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Building Innovation Skills to Overcome Gender Inequality

Mexico, India, and Brazil

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INTRODUCTION

"Without women, life is pure prose," wrote Nicaraguan poet Rubén Darío. Not only have women inspired male poetic creativity, but they have also contributed to progress in the world, and evidence of female artistic and intellectual attributes has been left behind throughout history. During prehistoric times, women must have been anonymous inventors, creating a number of objects and activities needed for everyday survival while the men were off hunting. The creative potential of the "fairer sex" has been marginalized, limited, and unacknowledged due to unequal gender treatment at different periods in human history.

This chapter attempts to shed light on the efforts that women inventors from three emerging countries – Brazil, India, and Mexico – have undertaken to overcome the obstacles of inequality and how relevant these challenges can be for economic development and society. In particular, it seeks to (1) analyze gender differentiation in creativity, innovation, and science; (2) define the nature and dynamics of female inventive activity by using data provided by the U.S. Patent and Trademark Office (USPTO) on patents granted in Brazil, India, and Mexico; (3) determine which factors influencing the growing propensity of women to invent help reduce gender inequality in knowledge economies; and (4) contribute policy proposals that target greater female participation in inventive activities.

The key questions for this research are thus: What are the characteristics and dynamics of female inventive activity in emerging countries with different economic development paths? What factors influence women's propensity to invent? Do female inventive skills complement those of men?

We consider that women possess potential abilities for invention-innovation and that their propensity to be inventors, by themselves or in co-participation with men, will depend on their scientific background and variables related to inventive activity.

The findings of this research suggest that factors influence, to varying degrees, the propensity of women to invent in Brazil, India, and Mexico. Each case offers different strands of analysis according to the innovation trajectories of each country and the incorporation of women into scientific and technological (S&T) research. For instance, the fact that the stock of prior knowledge is significant only in the size of inventor teams has a positive influence on women inventors in Brazil and Mexico. Concerning patents, patents by firms positively affect women inventors in Mexico and India, while patents by institutions and individuals only affect Mexico and Brazil, respectively. Regarding the technological field, mechanical is significant in Mexico, while pharmaceutical, medical, electrical and electronics, and "others" are important in Brazil. In contrast, in India, no particular field is influential on the propensity of women to invent. The presence of foreign researchers increases this propensity in Mexico. The outcomes suggest specific policies that will promote the incorporation of women and the development of their inventive potential in the different technological fields. To that extent, gender inequalities in inventive activity can be overcome, and this will be expressed through improved economic growth and social welfare.

The following section provides a short, specialized literature review on the factors influencing women's ability to display their inventive capabilities. The second section deals with whether policies geared toward reducing gender inequalities in education, science, and technological knowledge have been implemented in Brazil, India, and Mexico. The third section focuses on analyzing the dynamics of female inventive activity in these emerging countries, specifying the empirical model used to test the hypotheses, analyze the results, and formulate policy proposals. The last section presents conclusions and advances some policy recommendations.

7.1 REVIEW OF LITERATURE ON WOMEN INVENTORS

Despite women's enormous potential to contribute to economic growth through scientific, technological, inventive, management, and business activities, they have historically been marginalized in education, particularly in S&T fields of study (Asgeirsdottir, 2006). The growing incorporation of women into S&T careers and their professional performance in these fields is seen as a potential source of economic growth and well-being in society (Hunt et al., 2012; Huyer, 2015; Kahler, 2012; UKIPO, 2016). As more women develop new scientific knowledge and technological innovations, a positive impact on countries' productivity, economic growth, and social well-being is expected (European Commission, 2008). Especially when women are involved in science, technology, engineering, and mathematics (STEM) fields, they acquire the skills to develop new S&T ideas that have innovative potential and foster entrepreneurship (Kuschel et al., 2020).

Some authors maintain that women have participated in the development of science since the beginning. Yet, their involvement and contributions have been mainly ignored by historians or deliberately concealed behind male figures (van den Eynde, 1994). Today, the deficiencies in women's participation in science and technology are more visible (UNESCO, 2018).[1]

Historic gender discrimination notwithstanding, some women have succeeded in standing out for their scientific work. For example, Marie Curie received two Nobel Prizes: in 1903 for physics, shared with her husband Pierre and Henri Becquerel, and in 1911 for chemistry, all by herself. Rosalind Franklin's X-ray diffraction photographs were crucial for the double helix model of DNA, for which James Watson and Francis Crick were awarded the Nobel Prize in Physiology or Medicine in 1962.

In the realm of technology, women have also developed inventions that have significantly impacted industrially and successful businesses at different times in history. Women's inventions have moved from household utensils, clothing, and other fields to inventions of greater technological complexity (Table 7A.1). Women inventors in developed countries stand out. As developing nations have made efforts in science and technology, women involved in these fields – albeit in a much smaller proportion than men – have been publishing scientific findings in journals, patenting inventions, and receiving awards – including "Women in Science" Awards from UNESCO–L'Oréal–ABC (Agência Brasil, 2018). Concerning the emerging countries selected in this study, India reports significant scientific achievements from women in various fields (Ramesh, 2020). Brazilian women scientists have been critical players in life sciences and health, and women in Mexico have made essential contributions in the same area (Table 7A.1).

The interest in studying the contributions of women inventors is recent. Several studies offer a historical focus, giving an account of the social impact of inventions made by women in different periods and industrialized countries (Blashfield, 1996; Braun, 2007; Currie, 2001; Karnes and Bean, 1995; Whittington and Smith-Doerr, 2008, among others). Others have made remarkable efforts to identify women inventors across countries, regions, technological fields, and sectors, using data on Patent Cooperation Treaty (PCT) applications from the World Intellectual Property Organization between 1995 and 2015 (Martínez et al., 2016). Another effort to identify women inventors was made by the UK Intellectual Property Office (2016), which analyzed ninety million documents compiled from the European Patent Office (EPO) and its Worldwide Patent Statistical Database (PATSTAT). Additionally, the USPTO (2020) has analyzed patent data from 1976 to 2019 to identify women inventors compared to men. The findings of these studies coincided, identifying that a vital gender gap still exists, but there is a growing trend in

[1] UNESCO (2018: 13) reports that 28.8 percent of researchers and 35 percent of students in STEM-related fields are women. Two regions studied (Central Asia and Latin America) have increased gender parity among researchers (48.1 percent and 45.4 percent, respectively), while almost a third of all countries worldwide had done so since 2016.

the incorporation of women in inventor teams. There are also differences between countries in the technological fields in which women are involved (Martínez et al., 2016; UKIPO, 2016; USPTO, 2020).

Some studies centered on analyzing patented inventions with female inventors' participation in information technology (Ashcraft and Breitzman, 2012; Kahler, 2012). Still, other studies have spotlighted the problem of the significant gap in female participation as inventors, as patent owners, and in the commercialization of inventions (Frietsch et al., 2009; Giuri et al., 2020; Hunt et al., 2012; Jung and Ejermo, 2014; Kahler, 2012; Milli et al., 2016; Whittington and Smith-Doerr, 2008) (Table 7A.2). Considering that women have gradually increased their participation in academia over the past sixty years, some studies have focused on women's working conditions, seeking to identify reasons that inhibit greater female involvement in S&T research projects. Some authors point out that family/career tradeoffs disadvantage women's academic positions and, therefore, women in science may value authorship of scientific articles more than inventorship reflected by patents (Lissoni et al., 2013). In the view of these authors, women are less likely to patent than men (Whittington and Smith-Doerr, 2008), even if they have a similar history of publications (Azoulay et al., 2007; Breschi et al., 2005; Stephan et al., 2007, cited by Lissoni et al., 2013).

Either way, gender-differentiated academic performance is seen across scientific fields and countries in terms of the number of women and men authors and their productivity, citations, recognition, and salary. This seems related to diverse publishing, career longevity, and dropout rates, particularly in academic careers across STEM fields (Huang et al., 2020). The fact that women graduate with STEM degrees in a lower proportion than men means that they have fewer opportunities to operate in business and commercialization circuits, even if they are inventors (Giuri et al., 2020; Kuschel et al., 2020; Lissoni et al., 2013). However, in some fields, such as biotechnology, women scientists are more likely to become inventors in patents by firms, especially when those firms are more flexible and less hierarchical in their organizational management and favor collaboration with academia and other companies.

Other reasons explaining the persistent academic gender productivity gap include "differences in family responsibilities, … career absences, resource allocation, the role of peer review, collaboration, role stereotypes, academic rank, specialization, and work climate." Insofar as the case studies are limited, the analysis of this phenomenon needs to be deepened, covering the whole longitudinal, disciplinary, and geographical landscape (Huang et al., 2020: 4609).

As for emerging and developing countries, studies of Mexico (Guzmán, 2012) and comparative studies of Latin American countries (Sifontes Fernandez and Morales Valera, 2014) have been conducted. These studies show the huge gap in female participation in inventive activities, identify the technological sectors in which women participate, and explain the rate of female involvement in an innovative activity associated with external collaboration and the patenting of universities and institutions (Sifontes and Morales, 2020).

The literature on women inventors[2] and, in particular, on factors affecting women's propensity to invent remains limited. However, once the barriers faced by women in accessing patenting and commercializing innovations have been identified, the authors put forward interesting suggestions to overcome these barriers (Hunt et al., 2012; Meng, 2018; Milli et al., 2016). The relevance of this research resides in the fact that it identifies factors influencing the propensity of women to be inventors, in addition to characterizing the activity and dynamics of inventive activity involving at least one woman in three emerging countries. This analysis allows us to corroborate the extent to which the U.N. Sustainable Development Goals are met, which will contribute positively to their economic and social development (Table 7A.2).

7.2 HAVE THERE BEEN POLICIES IN BRAZIL, INDIA, OR MEXICO FOR REDUCING GENDER INEQUALITIES IN EDUCATION, SCIENCE, AND TECHNOLOGICAL KNOWLEDGE?

A crucial aspect of sizing gender inequalities in the knowledge economy is highlighting the stylized facts,[3] of the gaps in the Gender Development Index (GDI)[4] and in human capital specialization by gender. This paves the way for the empirical analysis of women inventors in the emerging countries selected. Therefore, the next section deals with whether policies geared toward reducing gender inequalities in education, science, and technological knowledge have been implemented.

7.2.1 *Gender Inequality Index: Brazil, India, and Mexico in the Global Context*

According to the Gender Inequality Index (GII),[5] Brazil and Mexico stand out for nearly converging in the 2014 GDI (with index scores of 0.997 and 0.943, respectively), whereas India has a lower index score of 0.795 (Figure 7A.1). India, however,

[2] "Women inventors" are defined as women who take part in the invention of a patented product or process. Although not all inventions are patented, patent-classified documents provide consistent (in the statistical sense), long-term information identifying inventors, and therefore also women inventors – of course, after a lot of hard work by the researchers.

[3] Stylized facts refer to empirical evidence – that is, observable data over time that lead to theoretical analysis. See Oxford Reference (n.d.).

[4] "GDI measures gender inequalities in achievement in three basic dimensions of human development: health, measured by female and male life expectancy at birth; education, measured by female and male expected years of schooling for children and female and male mean years of schooling for adults ages 25 years and older; and command over economic resources, measured by female and male estimated earned income" (UNDP, n.d.-a).

[5] "GII is a composite metric of gender inequality using three dimensions: reproductive health, empowerment and the labour market. A low GII value indicates low inequality between women and men, and vice-versa" (UNDP, n.d.-b). The GII, produced by the U.N. Development Programme, includes 166 countries, divided into four categories of human development: very high, high, medium, and low. Despite unavailable data for previous years, we are able to see the gender gaps, which appeared four to eight years after the launch of the U.N. Millennium Development Goals in 2000.

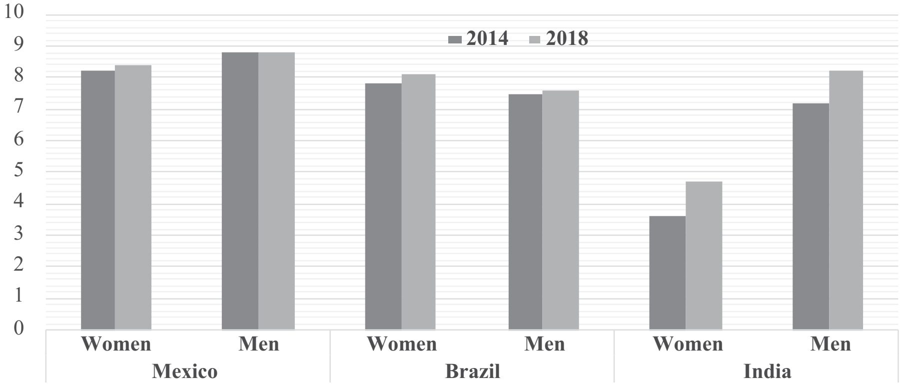

FIGURE 7.1 Average years of schooling by gender, 2014 and 2018: Mexico, Brazil, and India.
Source: U.N. Development Programme (n.d.-c).

rose in the GDI in 2018; Mexico and Brazil had marginal improvements. The Latin American countries' GII scores rank between very high human development (VHHD) and high human development (HHD), while India ranks in the low human development category.

In terms of average years of schooling, gender advances were observed between 2014 and 2018 in the three emerging countries studied (Figure 7.1). Compared with VHHD and HHD countries, the average years of schooling in Brazil, India, and Mexico were lower for both sexes, especially in India. In Mexico, there was a marginal increase in average years of schooling from 8.2 to 8.4, while the corresponding figure remained 8.8 years for men. In Brazil, women exceeded the average years of schooling for men: 8.1 versus 7.6 average years, respectively, in 2018. Finally, there were more significant differentials in India, with only 4.7 average years of schooling for women and 8.2 for men.

7.2.2 *Human Capital Specialization by Gender: Toward Which Scientific Disciplines Are Women in Higher Education Oriented?*

The graduate gender gap in the scientific field has different dimensions across countries. Having gender gaps in engineering, manufacturing, and construction, as well as in STEM, is a fact for all three countries (Figure 7.2). There has been very little improvement from 2014 to 2017 – with none, in fact, in Mexico in the STEM field. More men than women in Brazil and Mexico graduate in information and communication technologies, and the same is true for India's agriculture, forestry, fisheries, and veterinary sciences. These gaps have even increased from 2014 to 2017. However, across all three emerging countries, graduation percentages for women are higher in natural sciences, mathematics, and statistics and are robust in health and welfare. Only minor changes have occurred (UNESCO, 2016, 2018).

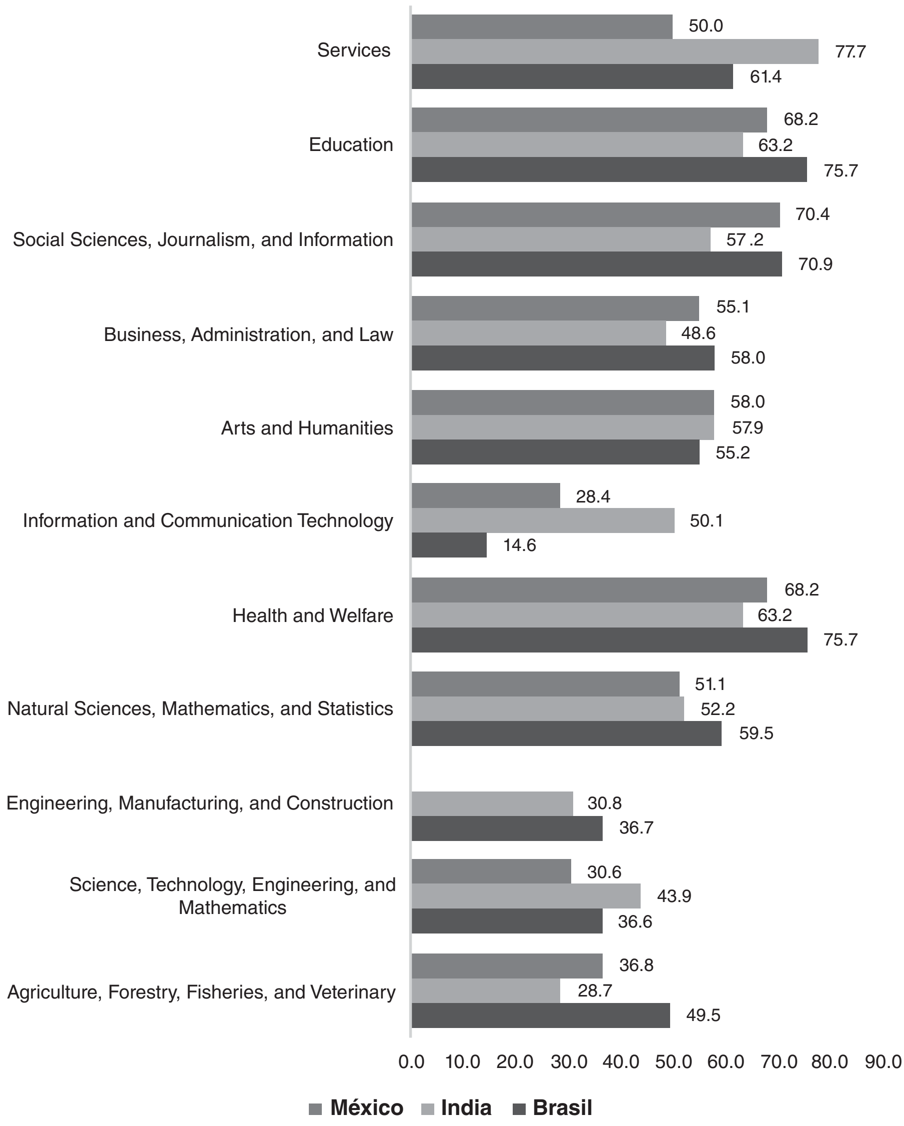

FIGURE 7.2 Percentage of female graduates by STEM career categories, 2017.
Sources: UNESCO (n.d.); UNESCO, UIS Statistics. Distribution of tertiary graduates by field of study Years selected. http://data.uis.unesco.org/index.aspx?queryid=3830

Participation of female graduates in STEM careers in 2017 registered significant and differentiated progress across countries. In India, female graduates reached parity in information and communication technologies. In health and welfare, women surpassed men in all three countries, especially in Brazil (75 percent women). Women

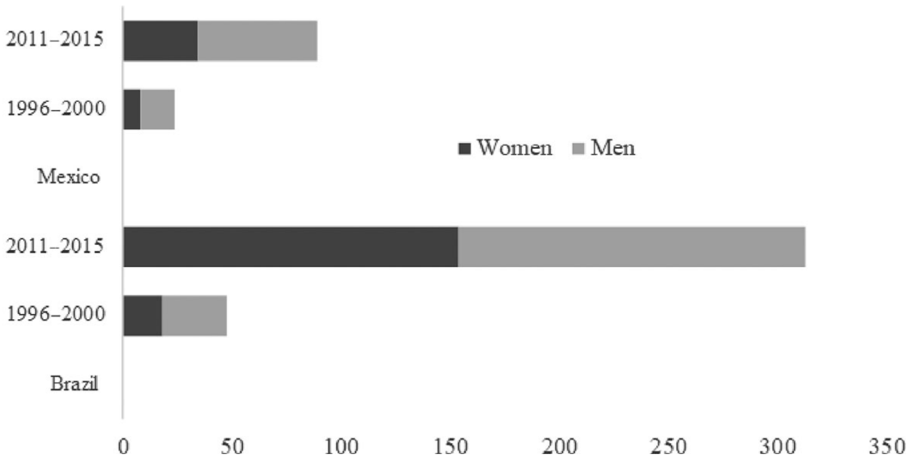

FIGURE 7.3 Number of researchers by gender* in Mexico and Brazil, 1996–2000 and 2011–2015 (thousands of researchers).
* Among named and gendered author profiles.
Source: Elsevier Research Intelligence (2017).

reached parity in natural sciences, mathematics, and statistics, especially in Brazil (59.5 percent). However, women still lagged behind men in traditional fields (Figure 7.2).

7.2.3 *Inclusion of Women in S&T Research*

The participation of women within the total group of researchers in Brazil and Mexico[6] improved between 2011 and 2015, when compared with the period between 1996 and 2000 (Figure 7.3). In general, the number of researchers in Mexico increased more for men (an increase of 39,000) than for women, from 8,100 to 34,400 researchers (an increase of 26,300). As for Brazil, the increase was noteworthy and even higher for women (136,000 women researchers compared with 129,000 men researchers).[7] The differential between Mexico and Brazil (89,500 compared with 312,800 researchers) is most likely associated with the fact that Mexico has had little GDP expenditure on research and development (R&D) (an average of 0.4 percent). In contrast, Brazil intensified its efforts in this area (1 percent) (Table 7A.3).[8]

When identifying researchers by scientific areas in the two Latin American countries between 2011 and 2015, diversification and greater integration of women

6 Information was not available for India.
7 In the United States, the increase in women researchers was slightly higher than the increase in men. As a whole, the increase for the twenty-eight European Union countries slightly favored men (Elsevier Research Intelligence, 2017).
8 In Mexico, military defense spending is 1 percent of the GDP (National Institute of Statistics and Geography, INEGI).

in the various scientific fields are observed. Although Brazil and Mexico, respectively, have 25 percent and 22 percent of women in medicine, the differential between the two countries in the number of women researchers in this field was substantial (see Figure 7.3). The count for Brazil was 80,600 during 2011–2015, an increase of 9.4 times from 1996 to 2000, and the corresponding figure for Mexico was 17,300 researchers during 2011–2015, an increase of 4.6 times. Other areas of importance are agriculture and biological sciences, biochemistry, genetics, and molecular biology (an average of 10 percent each) and, to a lesser degree, immunology, and microbiology (5 percent), with only marginal percentages in other fields.

7.2.4 *Launch of Knowledge Empowerment Policies*

We find STEM and Gender Advancement (SAGA) among the international projects. Efforts have focused on pushing for reforms to close gender gaps in STEM at the education and research levels – and also drawing lessons from evidence and the policy mix to improve national science, technology, and innovation (STI) policies. These efforts encourage the incorporation of women into the knowledge economy. In addition, they develop a better understanding of women and girls in science. Finally, they provide estimates and help build sex-disaggregated data, and design and implement the STI policy instruments that affect gender equality in STEM (UNESCO, 2016).

As noted in the UNESCO study, there are several important facts about women researchers: (1) Women are slightly less likely than men to collaborate across academic and corporate sectors on research papers; (2) there is a relatively slight variation between comparator countries and regions in the percentage of cross-sector collaboration between academia and industry; (3) the proportion of scholarly output resulting from the academic–corporate collaboration is slightly lower for women researchers than for men researchers; (4) women tend to have a slightly higher share of the top 10 percent of interdisciplinary scholarly output relative to their total scholarly output than men; (5) among researchers, women are generally less internationally mobile than men; and (6) the highest citation impact is associated with transitory researchers (those who move internationally for periods of less than two years) (Elsevier Research Intelligence, 2017: 7).

7.3 EMPIRICAL STUDY: FACTORS AFFECTING THE PROPENSITY OF WOMEN TO INVENT

This section analyzes the nature and dynamics of female inventive activity in Mexico, Brazil, and India and then tests a hypothesis. First, we characterize the inventive activity of USPTO patents granted to those emerging countries where at least one woman participates. Second, we state the hypothesis and specify the econometric model seeking to identify the factors that contribute to increasing the propensity of women to invent. Third, we verify the validity of the hypothesis and analyze the results.

7.3.1 *Nature and Dynamics of Female Inventive Activity: Data*

Our analysis of emerging female inventors focuses on three countries in the study: India, Brazil, and Mexico. We have used the USPTO database of patents granted to the holders in three countries. The period for each country is different: Mexico, 1980–2015; Brazil, 1997–2013; and India, 1997–2010. We identified those patents with at least one woman inventor and then organized the list of women inventors, associating with them the information on the patent(s).

We observe different growth dynamic paths for USPTO patents granted to the three countries. On the one hand, India was favored by a ten-year transition period following the adoption of the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS Agreement), showing an increasing dynamic in the case of pharmaceuticals. From 1997 to 2010, 2,685 patents were granted to Indian holders, of which 1,219 involved at least one woman inventor and 1,416 involved only men inventors (see Figure 7.4). India registered an annual average growth rate (AAGR) of 20.9 percent, which was higher for those patents with at least one woman inventor (24.7 percent). Two subperiods stand out in the evolution of patents granted to Indian holders. The first, 1997–2003, showed an AAGR of 40 percent on total patents, and patents with female collaboration were notably higher (54.2 percent). The second subperiod, 2004–2010, had a lower AAGR of 8.34 percent, particularly for patents with women inventors (6.7 percent) (Figure 7.4). Perhaps in the following years, patent expansion grew and was equaled by that of at least one woman.

On the other hand, we have Mexico with lower growth. Indeed, 1,193 USPTO patents were granted to Mexican assignees from 1986 to 2015, with an AAGR of 8.4 percent. Although female participation in total patents is characterized by a large gap, the 108 patents identified with at least one woman inventor were slightly higher (AAGR of 8.7 percent). Women's collaboration increased in 2007, with seven patents, and reached seventeen in 2014 (Figure 7.5). Innovative activity in Mexico remains low because of a lack of entrepreneurial and institutional investment in R&D activities that target innovation and patenting.

Concerning Brazil, of the 1,434 patents granted to Brazilians between 1997 and 2013, 388 (27 percent) had at least one woman inventor on the team of researchers. The growth path was very similar to that for all patents. The country has a small and volatile trajectory, but this trajectory is growing as the R&D/GDP percentage increases (Figure 7.6). Although the most significant proportion of patents with female involvement in Brazil is individual, teams with two or more inventors have become the practice since the end of the 1990s.

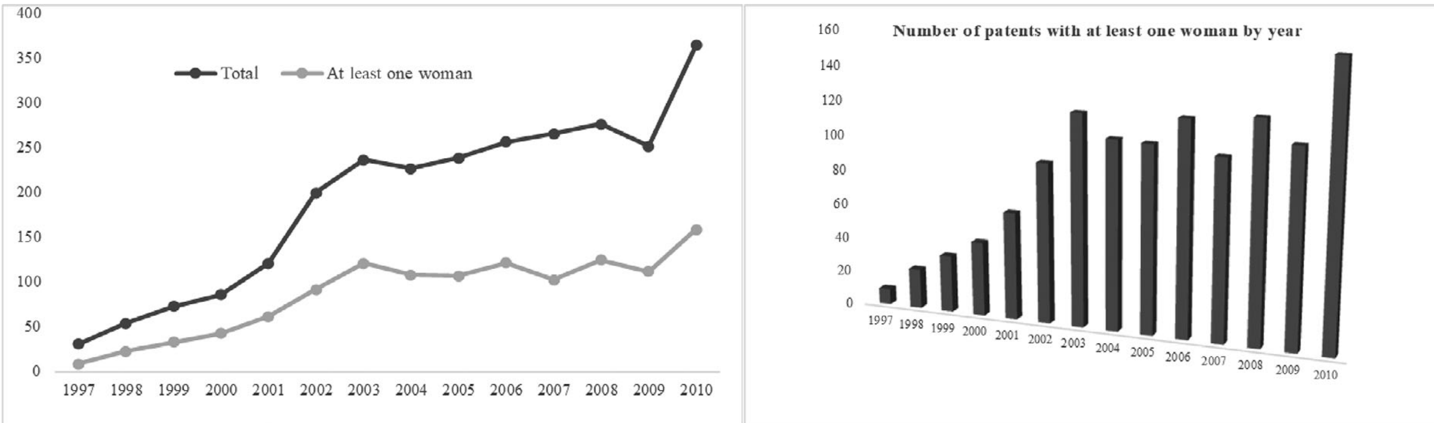

FIGURE 7.4 India: Evolution of USPTO patents granted (total and those having at least one woman inventor), 1997–2010.
Source: Authors' own elaboration, based on USPTO data.

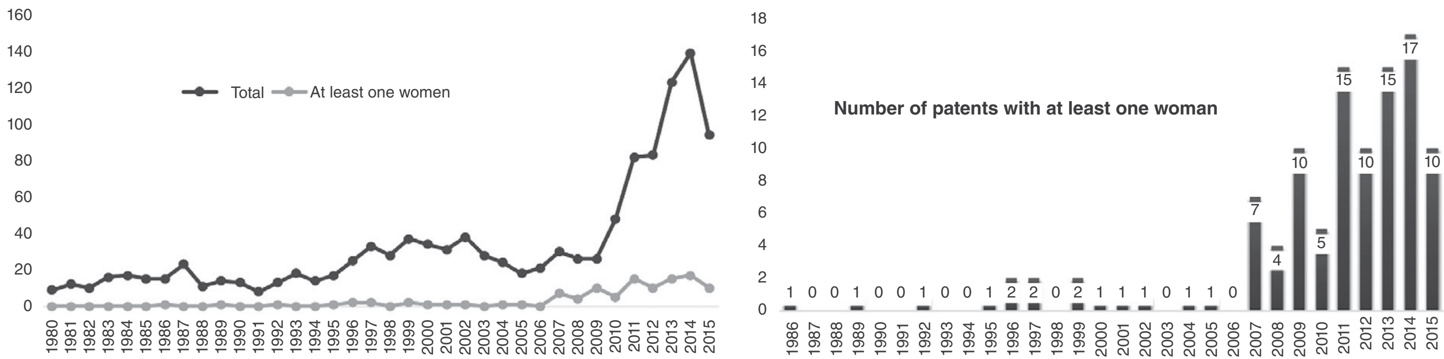

FIGURE 7.5 Mexico: Evolution of USPTO patents granted (total and those having at least one woman inventor), 1980–2015.
Source: Authors' own elaboration, based on USPTO data.

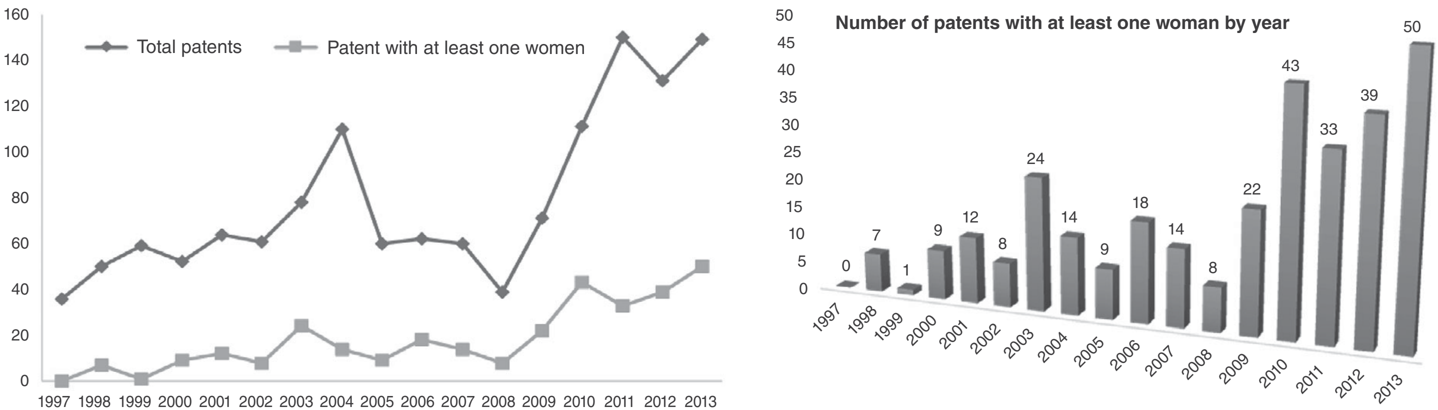

FIGURE 7.6 Brazil: Evolution of USPTO patents granted (total and those having at least one woman inventor), 1997–2013.
Source: Authors' own elaboration, based on USPTO data.

In short, the evolution of granted patents analyzed shows that even if the participation of women inventors in each country is still marginal, it has been increasing, especially in India. It is worth pointing out that men are also on those inventor teams with at least one woman inventor. The differentiated abilities across genders seem to strengthen the scope of innovation.[9] We assume that the increase of women in inventor teams is associated with the increasing incorporation of female inventors in STEM careers and related research activities. This phenomenon is more evident in India and Brazil. There is growth in Mexico but at a lower level.

7.3.2 *Nature of Innovation*

We proceed to identify the features of patents involving women inventors. It is interesting to compare the patent number by team size in the three emerging countries in this study. In general, the teams are mixed, except in patents with only one inventor. India leads with 45 percent of patents with groups including women, followed by Brazil with 24 percent and Mexico with just 21 percent. During the total period analyzed, the whole patents with teams of two to five inventors predominate in all three countries: two-thirds in India and just over 70 percent in Mexico and Brazil.

Regarding teams with more than six researchers, India stands out, with almost one-third of the patents, and the two Latin American countries have around 10 percent. Individual women's participation in patenting is relatively marginal. This is especially the case for India, where 3.4 percent of patents are characterized as individual patents. Mexico and Brazil slightly exceed 15 percent. In contrast, for patents in which only men participate, individual participation is significant in Brazil and Mexico, but the figure is lower in India (see Table 7.1).

Regarding patent assignees, institution holders are prominent in India (65 percent) and Mexico (54 percent). In contrast, firms have greater weight in Brazil (73 percent), although there has been less participation in patents with women inventors in Mexico (44 percent) and India (34 percent) (Figure 7.7).

During 1997–2013 in Brazil, 401 female inventors were identified, representing 18.5 percent of all inventors. In 2003, the Natura companies and the Johnson & Johnson subsidiary in Brazil had the greatest participation, in many cases with inventor teams composed of several researchers. In 2006, a similar situation was seen with the Foundation for Research Support in the State of São Paulo. There is a clear growing trend, which has been most noteworthy in the past few years and seems to be associated with a higher incidence of larger inventor teams.

9 Taking into account studies on neuronal differences, men and women also have differentiated abilities. Therefore, by combining the abilities of both sexes, the creation of new ideas is enhanced, and the breadth of innovation strengthened (Morales Otal et al., 2009).

TABLE 7.1 *Patents by size and gender of team in Mexico, Brazil, and India*

Country	Team size	Total number of patents	Number of patents with at least one female inventor by team size	Number of patents with only male inventors by team size
Mexico	One inventor	227	20	207
	Two to five	324	87	237
	Six or more inventors	36	16	20
Brazil	One inventor	631	62	569
	Two to five	688	256	432
	Six or more inventors	115	31	84
India	One inventor	348	41	307
	Two to five	1,801	796	1,005
	Six or more inventors	537	371	166

Source: Authors' own estimation, based on USPTO data.

During 1980–2015 in Mexico, sixty-one female inventors were identified, representing 5.3 percent of the total number of inventors. Outstanding for their participation are Sabritas (six of the sixty-one), Mabe (three), El Instituto Mexicano del Petróleo (nine), and the Universidad Nacional Autónoma de México (seven). As in Brazil, the trend is for working in relatively large teams. The average number of researchers per patent is three, but as many as five in the chemical, pharmaceutical, and medical sectors. Individual patents are registered only in the electrical and electronic sectors.

From 1997 to 2010 in India, 219 female and 659 male inventors were identified in the 1,208 patents with at least one woman. Over half (53 percent) of the patents had the Council of Scientific and Industrial Research as the patent assignee. Companies that had more than seven patents were Aurobind–Pharma (seven), Dr. Reddy's Laboratories (nineteen), Hetero Drugs (twelve), Indian Oil Corporation (twelve), Ittiam Systems (fourteen), and Reliance Life Sciences (forty-one). A trend toward working in increasingly larger teams of inventors has been recorded in India, as it is the country with the most effective teams – in fact, with ten inventors in the "others" category and nine inventors in chemical. In Brazil, the largest teams of inventors are in pharmaceutical and medical (nine inventors), chemical (seven inventors), and "others" (seven inventors).

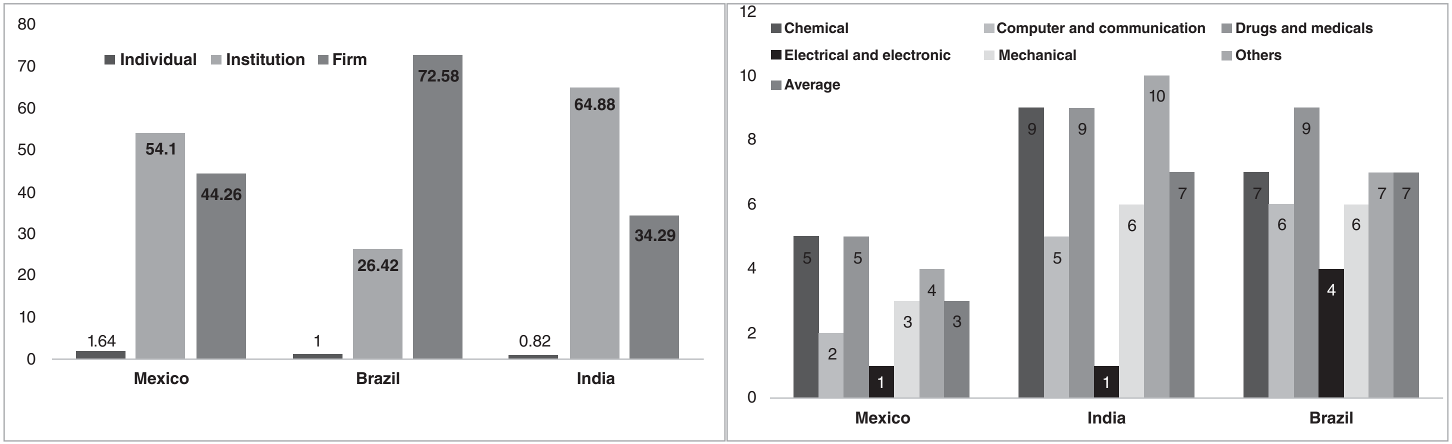

FIGURE 7.7 Distribution of women in patent assignee type and by technological field in Mexico, Brazil, and India (by percent).
Source: Authors' own estimation, based on USPTO data.

For the field of technology, where patents are classified, we underscore the following evidence. In all three countries, women's participation stands out in pharmaceutical, medical, and chemical patents. Specifically, nearly two-fifths of India's women inventors are in the pharmaceutical and medical sector, and 42 percent are in the chemical sector, according to the higher percentage of women graduates in these sectors and their integration as researchers (Table 7A.3). Studies have found a positive correlation between the increasing number of women graduates in STEM careers and research activities and a higher number of female inventors (Giuri et al., 2020; Kuschel et al., 2020; Lissoni et al., 2013). However, this study did not explore such correlations due to a lack of information on each woman.

The distribution of women inventors in Brazil and Mexico is similar in the pharmaceutical and medical sectors – 37 percent and 29 percent, respectively. In the chemical sector, the distribution is 31 percent and 26 percent, respectively. Few women inventors, however, are found in mechanical, electrical, and electronic sectors, with percentages ranging between 2 percent and 4 percent. In the "others" category, differentials are observed among the three countries, with Mexico – where women inventors collaborate on a third of the patents – standing out.

In every patent document, previously consulted patents are recorded as Backward Patent Citations (*BwPatCit*) to show that the work done by the researchers is state of the art in their technological field. We consider this variable the stock of previous technological knowledge. We estimate this indicator based on the average of *BwPatCit* per patent where a woman is present. Mexico has the highest average (forty-seven citations per patent), whereas India and Brazil have averages of fifteen and sixteen citations, respectively.

Regarding patent value, we use the number of forward patent citations (*FwPatCit*) per patent as a proxy variable. We observe that, in all three countries, the importance is still relatively low, especially in India.

India has a notably higher percentage of claims in the pharmaceutical and medical sector and the chemical sector (a combined 83 percent). Both sectors are essential for the other two countries, but with a lower proportion: 66 percent for Mexico and 68 percent for Brazil. The percentages for the "others" category are 29 percent and 19 percent, respectively. There is marginal diversification in the other technology categories.

Table 7.2 shows the distribution of patents with at least one woman inventor by variable, which we consider the nature of innovation, and by technological field. It summarizes what was previously said.

7.3.3 *Hypothesis Research and Model Specification*

Considering the historical marginalization of women in S&T activities, we expect that women possess potential abilities for invention-innovation and that their inclusion in the sphere, in co-participation with men, will positively affect the

TABLE 7.2 *Women's participation according to innovation nature variables*

		Mexico	Brazil	India
TechField		%	%	%
	Chemical	26	29	42
	Computer and communication	3	4	8
	Drugs and medicals	31	37	40
	Electrical and electronic	3	2	2
	Mechanical	2	4	3
	Others	34	24	6
	Total	100	100	100
Ȧ		%	%	%
	Chemical	51	28	4
	Computer and communication	1	2	9
	Drugs and medicals	8	46	75
	Electrical and electronic	2	2	2
	Mechanical	0	5	2
	Others	38	17	8
		100	100	100
ValuePat		%	%	%
	Chemical	34	29	28
	Computer and communication	0	5	3
	Drugs and medicals	18	45	57
	Electrical and electronic	1	0	2
	Mechanical	0	2	3
	Others	47	18	7
		100	100	100
TechInnScope		%	%	%
	Chemical	38	29	42
	Computer and communication	3	4	7
	Drugs and medicals	28	39	41
	Electrical and electronic	2	3	1
	Mechanical	0	6	3
	Others	29	19	5
	Total	100	100	100
AssigPat		%	%	%
	Individual	2	1	1
	Institution	54	26	65
	Firm	44	73	34
	Total	100	100	100
MobInv		%	%	%
	1	93	90	99
	More than 1	7	10	1
	Total	100	100	100

		Mexico	*Brazil*	*India*
SizeRT		Average	Average	Average
	Chemical	5	7	9
	Computer and communication	2	6	5
	Drugs and medicals	5	9	9
	Electrical and electronic	1	4	1
	Mechanical	3	6	6
	Others	4	7	10
	Total average	3	7	7
Women by team participation		%	%	%
	Chemical	50	45	35
	Computer and communication	75	43	47
	Drugs and medicals	67	50	40
	Electrical and electronic	100	59	56
	Mechanical	66	49	37
	Others	60	64	36
	Total average	70	52	42

Source: Authors' own estimation, based on USPTO data.

creation of new processes and technological products. The factors associated with innovation that especially affect this propensity are (1) the stock of previous knowledge, (2) the type of patent assignee, (3) the technological field of the patent, (4) the invention scope of each patent, (5) international inventor mobility, and (6) patent value. Therefore, we propose a regression model, which is estimated for each woman inventor in Mexico, Brazil, and India and is specified in the following equation:

$$Wm_j PropInv_{ij} = \dot{A}, SizeRT, AssigPat, TechField, TechInnScope, ScTech\_links, MobInv, ValuePat$$

Where the dependent variable:

$$Wm_j PropInv_{ij} = \text{women's propensity to invent. It has been estimated as follows :}$$

$$Wm_j PropInv_{ij} = \text{number of women inventor patents/number of patents where there is at least one woman/total of patents granted by the USPTO to Mexican, Brazilian, or Indian holders.}$$

According to this estimate, a reduced $Wm_j PropInv_{ij}$ is shown in the three countries (Table 7.3). Compared with Mexico, India and Brazil are relatively higher.

TABLE 7.3 *Women's propensity to invent, by country*

		Mexico	Brazil	India
$Wm_jPropInv_{ij}$		Average	Average	Average
	Chemical	0.19	0.26	0.21
	Computer and communication	0.08	0.22	0.23
	Drugs and medicals	0.22	0.4	0.26
	Electrical and electronic	0.08	0.23	0.12
	Mechanical	0.16	0.24	0.21
	Others	0.14	0.24	0.21
	Total average	0.15	0.27	0.21

Source: Authors' own estimation, based on USPTO data.

They are similar in all technological fields – except that India is higher in the electrical and electronics sector while Brazil is higher in the pharmaceutical and medical sectors. Mexico is notably lower in almost all sectors, although less so in the pharmaceutical, medical, and chemical sectors.

The independent variables are taken from USPTO patent information. They characterize the inventions. Based on the literature reviewed, these variables allow us to assume how each invention influences $Wm_jPropInv_{ij}$ (Table 7.4).

7.3.4 *Analysis of Outcomes*

According to the results of each model, we have partially verified our hypothesis, with a different pattern in each of the three countries. The independent variables – the stock of prior knowledge, the size of inventor teams, the type of patent holder, technological field, and presence of foreign influence – impact positively on women's propensity to invent ($Wm_jPropInv_{ij}$) in a differentiated manner in each country. In some cases, they did not. These results are detailed subsequently and shown in Table 7.5.

Concerning the stock of previous knowledge, $\dot{A}$ has been statistically significant only in Mexico. According to our elasticity estimation (0.012), if the number of *BwPatCit* increases by 10 percent, the propensity for women to invent grows by 0.12 percent. In the tradition of Griliches (1990), several authors have used *BwPatCit* to study knowledge flows and *FwPatCit* to analyze the invention value (Gay et al., 2008; Lerner and Seru, 2017, among others). An essential aspect to consider, however, is when it is used as a proxy value for knowledge links among inventors to explore the nature of knowledge flows and the factors affecting these flows (Jaffe and Rassenfosse, 2017). In this research, we consider *BwPatCit* as the stock of previous knowledge upon which inventors develop their new ideas. As references to prior technology that has been used or on which current patents build (Hall, 2005), *BwPatCit* involves an R&D effort, which, when increased, makes it possible to include women in inventive activities. The fact that it has positively impacted

TABLE 7.4 *Independent variables and hypothesis*

Variable	Variable proxy	It is expected that
$\dot{A}$	Stock of previous knowledge. Number of *BwPatCit* as a proxy variable	. . . the higher the *BwPatCit*, which reflects increased R&D expenditure, the higher is the propensity of women to become inventors (Aldieri et al., 2019; Duguet and MacGarvie, 2005; Guzmán et al., 2020; Hall, 2005; Jaffe et al., 1993)
SizeRT	Size of research teams. Number of inventors involved in the generation of the patent	. . . a larger research team, by incorporating women, increases the diversity of new technological ideas and therefore the propensity of women to become inventors (Bianco and Venezia, 2019; Breitzman and Thomas, 2015)
AssigPat	Patent assignee. 1 = Firm; 2 = Institution; 3 = Individual; 4 = Co-patent firms; 5 = Co-patent firm-institution	. . . the higher number of firms patents a greater probability to scale at the industrial level, to eventually commercialize, and for government and university innovation efforts to crystallize in patents, and therefore contributed to a higher propensity of women to become inventors (Chatterjee and Ramu, 2017; Giuri et al., 2020; Meng, 2018; Murray, 2004; Whittington and Smith-Doerr, 2008; Woolley, 2019)
TechField	Technological field of the patent. 1 = Chemical; 2 = Computer and communication; 3 = Drugs and medical; 4 = Electrical and electronic; 5 = Mechanical and 6 = Others	. . . the higher distribution of women inventors by technological fields will be differentiated among countries according to the importance of those fields and the advances in science and technology in each case (Cook and Kongcharoen, 2010; Hunt et al., 2012; Kahler, 2012; Maldonado Carbajal et al., 2015; Martínez et al., 2016)
TechInnScope	Invention scope of each patent. Number of claims as the proxy variable	. . . the higher the number of claims, the higher is the propensity of women to become inventors (Jensen et al., 2018)

(*continued*)

TABLE 7.4 (*continued*)

Variable	Variable proxy	It is expected that
MobIn	International inventor mobility. Dummy variable, where 0 = inventors of the same nationality; 1 = foreign inventors	. . . the higher mobility favors the spillover of codified and tacit knowledge, and therefore contributes to as higher propensity of women to become inventors (Bianco and Venezia, 2019)
ValuePat	Value of the patent. This variable specifies the number of patent citations made in successive patents. A proxy variable is the number of *FwPatCit* obtained	. . . the larger the *FwPatCit*, which suggests a wider diffusion of new patents and increased importance of new knowledge, the higher is the propensity of women to become inventors (Bransteter, 2003; Branstetter and Ogura, 2005; Breschi et al., 2005)

Source: Authors' own elaboration, based on USPTO data.

TABLE 7.5 *Empirical model outcomes: Factors affecting the propensity of women to invent*

Variable	Mexico	Brazil	India
Ȧ	0.0004**	0	
SizeRT	0.020***	0.051***	0
AssigPat			
Institution	0.020***		
Firm	0.081***	0.006	0.0442***
Individual		0.104**	
TechField			
Computer and communication;	-0.004	-0.023	0.03
Drugs and medicals	-0.007	0.055**	0.024
Electrical and electronic	-0.035	0.157***	0.008
Mechanical	0.039**	0.017	-0.023
Others	-0.031	0.130***	0.019
TechInnScope		0	0.0002***
MobInv	0.140***	-0.083	0.017
ValuePat	0	0	0.045
_cons	0.046	-0.073	-0.05
	0.236	0.163	0.477
N	61	299	728
R^2	0.67	0.76	0.68
F	6.89	9.14	3.06

Note: p < 0.01*** p < 0.05** p < 0.010*
Source: Authors' own estimation based on model proposed.

$WmjPropInv_{ij}$ is a reminder of the need to disclose patents, just as they are meant to be.

Relative to *SizeRT*, there is a positive influence in Mexico and Brazil. When the research team is 10 percent bigger, $Wm_jPropInv_{ij}$ increases 4.9 percent (Mexico) and 10.9 percent (Brazil). Bianco and Venezia (2019: 14) state that "the presence of more members on a team certainly brings more diverse and variegated knowledge and can therefore produce better results."

Contrary to the importance of institution holders in Mexico and India, firms have a positive influence on $Wm_jPropInv_{ij}$ in both countries (0.08 and 0.04, respectively). Institutions have been positively significant for Mexico as well, but only individual assignees are positively significant in Brazil. The reason for a positive effect is understandable considering the importance of public R&D expenditure in Mexico and India, even though such expenditure remains marginal in Mexico. Women academic inventors are key to understanding their involvement in scientific research – and eventually the discovery of new products and processes that could make it to the productive sphere, depending on the degree of links between firms and institutions. According to Murray (2004: 643), "The first element that the firm may leverage is the academic's local laboratory network – a network to current and former students and advisors established by the inventor through his laboratory life."

Although Martínez et al. (2016), in their study of women inventors from 182 countries with PCT patents, do not analyze the causal effects of ownership on $Wm_jPropInv_{ij}$, they have identified that an average of 48 percent of women participate in the academic sector, while only 28 percent are in the business sector. Their findings coincide with previous studies (Whittington and Smith-Doerr, 2008). It is pointed out that China, Brazil, and Spain have higher percentages of PCT patent applications with women inventors in the academic sector (around two-thirds). In particular, Mexico has 69 percent participation in the academic sector and 26 percent in firms (Martínez et al., 2016). Unlike India, Mexico has few entrepreneurial businesspeople, and technological dependence dominates every sector. Women in India have increased their presence in business activities, and they discuss the challenges that they have to face to reduce inequalities (Chatterjee and Ramu, 2017). In Brazil, however, the increase in R&D efforts surpasses the inventive activity of institutions toward companies (Maldonado Carbajal et al., 2015).

Regarding the technological field, the mechanical sector is statistically significant for Mexico, while the fields of pharmaceutical and medical, electrical and electronic, and others are statistically significant for Brazil. In India, however, not a single field has an impact on $Wm_jPropInv_{ij}$. We have confirmed the results of previous research on the positive influence of the pharmaceutical and medical sector in Mexico and Brazil, but we are now modeling each woman inventor and not each patent (Guzmán and Orozco, 2011; Maldonado Carbajal et al., 2015). The current study is also connected to the importance achieved by female graduates and researchers in medicine and related disciplines. Our findings coincide with the study by Cook and Kongcharoen (2010), where advancement by women in life sciences places them in the realms of innovation and marketing. The involvement of women inventors in different technological fields is one of the topics that have been addressed more in studies, especially with a focus on identification. Some of these studies find that technological fields differ across countries (Martínez et al., 2016) and are probably associated with the country's technological specialization, as in certain Latin American countries where chemistry and metallurgy are the main sectors (Sifontes Fernandez and Morales Valera, 2014). Few studies have thus far analyzed the impact of factors relating to the nature of innovation on the propensity of women to invent, let alone provide analysis based on a micro-level model that considers each woman inventor. Hunt et al. (2012) find that to close the gender gaps in patenting, it is essential for the participation of women in physics and engineering to grow. That could increase the GDP by 2.7 percent if we keep in mind GDP growth among countries in the long run and that patents are found among explanatory variables of the country.

In economic literature, mobility has been detected as a factor favorably affecting innovation. In Mexico, we find that the presence of foreign inventors has a positive influence on research teams; when there is a 10 percent increase in foreign inventors, $Wm_jPropInv_{ij}$ grows by 0.5 percent. The results reinforce the finding of Bianco and Venezia (2019: 14) that "the presence of external inventors broadens the scope of the patent, [and] longer working experience of inventors affects technological and market value, whereas inventors who have already patented in the past develop new product architectures, with broader scope and higher scientific value." The results also confirm consistency with contributions by previous authors, underscoring that openness and experience positively influence the innovative capabilities of teams. In India, female researcher mobility tends to occur outwardly, and knowledge spillovers take place in research centers with other colleagues. The need for such mobility finally finds channels of communication in India.

We cannot, however, confirm the influence of patent value for any country. The fact that the countries studied are emerging may mean their innovations are essentially incremental as they follow leading countries, so they are not as well recognized as industrialized countries yet. Patent value is still low, but it might be interesting to study Indian, Brazilian, and Mexican inventors collaborating on patents in developed countries and identify the contributions of women therein. New technology patented by mixed teams is often cited in the following patents. This suggests that diversity of ideas could lead to the development of patents that are more useful and consequently more successful (Hunt et al., 2012).

CONCLUSION AND RECOMMENDED POLICIES

Some countries have achieved gender parity in scientific training or are close to doing so. For others, the gap remains wide. Among emerging countries, Brazil, India, and Mexico have made progress in overcoming gender disparities in education, with differences in specializations. Brazil and India stood out for striving to increase R&D spending, thereby helping to incorporate more researchers – among them women – while expanding innovative domestic capacities. Such development is especially notable in India, whose patents are in high technology (Mani, 2015).

Analyzing each country separately, we observed different patterns for women inventors in the three countries. We also found that some policies could be furthered through our model's estimations.

The evidence of factors in Mexico that positively affect $Wm_jPropInv_{ij}$ indicates that policies must be oriented toward fostering diffusion of the technological knowledge codified in patent documents. As team inventors increase the number of *BwPatCit*, the stock of previous knowledge ($\dot{A}$) and the propensity of women to join as inventors could go up.[10] Another recommendation is to increase inventor team size and include more women inventors. Indeed, an increase in innovation in firms and institutions favors $Wm_jPropInv_{ij}$. As Mexico has specialized in the mechanical sector, one recommendation is to support development and innovation in this area, incorporating more women inventors and thus diminishing gender inequalities. That, nevertheless, does not eliminate the importance of other fields, especially those with greater knowledge intensity. Finally, the presence of foreign researchers in the inventor teams could be suggested as a way of having positive effects on increasing $Wm_jPropInv_{ij}$.

In Brazil, the results suggest a focus on the following policies: (1) increasing the number of researchers on teams, encouraging women to join; (2) further stimulating individual innovation (surprisingly for this Latin American country); and (3) coinciding with Brazil's specialization, strengthening patented innovation in the pharmaceutical and medical, electrical and electronic, and sectors in the "others" category.

Finally, in India, the right policies could be directed to improve innovative firms, and therefore patents, and incorporate more women in R&D activities – especially in the pharmaceutical and medical sector, the electrical and electronic sector, and sectors in the "others" category. Encouraging an increase in claims per patent (*TechInnScope*), which is apparently associated with seeking a broader range of claims, requires not only the talents of men but also women. This requirement differs from the idea that each sex has different creative abilities neurologically. While India is the most backward country in terms of the various aspects of the GII, the country has registered steps forward that make greater inventive activity possible for women and are thus reflected in the dynamism of patent growth, especially those

[10] The fact that $\dot{A}$ positively impacts the propensity to innovate leaves the lesson about the externalities of technological knowledge. In this sense, patent disclosure should be leveraged with increasing R&D efforts. That is, deepening the frontier of patent knowledge in the required scientific field, incorporating more female researchers, and investing in fully equipped research laboratories will contribute to the propensity of women to become inventors.

that are more technologically intense. The potential growth and well-being of nations in the world will have to be supported by the merging of cognitive skills and innovation of women and men.

This empirical study focused on a model where independent variables correspond to patent data that characterize innovation in each USPTO patent. However, the results could be strengthened by incorporating individual information from women inventors on their level of education and age, among other characteristics. In future research, we can go deeper with new model proposals.

ANNEX

Multicollinearity, Reset, and Normal Test

	VIF	Reset	Normal
Mexico	6.73	0.00	0.00
Brazil	1.25	0.00	0.00
India	1.09	0.00	0.00

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APPENDIX A

TABLE 7A.1 *Women inventors from developed countries and scientific women in Brazil, India, and Mexico*

Woman inventor from developed countries	Invention	Year	Acknowledged scientific woman and woman inventor from . . .	Scientific field of contribution
Tabitha Babbitt	Circular saw	1812	**Brazil**	
Jeanne Villepreux-Power	Glass aquarium	1832		
Nancy Johnson	Ice cream maker	1843	Ethel Wilheim, Angélica Viera	Therapies for the treatment of respiratory
Ada Lovelace	Computer algorithm	1843		conditions
Sarah Mather	Submarine lamp and telescope	1845	Fernanda Cruz	Therapies for the treatment of respiratory
Margaret Knight	Paper-bag-making machine	1871		conditions
Josephine Cochran	Dishwasher	1872	Sabrina Lisboa	Posttrauma stress disorder and how it affects the
Ellen Fitz	Globes	1875		brain
Mary Walton	Locomotive chimney	1879	Nathalia Bezerra	Method to increase the durability of cement
Adeline D. T. Whitney	Alphabet blocks (to reduce train noise)	1882	Chu Ming Silveira	Designs for telephone booths
Maria Beasley	Life raft	1882	**India**	
Josephine Cochran	Mechanical dishwasher	1886		
Anna Connelly	Fire escape	1887	Asima Chatterjee	Chemistry
Sarah Boone	Ironing board	1892	Darsha Ranganathan	Biochemistry
Margaret A. Wilcox	Car heater	1893	Kamal Ranadive	Pathology
Letitia Geer	Medical syringe	1899	Kadambini Ganguly	Physics
Florence Parpart	Street sweeper	1900	Rajeshwari Chatterjee	Physics
Mary Anderson	Windshield wiper	1903	Raman Parimala	Mathematics
Hedy Lamarr	Wireless transmission technology	1941	Anna Mani	Meteorology
Maria Telkes	Thermoelectric power generator	1947	Muthayya Vanitha	Mission Chandrayaan-2
Maria Telkes	Solar heating system;	1953	Gagandeep Kang	Medicine (rotavirus and COVID-19 vaccines)
	thermoelectric refrigerator		Kamakshi Sivaramakrishnan	Communication chip used on board the
Grace Murray Hopper	Computer software	1952		NASA's New Horizons spacecraft
Erna Schneider	Automated telephone switching system	1954	Pratibha Gai	Atomic-resolution environmental transmission electron microscope

Edith Flanigen	Oil refining	1956	Sylvia Ratsanamy	Distributed hash table
Rachel Fuller Brown and Elizabeth Lee Hazen	Antifungal antibiotics	1957	**Mexico**	
Gertrude Belle Elion	Immunosuppressive drug	1957	Esther Orozco	Biologist, specialized in amoebas and genetics
Evelyn Berezin	Word processor	1971	Alejandra Bravo	Bacterial toxin that acts as a potent insecticide
Olga Gonzalez-Sanabria	Space station batteries	1980	Victoria Chagoya	Biochemistry, cirrhosis and liver remodeling, structural and functional remodeling of the heart after experimental infarction or heart failure
Patricia Bath	Laser cataract surgery	1986		
Ann Tsukamoto	Stem cell isolation	1991		
			Isaura Meza	Biologist, structure and characterization of cytoskeleton protein genes in eukaryotic models
			Tessy López	Chemistry, catalytic nanomedicine treatment of cancer, epilepsy, and chronic lesions

Sources: Green (2019); Krishna (2022).

TABLE 7A.2 *Review of women inventors*

Authors	Data	Aim	Findings
Ashcraft and Breitzman (2012)	USPTO patents granted in information and communication technologies (ICT), 1985–2010	To examine the growth rate of women's patent applications in the ICT field	Thirteen percent of the patents during 1985–2005 have at least 1 woman inventor. The women's growth rate has increased (1980s: 2 percent; 2005: 6 percent, and 2010: 8 percent). It is more dynamic than in total patents.
Bianco and Venezia (2019)	Patents filed in IT hardware companies, 2000–2005 (PATSAT)	To characterize the R&D teams of sustainable firms (SF) and analyze how they perform in terms of patent quality	SF R&D teams feature a higher degree of mobility but less experience than those from non-SF. A less receptive attitude toward open innovation is observed. Even if SF develop fewer patents, the quality is higher, and the R&D size is associated with inventors who have published on Scopus.
Cook and Kongcharoen (2010)	USPTO patents, 1975–2008. U.S. Census Bureau's list common names by race and commercial technology	To identify ethnically heterogeneous women inventors; to analyze patenting and marketing patterns among women; to analyze recent African American patenting and patent-related marketing behavior	Gender and racial differences in commercial activity related to invention are less than previously thought. Advanced training in engineering is correlated with better marketing outputs for African American women than for U.S. inventors as a whole, for whom advancing in life sciences is more important.
Jung and Ejermo (2014)	Patent EPO 1993–1997; surveys from Japanese and U.S. studies (RIETI and Georgia Tech)	To examine gender, age, and education of Swedish inventors	The gender gap is closing but at a slower pace than in other areas of society. Level of education shows different patterns across different technologies. Inventor age has decreased since the late 1990s. There are three mechanisms for improving equality: (i) dynamic knowledge renewal, (ii) new technological opportunities, and (iii) a generally increased propensity to patent.

Giuri et al. (2020)	2,538 patents EPO application, 1996–2007, with Italian academic inventors. Own identification of the inventors' gender	To analyze if university patent transfer linkages with science and technology parks are positively associated with women's involvement in academic patenting	University policies play a positive role in addressing the gender gap in technology transfer activities.
Guzmán and Orozco (2011)	USPTO patents granted to Mexican assignees, 1980–2010	To analyze the evolution and nature of Mexican patents with at least one woman inventor; to analyze the association between gender variable and innovation-related variables	Women participation is still low, but growth tendency is increasing. Inventor teams are small. There is more woman inventor participation in drugs and medical products and chemical. Firm patent assignees with women inventors are higher. Women's involvement in patented inventions is associated with technological field and inventor team size.
Hunt et al. (2012)	U.S. patents commercialized survey with license from National University Graduates in 2003	To find how many women holders commercialize their patents	Commercialized patent holders account for only 5.5 percent. Only 7 percent of the gender gap is explained by a lower probability of women having a degree in science or engineering. In order to close gender gaps, the incorporation of women in STEM should be promoted at all levels of schooling.
Jensen et al. (2018)	2.7 million USPTO utility patent applications from 2001 to 2014	To find out, through the examination of individual U.S. utility patent applications prosecution process, how women are less favorable than men, in terms of patents granted, claims, and citations	Women inventors are belittled in this system, and they have fewer opportunities than men in the process of obtaining and maintaining patents and also to be cited. So, changes are needed to diminish the inequalities in the patent system.
Kahler (2012)	U.S. Statistics, Science and Engineering Degrees, 1996–2006 (National Science Foundation). USPTO patents assigned in electrical, mechanical, and chemical classifications	To set the stage for more meaningful and empirically based participation of women in IP and invention	Women are catching up in S&T fields and have a tendency toward becoming part of the inventor community. Patents with women inventors decrease in chemical, sharply rise in electrical, and have modest growth in engineering and computer science.

(*continued*)

TABLE 7A.2 (*continued*)

Authors	Data	Aim	Findings
Kuschel et al. (2020)	Research about (i) women's entrepreneurship and (ii) the gender aspect of STEM fields review	To propose addressing institutional, organizational, and individual factors influencing women's entrepreneurship in STEM, based on contributions of authors; to discuss implications and highlight areas for future research needed in order to close the gender gap in STEM fields	Proposals for future research are needed in the following directions: (i) define and explore the characteristics of women's entrepreneurship within the STEM fields; (ii) examine women in STEM who more often explore entrepreneurship as an option for STEM graduates; (iii) analyze beyond the early recruitment of women to STEM entrepreneurship the correlation between the nature of inventive activities and the (lack of) involvement in STEM entrepreneurship; and (iv) interrogate the gendered nature of entrepreneurial ecosystems, especially on technology entrepreneurial ecosystems.
Maldonado et al. (2015)	USPTO patents granted to Brazilian assignees, 1997–2013	To analyze the evolution and nature of inventive activities of Brazilian women inventors; to estimate, using a multifactorial model, the propensity of women to innovate and the explanatory factors	Dynamic growth of patents with at least one woman is higher than that of all patents. Collaboration of women and men inventors is mainly in chemical, drugs and medical products, and others. The propensity of women to become inventors is associated with R&D expenditure, holder firms, larger inventor team size, and technological and academic link in the patented inventions.
Martínez et al. (2016)	PCT applications, 1995–2015. 6.2 million inventor names for 182 countries to identify the gender	To analyze inventor gender in international patent applications, considering countries, technological fields, and sectors	There is a lack of gender equality in PCT applications; proportion of women inventors is improving over time. Involvement of women inventors differs substantially across countries, technological fields, and sectors.
Meng (2018)	USPTO domestic patents granted in nanotechnology classes 1990–2005	To analyze gender differences in technological productivity in nanotechnology, showing the relationship between gender and time, collaboration, research	The gap to women's disadvantage was smaller in nanotechnology than in all technology fields combined. While the patenting in more than 90 percent of patents across an industry is least likely to be collaborative, nano-patents have more diverse origins (9 percent industry; 21 percent universities, government, public institutions, and cross-sectoral collaboration) and are more likely to be collaborative outcomes (including industry). In nanotech

		preference, and workforce sector	environments, women are more able to get collaborative opportunities and engage in patenting. In order to close gender gaps, the incorporation of women in STEM should be promoted at all levels of schooling. It is also important to promote the participation of women in networks and value their efforts in performance evaluations.
Milli et al. (2016)	USPTO patents and trademarks granted to women entrepreneurs, 1977–2010	To study patents quantitatively and qualitatively with focal groups concerning patent benefits and barriers	Leadership in patents and trademarks increases in the period studied. Patents granted to women rapidly increase. Women have much greater participation in trademark activity than patents. The success of applications by women and men differs by a minimum of 73.4 percent in 1986 and a maximum of 93.6 percent in 2002. To overcome barriers to women inventors and potentially entrepreneurial activities, there should be support for patenting costs, access to start-up capital, or venture capital funding. These findings coincide with the proposals of Hunt et al. (2012).
Sifontes Fernandez and Morales Valera (2014)	USPTO patent applications from Argentina, Brazil, Mexico, Colombia, Cuba, Peru, Chile, and Venezuela, 1990–2006	To classify patents by gender; to analyze gender participation, contribution, and novelty impact across countries, agents, and technological fields	A fifth of inventions involve female contribution. There is greater gender inequality in Peru, Argentina, and Mexico. Chemistry and Metallurgy are the main fields of women inventors' participation.
Sifontes and Morales (2020)	USPTO patents granted to Argentina, Brazil, Costa Rica, Chile, Cuba, Colombia, Mexico, Panama, Peru, Uruguay, and Venezuela, 1976–2011	To explain the rate of female participation in patenting activity	The average involvement of women is 22 percent. External and internal collaboration, the institutional sector of the grantee, and innovations related to life sciences have impacts on the probability of having female participation in patenting in selected Latin American countries. There is likewise influence on women's fertility rate and human development.
USPTO (2020)	USPTO, patent data, 1976–2019	To identify and characterize the nature of female inventive	Patents with at least one woman inventor increased from 7 percent in the 1980s to 20.7 percent in 2016 and 21 percent in 2019. But only

(*continued*)

TABLE 7A.2 (*continued*)

Authors	Data	Aim	Findings
		activity vis-à-vis that of men inventors	12.1 percent and 12.8 percent of all inventors-patentees who take part in 2016 and 2019, respectively, are women. There is still a gender gap in science and engineering patents, even though women have increased their labor activities in the field. Among the top assignees, higher average women inventor rate is in healthcare products and pharmaceuticals, in a lesser degree in the ICT field, and still lower in electrical and mechanical engineering technologies. Women are increasingly likely to patent on large, gender-mixed inventor teams.
Whittington and Smith-Doerr (2008)	USPTO granted resident patents and data from a sample of academic and industrial life scientists working in United States, 1983–1995	To examine how variation in organizational logic affects sex differences in scientists' commercial productivity, measured by patenting	Women are less likely to patent than men. However, in biotechnology firms – industrial settings characterized by flatter, more flexible, network-based organizational structures – women scientists are more likely to become patent-holding inventors than in more hierarchical organizational settings in industry or academia.

TABLE 7A.3 *Number of researchers by gender and scientific field, 1996–2000 vis-à-vis 2011–2015*

		Brazil				México			
Scientific field	Period	Women	Men	Total	% Women	Women	Men	Total	% Women
Agriculture and Biological Sciences	1996–2000	4,429	6,253	10,682	41.5	1,652	3,014	4,666.00	35.4
	2011–2015	40,433	42,251	82,684	48.9	8,578	13,067	21,645.00	39.6
Arts and Humanities	1996–2000	61	91	152	40.1	50	70	120.00	41.7
	2011–2015	3,195	3,452	6,647	48.1	1,010	1,406	2,416.00	41.8
Biochemistry, Genetics and Molecular Biology	1996–2000	4,696	4,716	9,412	49.9	1,877	2,287	4,164.00	45.1
	2011–2015	34,620	28,462	63,082	54.9	8,690	11,305	19,995.00	43.5
Business, Management and Accounting	1996–2000	30	108	138	21.7	15	60	75.00	20.0
	2011–2015	2,334	4,317	6,651	35.1	413	869	1,282.00	32.2
Chemistry	1996–2000	1,977	2,838	4,815	41.1	328	962	1,290.00	25.4
	2011–2015	14,998	15,972	30,970	48.4	2,451	4,454	6,905.00	35.5
Chemical Engineering	1996–2000	896	1,802	2,698	33.2	821	1,497	2,318.00	35.4
	2011–2015	8,040	9,550	17,590	45.7	4,111	6,690	10,801.00	38.1
Computer Science	1996–2000	509	2,107	2,616	19.5	146	800	946.00	15.4
	2011–2015	5,985	19,896	25,881	23.1	2,333	7,833	10,166.00	22.9
Decision Sciences	1996–2000	51	193	244	20.9	10	78	88.00	11.4
	2011–2015	1,660	4,892	6,552	25.3	168	557	725.00	23.2
Dentistry	1996–2000	307	401	708	43.4	34	76	110.00	30.9
	2011–2015	7,073	5,682	12,755	55.5	199	272	471.00	42.3
Earth and Planetary Sciences	1996–2000	548	1,819	2,367	23.2	4,468	8,763	13,231.00	33.8
	2011–2015	444	1,480	1,924	23.1	1,722	3,902	5,624.00	30.6

(*continued*)

TABLE 7A.3 (*continued*)

		Brazil				México			
Scientific field	Period	Women	Men	Total	% Women	Women	Men	Total	% Women
Economic, Econometrics and Finance	1996–2000	36	125	161	22.4	36	119	155.00	23.2
	2011–2015	800	2,027	2,827	28.3	306	771	1,077.00	28.4
Energy	1996–2000	194	911	1,105	17.6	145	1,037	1,182.00	12.3
	2011–2015	2,684	7,539	10,223	26.3	423	2,453	2,876.00	14.7
Engineering	1996–2001	993	5,176	6,169	16.1	423	2,453	2,876.00	14.7
	2011–2015	11,549	27,783	39,332	29.4	3,638	11,806	15,444.00	23.6
Environmental Science	1996–2000	1,091	2,056	3,147	34.7	819	1,495	2,314.00	35.4
	2011–2015	13,248	17,725	30,973	42.8	4,247	7,550	11,797.00	36.0
Health Professions	1996–2000	135	319	454	29.7	61	135	196.00	31.1
	2011–2015	13,248	17,725	30,973	42.8	301	453	754.00	39.9
Immunology and Microbiology	1996–2000	2,944	2,629	5,573	52.8	996	1,347	2,343.00	42.5
	2011–2015	17,190	12,411	29,601	58.1	3,766	4,552	8,318.00	45.3
Mathematics	1996–2000	437	1,876	2,313	18.9	151	967	1,118.00	13.5
	2011–2015	3,657	11,058	14,715	24.9	1,384	5,614	6,998.00	19.8
Materials Science	1996–2000	924	2,629	3,553	26.0	483	1,603	2,086.00	23.2
	2011–2015	8,291	14,108	22,399	37.0	2,723	6,745	9,468.00	28.8
Medicine	1996–2000	8,617	11,194	19,811	43.5	3,721	5,784	9,505.00	39.1
	2011–2015	80,635	64,902	145,537	55.4	17,282	21,205	38,487.00	44.9
Multidisciplinarity	1996–2000	285	473	758	37.6	61	179	240.00	25.4
	2011–2015	2,681	3,347	6,028	44.5	520	1,039	1,559.00	33.4
Neuroscience	1996–2000	1,171	1,377	2,548	46.0	434	602	1,036.00	41.9
	2011–2015	8,860	7,008	15,868	55.8	1,790	1,376	3,166.00	56.5

Nursing	1996–2000	386	146	532	72.6	60	82	142.00	42.3
	2011–2015	10,556	3,916	14,472	72.9	1,524	1,027	2,551.00	59.7
Pharmacology, Toxicology and Pharmaceuticals	1996–2000	1,751	1,377	3,128	56.0	828	1,037	1,865.00	44.4
	2011–2015	8,860	7,008	15,868	55.8	2,930	3,175	6,105.00	48.0
Physics and Astronomy	1996–2000	1,144	4,171	5,315	21.5	506	2,383	2,889.00	17.5
	2011–2015	8,415	16,942	25,357	33.2	2,727	8,259	10,986.00	24.8
Psychology	1996–2000	221	242	463	47.7	254	236	490.00	51.8
	2011–2015	5,343	2,931	8,274	64.6	1,512	1,424	2,936.00	51.5
Social Sciences	1996–2000	450	658	1,108	40.6	282	468	750.00	37.6
	2011–2015	11,743	12,014	23,757	49.4	2,904	4,077	6,981.00	41.6
Veterinary	1996–2000	768	1,484	2,252	34.1	153	309	462.00	33.1
	2011–2015	11,385	10,908	22,293	51.1	1,072	2,178	3,250.00	33.0

Source: U.N. Development Programme (n.d.-c).

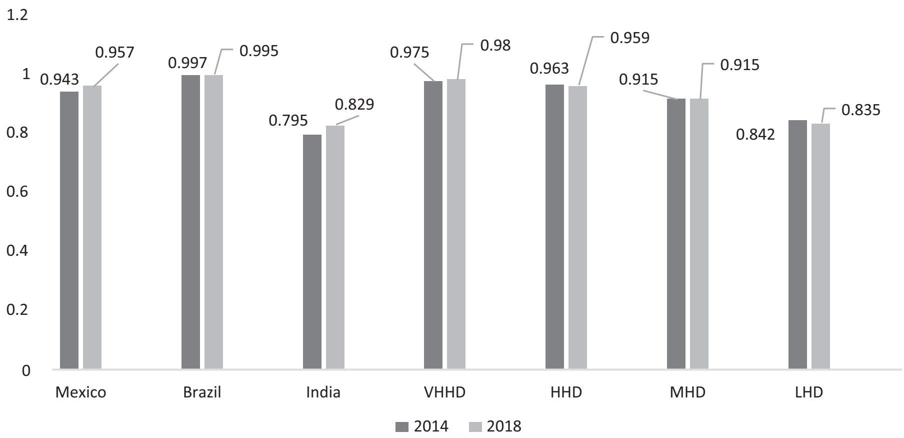

FIGURE 7A.1 GDI of Mexico, Brazil, and China vis-à-vis different country groups*.
*For the four groups of countries, it is GII average years.
Source: U.N. Development Programme (n.d.-c).