The Scarcity of Nobel Prizes in Latin America. A Culturalist Approach to the History of Brain Drain in the Region

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Abstract

This paper deals with two dimensions of brain drain studies: a classical one, that analyzes recent figures and debates, and an empirical one based on the life histories of five outstanding Latin American scientists. We refer to the testimonies of three Latin American scientists who won Nobel Prizes and of two Latin American mathematicians. Only two out of these five pursued their scientific careers in their native countries.

The end result is a reflection on the endogenous and cultural causes of brain drain such as corruption and an insufficient commitment to hard sciences in Latin America. Other factors such as the lack of adequate resources, local political upheaval and the region's economic dependency are also considered.

Introduction

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There is not very much literature in English addressing the migration of Latin American Nobel Laureates; nor is there much in Spanish or Portuguese. Between 1936 and 2019 only nineteen Nobel Prizes have been awarded to persons born in Latin America or the Caribbean. Of these, 13 were for literature or peace and 6 for science (chemistry, physiology or medicine). Five of these six science Nobel Prize winners were "drained brains"; that is, they emigrated from their native countries. The 6th one believed that the only way for governments to develop the science and technology (S&T) system was to send local scientists to study abroad, in spite of the risk of losing them.

Latin America is one of the regions most affected by the loss of its academics and highly educated personnel, surpassed only by Africa and Eastern Europe. A study by Deefort (2008) shows that brain drain from Central America increased consistently from 13.8% in 1975 to 16.7% in 2000, and from 3.6% to 4.2% for South America, while brain drain from North America[1] remained relatively stable, over this period, at less than 1%. At the same time, the percentage of highly-skilled among the resident immigrant population (what may also be studied as brain gain) almost doubled in North America from 26.6% in 1975 to 51.3% in 2000. For the countries of origin of the Nobel Laureates that we consider in this study (Argentina and Mexico), skilled emigration currently amounts to around 7% for the case of Mexicans in the United States (CONAPO 2019) and 38% in the case of Argentinians, and the tendency is on the rise. These are, however, not the largest cohorts of highly educated migrants in the US, when compared with the arrivals from India, China and other Asian countries. Furthermore this brain drain is

1 For statistical purposes, the region of North America is limited to the United States and Canada.

lower than for countries such as Haiti, where 73.7% of those who emigrated in 2000 could be classified as highly skilled (Beine, Docquier and Rapoport 2007), but it is a matter of concern since the availability of skilled human resources, especially scientists, is not high.

The lack of an appropriate science culture in Latin America may also be illustrated with OECD data on the number of researchers. For instance, while in (indicar año) the United States and other European countries had more than 9 researchers per thousand inhabitants, Argentina had 2.9 and Mexico less than 1. (OECD 2019, p. 17). Data from the same organization shows huge differences in triadic patents: Argentina had only 12 such patents in 2017, while the US had a thousand times more (12,454), which shows the combined effects of investment in R&D and immigration.

A study by Vaccarezza (1998) on the low spending on science and technology activities in Latin American countries found that it was reaching just under $8,000 million dollars annually, which represented 2.3% of world spending in the sector. For Latin American countries science and technology expenditures represent less than 0.5% of average GDP, while in developed countries such expenditures are between 2 and 3% in most cases, Vaccarezza notes.

Our hypothesis is that the small number of Nobel prizes in sciences obtained by Latin American scholars may be an indicator of various intertwined conditions, such as the low importance of some scientific disciplines in the historical development of the region, which has resulted in the migration of outstanding scientists (brain drain). This may be viewed as a culturalist approach, different from other claims about scientific development. For

instance, Van der Linden, Dutton, and Madison (2020) have studied the regional and country distribution of Nobel Prizes from a biochemical perspective, linking the presence of higher levels of androgens, or male hormones, in certain cultures to an increased interest in attaining high levels of scientific productivity and activity. However, our perspective does not affirm a disregard for scientific knowledge in the region and is compatible with postcolonial approaches that point out the great development of scientific disciplines, such as agroecology, in Latin America.

This paper is based on a multiple case study of outstanding scientists in Latin America and is structured as follows: a) background of Nobel Prize laureates in Latin America; b) theoretical claims; c) method; c) empirical overview; and d) conclusions.

Background: Scientific Prizes as Indicators of Brain Drain

In the same way that World War II brought hundreds of European scientists (many of them Jews) to the United States, the Spanish Civil War contributed to a revitalization of Latin American science. Between 1937 and 1942, about half a million people left Spain. Hundreds of Spanish scientists joined Latin American institutions. Most of them were physicians and engineers, but there were also pharmacists, chemists and researchers in basic sciences. Spanish refugees "had very strong technical skills, acquired in the best European schools of their time, that Spain had sent with great vision as one of the mechanisms (perhaps the most important) to promote social and cultural development" (Pérez Tamayo 2010, p. 244).

However, it is necessary to distinguish the scientific profile of those

Spanish exiles from that of the Jewish exiles to the United States. Many of the founders of quantum mechanics and relativity theory were German or Scandinavian Jews, to the extent that the Nazis came to characterize the new physics as "Jewish science." The two most important figures were none other than Albert Einstein and Niels Bohr. There was no equivalent development of physics and mathematics in Spain.

Consistent with the methodological approach adopted in this paper, it is useful to consider the small number of Nobel science prizes in Spain and Portugal, compared to those received by countries of similar size or even smaller (like The Netherlands, Poland, Denmark, Switzerland or Hungary). Spain has obtained only two Nobel prizes in medicine and physiology, and Portugal, just one. Neither of these European countries has obtained any Nobel Prize in physics, and they have no mathematician who has won the Fields Medal, the Abel prize or the Wolf prize.

While main receiving countries such as the US and the UK lead the list of Nobel prizes with 385 and 133 awards, respectively, the total number of Latin American prizes is 19. Argentina, the best ranked country in the region, with 5 awards (see table 1), stands in 27th place in the total list of awards. A complete list of the Latin American Nobel laureates and the fields in which they were recognized is provided in table 2.

Table 1. Data on Nobel Prizes awarded to Latin American countries

Ranking	Country	Total number of Nobel prizes	Number of Nobel prizes for science
27	Argentina	5	3
32	Mexico	3	1
38	Chile	2	0
39	Colombia	2	0
43	Guatemala	2	0
52	Brazil	1	1
55	Costa Rica	1	0
71	Peru	1	0
75	Trinidad and Tobago	1	0
77	Venezuela	1	1

Source: Based on Nobel Prize official website

Table 2. Nobel Prizes for Latin American Personalities

List of awards by country	Name	Field	Year
Argentina	César Milstein	Physiology or Medicine	1984
	Adolfo Pérez Esquivel	Peace	1980
	"Luis Federico Leloir"	Chemistry	1970
	"Bernardo Houssay"	Physiology or Medicine	1947
	"Carlos Saavedra Lamas"	Peace	1936
Brazil	"Peter Medawar"	Physiology or Medicine	1960
Chile	"Pablo Neruda"	Literature	1971
	"Gabriela Mistral"	Literature	1945
Colombia	Juan Manuel Santos Calderón	Peace	2016
	Gabriel García Márquez	Literature	1982
Costa Rica	"Óscar Arias Sánchez"	Peace	1987
Guatemala	Rigoberta Menchú	Peace	1992
	Miguel Ángel Asturias	Literature	1967

Mexico	"Mario José Molina Henríquez"	Chemistry	1995
	"Octavio Paz Lozano"	Literature	1990
	"Alfonso García Robles"	Peace	1982
Peru	"Mario Vargas Llosa"	Literature	2010
Trinidad and Tobago	"V. S. Naipaul"	Literature	2001
Venezuela	"Baruj Benacerraf"	Physiology or Medicine	1980

Source: Based on Nobel Prize official website

Latin America is one of the regions that have slightly improved their share of Nobel prizes, from .9% in the first half of the 20th century to 2% for the period 1946 – 2017. By comparison, Europe has experienced a decline in its share of Nobel prizes from 81% before the Second World War to 39% afterwards (see table 3). The great winner, as Kando notes, has been the US, thereby making North America the region that has won the highest number of Nobels since the end of the Second World War, increasing its share three times when compared with the previous period.

Table 3. Historical Comparison of Nobel Prizes by Selected Regions

Region	1901-1945		1946-2017	
	Number	Percentage	Number	Percentage
Europe	178	81%	268	39%
North America	30	13.5%	277	40%
Latin America	2	.9%	14	2%
South Asia, including India	2	.9%	7	1%
Africa	0%	0%	20	3%
Middle East	0%	0%	5	1%

Based on Kando (2018, p. 78)

Recent studies on Nobel Prizes awarded are in fact used as proof of a historical brain gain for the countries of destination where the winners actually lived. Such is the case of the work by Kando (2018), who analyzes Nobel laureates as a particular type of intellectual migration. Based on his study on Nobel prizes, Kando finds a massive "brain transfer" from Europe to America. "The open-door policy of the United States towards refugees and other immigrants served to make it stronger, whereas the "ethnic cleansing" policy of the Nazis made Germany weaker", says Kando (2018, p.69).

"America was the primary beneficiary of this gigantic brain drain … Both Germany and the Soviet Union could have beaten the U.S. in the space race had America not benefitted from the brain transfer. This enabled America to be the first to develop nuclear technology, to win World War II, and to win the space race", says Kando (2018, p.76).[2]

2 There is literature on the possible decline of US leadership in science and technology research (Gros, 2018), based on data showing that the US's *per capita* science productivity, in terms of Nobel prizes in the natural sciences, has been declining since the restrictive take on immigration, but this

Previous Literature/ Theoretical Claims

The notion of "brain drain" does not refer only to an economic reality that can be described in neutral terms. It is a concept associated with at least three political doctrines, according to Dumitru (2009):

a) Nationalism, which seeks to promote the nation or Latin American pride;

b) Sedentarism, which tries to explain migration and control it;

c) Developmentalism, which sees economic growth as a final purpose.

Trying to avoid the ideological exaggerations of the above mentioned doctrines we analyze the experience of Nobel laureates in terms of their importance in the scientific history of their respective countries. We build on previous findings from Inglis (2018), who demonstrates that the Nobel Prize has contributed to the creation of a world-level moral culture, in which the winners may be perceived as moral icons. Based on this explanation, we believe that scientific Nobel prizes also have a performative value, to visibilize and promote recognition for individuals who may be considered as symbols of the development of their areas of research both in their countries of origin and destination. Many of the winners are more cosmopolitan figures than individuals who may be subscribed to one nationality only.

Even when the literature on Nobel prizes has been quite extensive, we found no previous works that correlate brain drain and Nobel prizes for Latin America. However, we did find significant contributions that sustain, similar to our hypothesis, that Nobel Prize tendencies can be an essential

would be the subject of a different study.

indicator of national development (Aparicio et al. 2019). Schmidhuber's work (2010) confirms that the evolution of national Nobel Prize shares in the 20th Century clearly illustrates the century's migration patterns (brain drains and gains) in the sciences and other fields.

Our revision of previous literature also included those studies that question the functioning of Nobel prizes themselves. After more than a century of existence, Nobel prizes have indeed received several types of critiques, referring to eurocentrism, gender balance and the composition of teams, among other aspects. For instance, physicists Sondhi and Kivelson (2017) believe that Nobels are an outdated type of prize for science, as they fail to reflect how modern science is carried out. This is so because Nobel prizes are limited to a team of three individuals, while scientific teams may be larger these days, they affirm.

"While in 1901 this was quite enough to recognize important developments in science, today this is no longer the case –the landscape of frontier research has changed. We feel that the Nobel Prizes and most others awarded to scientists today are at best inaccurate snapshots of how breakthroughs come about and at worst produce perverse incentives for scientists to spend time rewriting history instead of moving on with the true business of science", say Sondhi and Kivelson (2017, 1).

However, we still believe that Nobels are a good indicator of some aspects of scientific activity in Latin America, especially due to this region's underrepresentation in the demographic history of the Nobel prizes, dominated by the "massive brain transfer" from Europe to America (Kando 2018, p. 82). In fact, Kando's study concludes that: "follow-up studies on this

demographic history of the Nobel prize could look at other factors like social traditions and educational institutions that might explain the concentration of Nobel Laureates among some demographic groups rather than others" (2018, p. 82). This might be considered as an additional justification for the present research.

Method

We offer a multiple case study to prove the academic brain drain phenomenon from a culturalist perspective (see table 4). We combine three types of empirical evidence: individual life histories of Nobel laureates (cases 1 and 2); comparative case studies of two scientists in Mexico and Argentina, the Latin American countries that most benefitted from international science prizes (case 3); and for purposes of contrast, a historical case to illustrate the need for a more cosmopolitan view that would validate scientific discoveries (case 4).

Even though the sample may seem reduced, it is based on a complete revision of the scientific Nobels for Latin America. Similar to other studies (Kando, 2018), we also found that classifying the national identities of the 126 multinationals was challenging. We therefore chose to consider the nationality of birth and the country where the Nobel laureate lived. Two other recipients of the Nobel Prize in Physiology or Medicine –the ones awarded in 1960 and 1980– were, in fact, Latin American citizens as a result of very particular family circumstances. Baruj Benacerraf and Peter Brian Medawar were born, respectively, in Caracas, Venezuela, and Petropolis, Brazil. However, each one left the country of his birth at an early age. In both cases the parents were not Latin Americans; Benacerraf's were North

Africans and Medawar's were British. For the purposes of this paper we had to skip the analysis of their appealing biographies. "Such people are truly 'world citizens' but, unfortunately, such a legal status does not (yet) exist." (Kando 2018, p. 72)

Each case we analyze includes selected data on the life history of the individual involved, as well as an interpretation of the specific political and scientific context. We use such empirical proof to demonstrate that the level of a country's scientific development is usually directly related to the degree of its participation in the internationalization of science.

Table 4. Synthesis of cases studies and related hypothesis

Case no.	Name of scientist	Country	Relevance as case study	Main case study hypothesis
1	"Bernardo Alberto Houssay"	Argentina	Nobel Prize for Physiology or Medicine (1947)	Scholarships abroad as a double-edged sword for brain drain
2	César Milstein	Argentina	Nobel Prize for Physiology or Medicine (1984)	Lack of financial resources and peace, necessary for science production in Latin America

3	Mario Molina and Alberto Calderón	Mexico and Argentina	Comparative case study. Nobel Prize in Chemistry (Mario Molina, 1995) and Wolf Prize in mathematics (Alberto Calderón, 1989)	Insufficient mathematical research and scientific culture in Latin America
4	Fray Diego Rodríguez	Mexico	Historical case study for contrast purposes (17th century)	"The question of unknown local scientists"

Source: Authors' elaboration

Empirical Overview

Case 1. Dr. Houssay: Scholarships abroad as a double-edged sword

In 1947, the Argentinean physician Bernardo Alberto Houssay received the Nobel Prize for Physiology or Medicine for his discovery of the role played by pituitary hormones in regulating the amount of blood sugar (glucose) in animals. Houssay was born in Buenos Aires, Argentina, in 1887. He became the first Latin American to win a Nobel Prize in the sciences.

Houssay often said that his career was a result of his own personal efforts and strictly based on merit.

> I have gotten all positions without ever asking for favors or recommendations. I apply these same criteria in my dealings with others. This has given me a reputation for harshness with

> myself and towards others, but I have the certainty that I am gladly and enthusiastically helping those who deserve it. On the contrary, I am not soft on those who don't have merits (McLean Evans 1943).

When he was very young he was admitted to the Pharmacy School at the University of Buenos Aires. At the age of 17, he started attending the Medical School and, three years later, he was appointed as a research and teaching assistant in the Department of Physiology. His PhD thesis was on the physiological activities of pituitary extracts, and it was published in 1911. After his doctorate, Houssay was hired as a Professor of Physiology at the University's School of Veterinary Medicine. He climbed, one by one, all the other steps: Chief Physician at the Alvear Hospital; Chief of the Section of Experimental Pathology at the National Public Health Laboratories in Buenos Aires; Professor of Physiology at the University of Buenos Aires' Medical School; Director of the Institute of Physiology.

As we can see, Houssay pursued his entire scientific career in Argentina. However, he believed in the absolute necessity of scholarships for study abroad.

> The only sure way to achieve this is to choose our most able and idealistic young people and send them to work with the most remarkable men in their respective specialty, so that they start their education or complete it and get intellectual discipline. Upon their return, we have to secure them a place to work related to their studies and guarantee that they do not

> have financial problems. In this way, they will work with full mental concentration; they will have the necessary tranquility to expand what they have learned abroad and to practice the methods of work they have acquired. (Houssay 1939, p. 302)

Historically, the participation of foreigners and the training of local scientists abroad have been fundamental to the development of the sciences in Latin America. For instance, in the second half of the nineteenth century the participation of American geologists in scientific enterprises charged with the design of maps and surveys of mineral resources was highly visible.

> As the practice of science revived [after political turmoil], Latin Americans sought training abroad, with different disciplinary groups showing partiality for distinctive European traditions. Thus, Brazilian engineers preferred to study in Belgium, Mexican chemists in Germany, Argentine mathematicians in Italy, and Mexicans in the United States. (Glick 2008, p. 782).

Houssay was aware of this situation, but claimed that scholarships should last only one or two years, in order to prevent "brain drain":

> Scholarships abroad should be awarded for one year and to a single place and they should not be modified without the authorization of research committees. They may be extended for another year, only if it is justified by the progress that the candidate makes, but never for a third one, said Houssay (1939).

Like many other scientists in Latin America, Houssay suffered the

consequences of political upheaval. In 1943, the military dictatorship dispossessed him of his university position, but instead of going into exile he choose to re-establish at the privately funded Institute of Biology and Experimental Medicine, maintaining his own research agenda and staff.

Given Houssay's dismissal in 1943 by the authoritarian Argentinean government, his Nobel Prize award in 1947 may be interpreted as a political message against populist politicians and authoritarian governments in Latin America. The prize was a manifestation of international support in favor of the freedom of research in the region. However, when Houssay was awarded the Nobel Prize, he had already received numerous prizes and honorary degrees. His contribution to studying the role of the anterior hypophysis gland in the metabolism of carbohydrates had stimulated the study of hormonal feedback control mechanisms. By that time, Dr. Houssay had also transformed the Institute of Physiology at the Medical School of the University of Buenos Aires into one of the world's leadings departments in experimental physiology and medicine.

In 1955, Peron was removed from power and Houssay returned to his laboratory at the University of Buenos Aires. In 1957, he was appointed Director of the National Scientific and Technical Research Council, where he contributed to the design of public policies for scientific development and medical education with a direct impact on the fight against the "brain drain". In 1966, Houssay complained that Argentina, which once exported grain and meat, had become a world power in sending scientists and technicians abroad. Houssay said:

> The total number of highly qualified emigrants from Argentina in 14 years (1950-1964) was 13,804 people, including 6,417 professionals and technicians, 2,008 senior managers and 5,379 skilled workers. These figures may actually be higher in reality. They do not include the Argentines who immigrated to other countries and from there to the United States. We do not have precise data on the number of Argentine professionals and technicians who have immigrated to countries other than the United States. Some suppose that the total number of skilled emigrants from Argentina is between 20 and 25 thousand. (Houssay 1966)

The numbers given by Houssay have been reconfirmed by other sources (Oteiza in Rocco-Cuzzi 1999) that give the same figure: 25,000 Argentineans abroad. A 2005 CEPAL study showed that Argentina led the brain drain from Latin American to the U.S., being the country that sent the most scientists and technicians to the US in the 90s. According to CEPAL, there were seven thousand Argentinian scientists living abroad. Of these scientists, only some 714 researchers have been repatriated (Cordo 2008). In a similar vein, the study by Argentinian scholar Vaccarezza concludes that Latin America's scientific and cultural dependency boosts the desire of academics to emigrate from the region. He notes that:

> Argentina constitutes a paradigmatic case. The history of the three Argentine Nobel laureates in science reproduces the effects of this policy in an emblematic way: as I said, B. Houssay carried out his research at a public university. The second, Federico Leloir,

> although he started out working at one (a public university), had to rely on the resources of a private foundation to have a suitable laboratory. The third, César Milstein, had to migrate directly to England because, after a national political crisis, he was separated from his position as a researcher at a public institution where he had begun to create the Continent's first molecular biology laboratory. This sequence of events describes the impediments to academic science in Argentina, which is surely the case, although perhaps to a lesser degree, for several other Latina American countries (ibid., p. 43).

However, the situation may have changed with the increase of Latin American skilled professionals who are choosing a career abroad. According to the National Science Foundation (Streeter 2015), for the year 1993, of the total number of scientific immigrants to the U.S., 65% came from Asia and only 13% were from Latin America. Among Latin American scientists living in the US, 165 were from Mexico, and 420 came from Peru, Argentina and Colombia combined, approximately in equal numbers (about 140 each for each country). According to the OECD, migratory movements have shown an increase in the emigration of skilled Mexicans to the United States. Due to educational development promoting higher education, but insufficient domestic opportunities for employment, an increasing number of professionals are leaving Mexico. Although they constitute only a small percentage of the labor force in the United States, these professionals comprise 8% of the Mexicans who immigrate to the US. By 2025, Mexico is projected to feel the effects of this 'brain drain'. (OECD 2010, p. 224).

In some sense, Mexico is already one of the countries with the largest deficit in the exchange of "brains" in the world (-1.7%), only surpassed by Ireland and at the same level as Portugal and Greece. This is the case if "Mexican-born individuals who arrived in the United States between the ages of 5 and 10 and graduated from U.S. higher-education institutions are counted as highly skilled immigrants." (Docquier and Marfouk 2004, 157). On the contrary, Argentina and Brazil are currently experiencing a good balance between the number of scientists who emigrate and those who immigrate, according to a study by Docquier and Marfouk.

It seems that Houssay was right when comparing Mexican and Argentinean emigration, in favor of the former: "The trouble", he wrote, "is that our migration is not made up of unskilled laborers or 'braceros'. It is formed by professionals, scientists and technicians, some of whom are highly specialized. Therefore it is a migration of the type called 'brain drain'… This is even more damaging than capital flight". (Houssay, 1966) While low skilled migration helped produce a huge stock of Mexican talent in the United States, Argentinian emigration was a real brain drain. The challenge for Mexico over the coming decades will be to stop the new phenomenon of massive migration of professionals and exploit the potential of its gigantic diaspora. Given that this diaspora developed their cultural capital and scientific capital abroad, the links to their native country may not be sufficient to assure that they will be able share those capitals.

Case 2. Dr. César Milstein: Neither money nor peace for science production in Latin America

As we said at the beginning, Houssay's profile was not similar to that of other Latin American scientists who have received a Nobel Prize. The others left the continent to pursue their scientific careers abroad. César Milstein was an Argentine biochemist specialized in the field of antibody research. He was awarded the Nobel Prize in Physiology or Medicine in 1984, sharing it with Niels K. Jerne (Denmark) and Georges Köhler (Germany).

Like Houssay, Milstein received his undergraduate and first graduate degree at the University of Buenos Aires. However, he left Argentina in 1958 with a fellowship from the British Council. Milstein joined the Biochemistry Department at Cambridge, and initiated a second PhD on the mechanism of metal activation of the enzyme phosphoglucomutase.

In 1984, he received the Nobel Prize for Physiology or Medicine, for his research on the development of the hybridoma technique for the production of monoclonal antibodies. Milstein's discoveries allowed physicians to register the changes that occurred in antibodies following antigen encounter. In his autobiography, Milstein acknowledged that Argentinean research institutions prepared him very well academically, but did not provide enough economic support:

> I started to work seriously towards a doctoral degree under the direction of Professor Stoppani, the Professor of Biochemistry at the Medical School. My PhD thesis was done with no economic support. Both Celia [his wife] and I worked part-time doing

> clinical biochemistry, between us earning just enough to keep us going. (Milstein 1985)

After earning his second doctorate at Cambridge in 1960, Milstein returned to Argentina as Head of the Division of Molecular Biology of the National Institute of Microbiology. He could only stay for one year and had to return to England after the military *coup d'état* in 1962. He remembered:

> The political persecution of liberal intellectuals and scientists manifested itself as a vendetta against the director of the institute where I was working. This forced me to resign and return to Cambridge to rejoin Fred Sanger, who by then had been appointed Head of the Division of Protein Chemistry in the newly-formed Laboratory of Molecular Biology of the Medical Research Council. (Milstein 1985)

Undoubtedly one of the most important causes of brain drain in Latin America has been the political situation in the region, jeopardized by the lack of democracy and peace. Of course, there are always some countries with particularly aggravated circumstances and others enjoying periods of relative calm. We know, for example, that Argentine scientists who emigrated during the 60's and 70's did so to escape the violence of the military regimes. Since 1976, some five thousand professionals emigrated from Argentina for political reasons (Cordo 2008). In a similar way, Colombian high skilled migrants in the eighties were driven primarily by the violence caused by the war against drug traffickers and guerrillas. "In the 1990s and early 2000s, the largest number of intra-regional migrants

came from Colombia" (Guzmán 2002, p. 567). They migrated for security reasons.

During those same decades, Mexicans with scientific potential who migrated to the United States were attracted mainly by economic opportunities and by the model of American scientific institutions. The existence of a large Mexican community in that country facilitated the procedure of migration and settlement. This explains the difference between "skilled migrants" (as illustrated by Argentineans in the 60s) and "migrants becoming skilled" (as represented by Mexicans in the last decades). The difference is between "brain drain" *stricto sensu* and "brain development".

In general, immigrants from the Caribbean and South America have been characterized by a much higher level of education than the Mesoamericans (Guzmán 2002, p. 569). The fact that a large proportion of immigrants from Mexico and Central America are admitted through family preferences contributes to explaining a lower educational level (Özden and Schiff 2007, p. 243).

Even though Mexicans used to migrate for family reasons and for educational improvement, violence has now become a cause of migration, as happened in the past with Argentinean and Colombian professionals. Although Mexico has laws specifically aimed at combatting organized crime, since 1996 it has replaced Colombia as a hub for major Latin American drug cartels (Merlen and Ploquin 2002, 300). These examples confirm that difficult political situations in the region and generalized insecurity have been recurring problems that explain a large part of the "brain drain" that has been going

on for a long time (Tigau 2013 and 2020). The cycles of violence and peace explain the extensive intra-regional population movements that characterize the region of Latin America and the Caribbean. Until recently, Chile, Costa Rica and Mexico were the countries where immigration from neighboring countries had augmented, thanks to their orthodox macro-economic policies or their proximity to the United States (OECD 2010, p. 224). Mexico has now become a country of transit and destination for Central American migrants who flee violence, draught and poverty. However this was not always the case and may not be the case anymore. The new leftist government, elected in 2018, has had numerous confrontations with a significant part of the Mexican scientific community.

> Favored by geographical and cultural proximity, intra-regional migration mainly involves countries offering the best employment opportunities or the most advantageous social conditions. Along with these structural factors, migratory patterns have been affected by cycles of economic expansion and recession and by sociopolitical upheaval (Pellegrino, 1993, 1995, 2000). This is the case for the Central American countries that were governed by totalitarian regimes during the 1970s and 1980s. However, the restoration of democracy in the 1990s did not slow down emigration, which is probably determined by a more complex set of factors. Chile and Costa Rica are the only countries where immigration from neighboring countries has increased, thanks to their economic and political stability (Guzmán 2002: 567).

Case 3. Mario Molina and Alberto Calderon: Not enough mathematics in our native countries

Mario Molina is the only Mexican citizen to win a Nobel Prize for hard sciences. He actually contributed to elucidating the threat to the Earth's ozone layer from chlorofluorocarbon gases.

Molina earned a bachelor's degree in Chemical Engineering at the National Autonomous University of Mexico in 1965. Then he got a postgraduate degree from the University of Freiburg, in 1967 and a doctoral degree in Chemistry from University of California at Berkeley in 1972. Two years later, he and F. Sherwood Rowland (United States) highlighted the threat of chlorofluorocarbon gases to the ozone layer in the stratosphere. Ultimately this led to the worldwide elimination of those gases from aerosol cans and refrigerators and to the Nobel Prize in chemistry in 1995. He recalls in his autobiography:

> In 1960, I enrolled in the chemical engineering program at UNAM, as this was then the closest way to become a physical chemist, taking math-oriented courses not available to chemistry majors.
>
> After finishing my undergraduate studies in Mexico, I decided to obtain a Ph.D. degree in physical chemistry. This was not an easy task; although my training in chemical engineering was good, it was weak in mathematics, physics, as well as in various areas of basic physical chemistry –subjects such as quantum mechanics were totally alien to me in those days. (Molina 2020)

Mexico and Argentina have had different political histories during the 20th century, marked by an official ruling party, in one case, and several military coups in the other. However, Molina's case may also be interpreted to exemplify the relationship between chronic political instability in Latin America and the lack of development of basic science (Trabulse 1984, 23). During the independence period, Creole elites which had considered science as a path to prestige and development, turned toward the more pressing problems of building national-states, with efficient civil-services and military viability. "If the military was the surest road to success, parents would not encourage their children to take up scholarly careers. Medicine, military engineering, surveying, and a few other fields for which there was constant demand constituted exceptions. Science, therefore, may be pictured as having taken refuge in the most proximate fields available in these years of severe deinstitutionalization: during the first half of the nineteenth century, biology was cultivated by medical doctors and physics, by military engineers" (Glick 2008, 781). Neither theoretical physics, nor mathematics was the specialty of Latin-American universities.

No Latin American has ever won a Nobel Prize in physics, the prestigious Abel Prize or the Fields Medal in mathematics. However, in 1989 the Argentinean Alberto Calderon received the prestigious Wolf Prize in mathematics for his studies on singular integral operators. Calderon is widely considered as one of the 20th century's most important mathematicians, and probably Latin America's most noted mathematician of all time. He was born in Mendoza, in 1920 and graduated in civil engineering from the University of Buenos Aires in 1947. Calderon earned a Ph.D. in mathematics from the University

of Chicago in 1950.

Calderon is an excellent example of an Argentinean "drained brain" because he pursued his career in the United States. Aside from brief periods in which he came back to Argentina, he held academic positions at Ohio State University, the Institute for Advanced Study (IAS), located in Princeton, New Jersey, the Massachusetts Institute of Technology and the University of Chicago. He was an honorary professor at the University of Buenos Aires since 1975. (The University of Chicago Chronicle 1998)

When Alberto Calderon entered the university, in Argentina there were only small schools of mathematics in Buenos Aires and La Plata. However, Calderon preferred to study civil engineering due to the precarious chances of earning a living as a mathematician at the time. After graduation, Calderon attended the advanced courses of the mathematician Julio Rey Pastor. At 27, Alberto Calderon was finally a mathematician. Nevertheless, like many Argentine university academics that lacked full-time positions at the university, Calderon had to work at the Geophysical Research Laboratory of YPF, the Argentine state-owned oil company.

He later worked as an assistant to Professor Alberto Dominguez Gonzalez, at the Faculty of Sciences. In 1948, the Polish mathematician Antoni Zygmund taught a course in Argentina and met Calderon. Zygmund was a professor in the United States and had written a book on trigonometric series. Zygmund temporarily occupied Dominguez Gonzalez's chair and so Calderon had the chance to work as Zygmund's assistant in Buenos Aires. Then he went to Chicago with a fellowship from the Rockefeller Foundation. Calderon

received his doctorate in 1950, after only one year. As we can see, the way in which he became an international mathematician was unexpected and roundabout. (Zarantonello 2000)

The cases of Molina and Calderon illustrate the absence of a sufficiently robust institutional framework for the advanced study of mathematics in Latin America, during the twentieth century. Aiming to be objective, even though it may be uncomfortable, we dare to say that Latin American mathematical and experimental sciences have been relegated for decades. One might wonder why we have not put the accent on the strengths of local scientific traditions which are evident in agroecology and mining engineering, for instance, instead of pointing out the weaknesses. Scientists such as Linnaeus and Darwin did not belong to the physical-mathematical tradition that goes from Galileo to Einstein. No one would deny the importance of the revolutionary theories of Linnaeus and Darwin; similarly, someone may wonder whether Latin American or Hispanic American science belongs to, or necessarily should belong to, the style or tradition of physical-mathematical science.

However, this objection ignores the rhythm of development of the sciences, wherein originally it was easier for Latin American scientists to be informed, participate and contribute. During the 18th and 19th centuries there were scientific revolutions in taxonomy (Linnaeus) and in evolutionary biology (Darwin) that were still a part of the general scientific culture and which could be accessed by importing books and translating them in Latina America. It was in the 20th century that we witnessed an enormous increase in the publication of experimental studies, and mathematical modeling that

require a huge infrastructure in universities and significant government support. The Nobel Prizes in the sciences contributed to consolidating this new science where year after year countries compete to see which one has the most awards and the best universities. The culmination of this rising tide of professional science is called the economics of knowledge and associates a country's wealth with its patents and technologies. The fact that Latin America is far behind in this respect should not be interpreted as confirmation that Latin Americans are culturally divorced from scientific reasoning.

Case 4. Fray Diego Rodríguez: The issue of unknown local scientists

In this essay, we have emphasized the insufficient development of mathematical and experimental sciences as significant causes of brain drain in Latin America. Moreover, certain cultural characteristics of the Hispanic tradition may be attached to the problem. Many may wonder whether Nobel prizes may be an objective way to assess the causes of brain drain in Latin America. Nobel Prizes are a European institution that mainly recognizes Americans and North Europeans.

This argumentative strategy is often used by the defenders of the local perspective in the history of science, microhistory and postcolonial history of science. To them, the brain drain problem is better explained by dependency theories rather than by cultural aspects. From this perspective brain drain is the other side of the coin of brain attraction or even scientific "head hunting". Brain drain implies, therefore, for those who hold this point of view, that it is not possible for dependent countries to preserve their local

scientific traditions. These perspectives denounce asymmetric international relations and, indirectly, make an appeal for a nationalistic defense of local science or what might be considered a form of scientific sovereignty.

Some historians of science claim that rather than an absence of major mathematical and experimental scientists, Latin America has suffered from the disregard of the West. Therefore historians have to discover the names of those who have not been highlighted by the "official history of science" because they did not leave the region in order to work at universities in North America or Europe, or because they did not received a Nobel Prize.

This diagnosis does not seem convincing. While it is true that historians of science can bring to light the names of little known local scientists, the existence of these great minds did not change the landscape of classical sciences (especially mathematics, physics, and chemistry) in the region. Moreover, the historical rescue of the work of these great minds does not change today's scientific panorama. We believe that the history of brain drain in Latin America must be more than an exercise that explores the region's recent history. For instance. Elias Trabulse (1984) has praised the life and work of Fray Diego Rodriguez. This seventeenth-century monk should have been recognized as a world-class mathematician but, as Trabulse (1984) points out, his manuscripts were not published despite the fact that he was an important professor. Trabulse says of Diego Rodriguez:

> His vast mathematical-astronomical work fills several hundred pages of manuscripts, which unfortunately were never brought to the printing press, even though the author enjoyed a long and

> deserved reputation as a scientist at the time. He served for more than thirty years (1637-1668) as professor of mathematics at the Royal and Pontifical University of Mexico and was also an expert in engineering and an accomplished astronomer. (Trabulse 1984, p. 66-67)

Unlike other scholars of the time, Rodriguez never left New Spain (which is now Mexico). He was not a "drained brain". For contemporary nationalist historians, the disregard for his mathematical work can be explained by the Eurocentric and colonial nature of scientific institutions. We propose an alternative interpretation that also benefits the work of local historians of science but distances itself from nationalist approaches. Thanks to the work of Trabulse (1984), we have some revealing data about the difficulties faced by a seventeenth century Latin American scientist in his own country. In 1640, Rodriguez participated in a famous dispute over the case of a professor of medicine whose ascension to his position was imposed upon the university authorities by the Viceroy Marques de Villena. At the same time, Rodriguez sent his treaty on logarithms to Spain but did not receive any response. Rodriguez also failed in his attempt to establish a scientific exchange on the same topic with a Peruvian mathematician, who was his former disciple.

Even though direct testimonies of some of the greatest Latin American scientists are available today, Rodriguez's is missing. We can however assert that Diego Rodriguez, like other scientists in the region, was a victim of his own society and culture. The Spanish society was centrally organized and less dynamic than the northern European society, if we consider the number

and intensity of scientific epistolary exchanges. The former suffered more political interference than the latter.

Discussion: The Inexorability of Culturalist Approaches

Sciences such as geometry and mathematical physics; laboratory techniques; probability and statistics; modern biological taxonomies or evolutionary theory have usually been regarded as Western achievements. Taken to its logical conclusion, Eurocentrism says that science itself is a European product, or at least a Mediterranean one. This is false in the light of Mayan astronomy, Nahua agroecology, Indian chemistry, Chinese mathematics, Arabic algebra, and so on. However, as a possible explanation for the brain drain from Latin America to the developed countries we have pointed out in this essay some of the weaknesses of Latin American classical sciences. We have quoted the opinions of some leading scientists and compared the number of major international science prizes obtained in the region. Now we can delve into the cultural argument and try to identify causes that have impeded the satisfactory development of science, beyond those already mentioned (political instability, lack of economic resources applied to innovation and insufficient support for mathematical research). Shared intellectual traditions and university practices common to most countries in the region could be useful to strengthen culturalist hypotheses.

We should also point out some broad indicators common to Latin America, Spain and Portugal, besides their lack of a powerful tradition in physics and mathematics. Some of these are the rankings of academic scientific production, in which no university in Latin America, Spain or Portugal is

usually among the one hundred best in the world. When evaluating countries by number of scientific and technical journal articles, India, South Korea, France, or Italy, publish more than Brazil, Spain or Mexico. To estimate the intensity of extra-institutional intellectual curiosity maybe we should even consider the number of articles created spontaneously, not necessarily by specialists, in the world's most widely consulted encyclopedia: Wikipedia. Despite the large number of native speakers of Spanish worldwide, in August 2020 there were more articles in the German (4.5% of all articles in different language editions) or French (4.1%) Wikipedia than in the Spanish version (3%). As a promising indicator, a decade ago the Wikipedia in Japanese and in Polish also had more articles than the Spanish one, but this is no longer the case.

Certain characteristics of the Hispanic university model also contributed to the drain of scientists from Latin America. Since the XVIth and XVIIth centuries, viceroys in America and the rest of the Spanish colonies imposed their will on universities and denied the autonomy of privileged universities as corporate institutions. Whenever educational institutions decided to confront directly confront the appointment of a professor by the Viceroy, they were defeated (Pérez Puente 2000, p. 137). In principle, to get a chair it was necessary to belong to an influential family and obtain the patronage of, say, the archbishop or other important members of the clergy.

It cannot be denied that "brain drain" is the best way to label or identify the inability to retain scientists in the south. And yet, it is not usual to consider the problems of recruitment of scientists at universities in Latin America as an explanatory variable for the phenomenon of brain drain. Education

researchers have shown that the failure to retain highly qualified staff is "due to a combination of low wages, precarious professional standards and few opportunities for professional development, poor training and lack of the relevant support for teaching" (Navarro 2002, p. 5).

In the late 20th century, the main criterion for recruitment of academic staff in public universities in Brazil, Bolivia, Colombia, Ecuador, Guatemala, Honduras, Peru, Uruguay and Venezuela "was the "concurso de oposición" (open competition)". In Argentina, Chile, Costa Rica, El Salvador, Nicaragua and Panama such institutions conducted "concursos de credenciales" (credentials competitions) o "concursos de antecedentes" (prior experience competitions). The differences do not seem to be very important (the latter often involves the existence of "ternas" (lists of three candidates)). However, in practice all these procedures usually continue to be influenced by political and ideological considerations, as well as by personal favoritism. "The selection process lacks transparency and is overcharged by non-professional criteria, including political patronage or technically ineffective criteria" (Navarro 2002, p. 3). Added to this is the fact that many private universities in Latin America do not hire teachers through competition, but by individual invitations (García 2002, 98). The importance of these issues was also emphasized by Houssay when addressing the problem of brain drain and local scientific development:

> Scholarships were constantly granted in our country, just not always to the most competitive persons. Most often, they were granted based on political or family relations; sometimes they were given to young people who had failed in our colleges and

> could not finish their studies. These youngsters often achieved graduation in Europe, either because they improved, or rather because of the easiness with which diplomas were awarded in Europe to foreigners who would return to their native countries. This is certainly not positive for the prestige of our country; they did not contribute to national improvement upon their return and they do not justify the expense they have caused. These errors and injustices defamed our system of scholarships for years. (Houssay 1939)

It is symptomatic that in several surveys on skilled workforce mobility in Latin America (Tigau 2013 and 2020, Domínguez and Vázquez-Maggio 2019), the great majority of participants considered that corruption is one of the three most serious problems in Mexico.

Conclusions

Brain drain as a theoretical and ideological concept does not allow a neutral empirical analysis, and may not even support a neutral scientific approach. In the 60s, studies of this phenomenon began considering it as catastrophic for the sending countries.

On the contrary, the new perspectives of brain drain in the 90s emphasized its supposed positive effects, such as remittances and the organization of the scientific diaspora to promote scientific collaboration and technology transfer. Another alleged positive impact of highly skilled migration is that it increases educational and cultural capital in sending countries. Indeed, it is believed that when many people have the expectation of leaving the

country to pursue graduate studies or find jobs as highly skilled workers, these people spend more resources on education than those who do not have the expectation of leaving their country. However, a third generation of studies on brain drain adopts new pessimistic views, such as the ones alleged in this paper.

Throughout this essay, we saw a historical heterogeneity in the causes for the emigration of Latin American scientists. The existence of dictatorships and civil wars in the country of origin is a cause of emigration different from family reunification or personal development aspirations. However, we can speak of a history of brain drain in Latin America, because all those heterogeneous causes have been cyclically experimented by all the countries in the region. Thanks to the testimonies of some very important representatives of Latin-American science, we have pointed out some common causes and explanations. Brain drain in Latin America has been a response to economic, political and cultural factors. Specifically, the decision to migrate has been historically motivated by political violence, corruption, lack of infrastructure and inadequate cultivation of certain disciplines such as advanced mathematics.

Graduate studies abroad are one of the main causes of brain drain. Many people who settle overseas do so after having studied there; according to the above mentioned survey (Tigau 2013), about half of those who have settled in the United States or Spain, did so only for the reason of having studied there. On the other hand, given that corruption and inequality remain pressing problems in Latin America, the best scholars are not necessarily those who get scholarships and academic tenures, because those positions

tend to be distributed among the economic and social elites, rather than being assigned to the most promising scientists. The latter, therefore, have to pursue their scientific endeavors abroad.

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