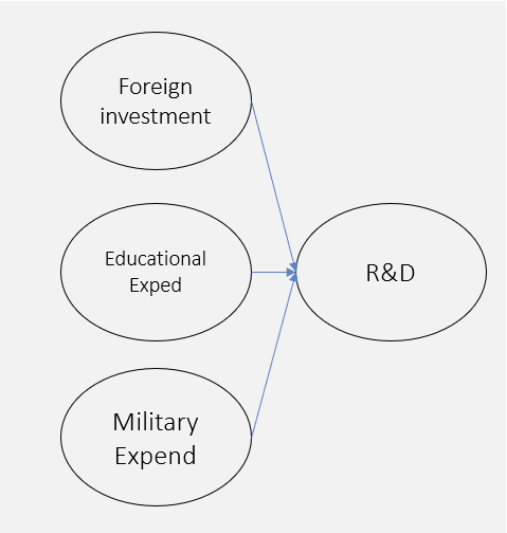
Finally, with Tudor et al (2022) he shows us the performance of development in R&D after the COVID-19 pandemic, it highlights in a very important way the effects of an investment in R&D mitigating the effects that the pandemic left on the economies of the countries. countries. In addition, it shows how even countries with higher spending on R&D are more energy-efficient, have fewer carbon emissions, and pollute the environment, compared to those with lower spending. He mentions the relationship of finding more sustainable economies hand in hand with greater spending on R & D, theorizing about the snowball effect that sustained investment in research in countries can have. He concludes his study by finding that periods with high intensity in R&D are followed by periods of even greater intensity, confirms the importance of having open policies regarding free trade between nations, and finds that countries with medium development are more benefited than countries with high development, and It ends with demonstrating that the greatest driver of development in nations is human capital. Finally, he advises nations not to stop investing in R&D even though the pandemic emergency has reduced the capital for investment in this area; It urges the positive effects and the commitment to invest the post-pandemic stimuli to be spent on R&D so that the effects of the pandemic are overcome more quickly.

3. Methodology and data source

To carry out the present work, a linear regression model is carried out by Ordinary Least Squares, taking as independent variables foreign direct investment, investment in education, and finally government spending on military equipment, which would affect the investment in R&D of the nation. , this last data was replaced by the number of historical patents for each year for Colombia.

Due to the amount of data and the magnitude of some variables, a Log-Log model is proposed so that the data can be comparable. Similarly, the data is taken from the https://data.worldbank.org/ database in a range by time panels from 2000 to 2019 where we had the last complete records.

Theoretical model



Graph 3. Source: Own

$$Log\ \#patents = LogIED_{Exp} + LogEducation_{Exp} + Logmilitary_{Exp}$$

Some observations about the variables taken:

The number of patents was taken because due to the time it was not possible to have the historical data for investment in R&D for Colombia, however, the number of patents is telling regarding the production of technology in the country, certainly, there could be better indicators that could show us not only a quantitative number of patents but also the investigative activity of the country and all the development carried out behind the patent output document.

Direct foreign investment, as well as military spending, were taken directly, and the Log was made for each data so that the variables could be compared. Military spending was taken as a reference since one of the largest portfolios that Colombia has is spending on its armed forces, it is important to mention that many of the technologies implemented for the army turn out to be applied later in different fields. Finally, investment in education was taken as a percentage of GDP, however, it needed to be transformed into an amount of money to then perform its log, like the other variables.

The hypotheses proposed in this work are:

H1. Is foreign direct investment in R&D significant?
H2. Is investment in R&D education significant?
H3. Is investment in military spending on R&D significant?

4. Analysis

Source	SS	df	MS	Number of obs =	20
				F(4, 15) =	68.15
Model	9.53691221	4	2.38422805	Prob > F =	0.0000
Residual	.524808738	15	.034987249	R-squared =	0.9478
				Adj R-squared =	0.9339
Total	10.0617209	19	.52956426	Root MSE =	.18705

lnpat	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
ano	.1328028	.0189635	7.00	0.000	.092383	.1732226
lnied	.2868791	.1459842	1.97	0.068	-.0242788	.598037
lnedu	.1396356	.6996927	0.20	0.844	-1.351724	1.630995
lnmil	-.7848943	.7543844	-1.04	0.315	-2.392827	.8230381
_cons	-253.6799	35.4749	-7.15	0.000	-329.2928	-178.0669

Tab 1. Source: Own

According to the results shown by the simple linear regression model, we can determine that:

The data explains the model in 93%, the coefficient of the year is positive, so we can infer a greater investment or an improvement in the development of patents from year to year, which may be due to better socioeconomic conditions. The most relevant result occurs in a direct foreign investment where we can see that it gives us the most significant value, investment in education was not significant, this is due in part to the fact that the total investment in education in the country was taken, entering values that have a lower incidence in the results of R&D, specifically, the most accurate value of education should be the investment in tertiary level education, the above would be more related to research or development work in new technologies. Finally, the impact of military spending is not significant by any means.

5. Conclusions

Although the model is fairly simple, however, for this work it was conclusive, on the one hand, the development of the hypothesis regarding military spending and its implications in R&D was not significant, it infers that this item is mostly intended for the maintenance of the armed forces, rather than the acquisition of new technologies for implementation in the field of war, another possibility could arise regarding the acquisition of new war technologies, usually, they are not disruptive and at the end of their useful life are not transferred to the population for use and reengineering. On the other hand, investment in education has a limitation in terms of the data taken, the total value of the investment in education in the country also includes first and second-level education; The foregoing does not optimally explain the possible results in the face of a change in R&D. A better sample may be the use of spending on education at the tertiary level, or directly using what is spent on development and research as a percentage of the country's GDP. Certainly, the result is not conclusive at a statistical level, however, if it demonstrates the need for a paradigm shift

in research on this matter, the foregoing means that the development of a country in R&D is not only determined by its investment in education, it is also important to develop concrete projects that promote the need to use more human capital. Researchers are not needed in Colombia, quite the contrary, projects and funds are needed to investigate. Finally, the most conclusive result of the presented work is perhaps the validation of what is found in the literature, the most significant result around a change in R&D is a foreign investment; The model is conclusive showing the positive increase that foreign investment in the country has had year after year, which has shown a positive impact on the change of patents in the country, which infers that their relationship is fully causal from one variable to other.

6. Limitations and future research

The limitations of the model are great, however, the development of this, however simple, turns out to be quite conclusive regarding the country's situation in R&D investment, first of all, mention seeking more data on the number of researchers per million inhabitants In Colombia, information is currently only found in a very short range of dates, 2013 to 2017, which leaves any model that is carried out without statistical foundation. On the other hand, as a basis for a future project detailing by economic sector which is the most influential in the generation of new technologies, finally, adding a component of investment in academic infrastructure by the government could shed light on state investment in infrastructure for R&D.

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8. ANNEX

```
. rename var1 ano

. rename var2 pat

. rename var3 ied1

. rename var4 edu1

. rename var5 mil1

. generate ied=real(ied1)

. generate edu=real(edu1)

. generate mil=real(mil1)

. generate lnied=lm(ied)
unknown function lm()
r(133);

. generate lnied=log(ied)

. generate lnedu=log(edu)

. generate lnmil=log(mil)

. regress pat ano lnied lnedu lnmil

      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(  4,    15) =   28.16
       Model |  445935.051     4  111483.763            Prob > F      =  0.0000
    Residual |  59389.4989    15  3959.29992            R-squared     =  0.8825
-------------+------------------------------           Adj R-squared =  0.8511
       Total |   505324.55    19  26596.0289            Root MSE      =  62.923

------------------------------------------------------------------------------
         pat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         ano |   39.65628   6.379307     6.22   0.000     26.05911    53.25345
       lnied |    44.7186   49.10888     0.91   0.377    -59.95451    149.3917
       lnedu |  -50.75152   235.3757    -0.22   0.832     -552.443    450.9399
       lnmil |  -214.8538   253.7739    -0.85   0.411    -755.7602    326.0525
       _cons |  -74454.27   11933.71    -6.24   0.000    -99890.37   -49018.17
------------------------------------------------------------------------------

. generate lnmil=log(mil)
lnmil already defined
r(110);

.
.  generate lnmil=log(mil)
lnmil already defined
r(110);
```

```
. generate lnpat=log(pat)

. regress lnpat ano lnied lnedu lnmil

      Source |       SS       df       MS              Number of obs =      20
-------------+------------------------------           F(  4,    15) =   68.15
       Model |  9.53691221     4  2.38422805            Prob > F      =  0.0000
    Residual |  .524808738    15  .034987249           R-squared     =  0.9478
-------------+------------------------------           Adj R-squared =  0.9339
       Total |  10.0617209    19   .52956426           Root MSE      =  .18705

------------------------------------------------------------------------------
       lnpat |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         ano |   .1328028   .0189635     7.00   0.000      .092383    .1732226
       lnied |   .2868791   .1459842     1.97   0.068    -.0242788     .598037
       lnedu |   .1396356   .6996927     0.20   0.844    -1.351724    1.630995
       lnmil |  -.7848943   .7543844    -1.04   0.315    -2.392827    .8230381
       _cons |  -253.6799    35.4749    -7.15   0.000    -329.2928   -178.0669
------------------------------------------------------------------------------
```