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REGIONAL DISTRIBUTION OF THE NATIONAL SYSTEM OF INNOVATION ACTORS AND ECONOMIC DEVELOPMENT: AN INTERNATIONAL COMPARISON

Ulisses Pereira dos Santos

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REGIONAL DISTRIBUTION OF THE NATIONAL SYSTEM OF INNOVATION ACTORS AND ECONOMIC DEVELOPMENT: AN INTERNATIONAL COMPARISON

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SUMÁRIO

ABSTRACT

It is believed that actors of the National System of Innovation (NSI) influence and are influenced by regional aspects, such as geographical distribution. Based on this perspective the scientific, technological and economical performances in sub-national divisions of nine developed and developing countries are analyzed in this paper. The aim is to evaluate the hypothesis on the existence of higher regional concentration of NSI actors in developing countries. The results suggest that this hypothesis may be correct, since science, technology and innovation activities are more likely to be regionally concentrated in the richest regions in the developing countries under consideration, contrary to that observed in developed countries.

Key words: National Systems of Innovation, Regional Development, Economic Development, Developing Countries.

RESUMO

Acredita-se que os atores do Sistema Nacional de Inovação (NSI) influenciam e são influenciados por aspectos regionais, como a localização geográfica. Pautado nessa perspectiva, a *performance* científica, tecnológica e econômica de divisões subnacionais em nove países, desenvolvidos e subdesenvolvidos, é analisada neste trabalho. O objetivo é avaliar a hipótese de existência de maior concentração regional dos entes do NSI em países subdesenvolvidos. Os resultados sugerem que esta hipótese pode estar correta, dado que as atividades de C,T&I tendem a apresentar maior concentração regional nas regiões mais ricas dos países subdesenvolvidos aqui avaliados, em oposição ao que ocorre nos países desenvolvidos.

Palavras-chave: Sistemas Nacionais de Inovação, Desenvolvimento Regional, Desenvolvimento Econômico, Países em Desenvolvimento.

JEL: O10, O57, R58

1. INTRODUCTION

Regional inequalities happen in every country worldwide in both developed and developing economies. Authors, like Hirschman (1977) and Perroux (1967), since the 1960s have pointed to the imbalances in regional economic growth, even in developed countries. Nonetheless, regional inequalities seem to be more prevalent in less advanced economies, as a consequence of their late development (Furtado 1967a, 1967b; Pinto 2000). One of the causes of this situation might be related to the unequal distribution of the actors of the national system of innovation (NSI) between sub-national regions in the developing countries. In less developed countries, those actors tend to be concentrated in richest regions, which may reinforce a trend towards the regional concentration of income.

From this perspective, this paper analyses data from nine countries, comprising 219 sub-national regions, aiming to identify regional concentration patterns for science, technology and innovation activities and their correlation to the national level of economic development. The main objective is to determine if the NSI actors' regional concentration is, in fact, higher, in less developed countries. To this end, the number of scientific articles published by residents in sub-national regions, the number of patent applications, and the regional level of income (regional GDP) and population are used in the current analysis.

The nine countries are divided in two groups, the developing countries: Brazil, China, India, Mexico and South Africa; and the developed countries: Australia, Canada, Germany and United States. Those countries were chosen based on the existence of well-established sub-national divisions, such as states or provinces. Characteristics such as the existence of federal systems and the territory extent were also considered, as well as the availability of sub-national data in official databases and the coverage of the five continents[1].

Information pertaining to regional income and population were taken from official national statistics departments in their web sites[2]. Since regional GDP is often available in those web sites only in local currency, the purchasing power parity index, provided by World Bank online database, was used to compare the regions in terms of income[3]. Those data are referent to the year of 2010.

Technological production is measured through the number of patent applications in the United States Patent and Trademark Office – USPTO – in 2010 for residents in the analyzed regions. These data were taken by an electronic tool developed to search for the desired information in the USPTO's website. Academic articles published in indexed journals by the Institute for Scientific Information – ISI – are used as proxies for regional scientific production for the year of 2010. USPTO and ISI data were chosen based on their constant use in international comparisons regarding to NSIs. These databases provide information about the regional location of patent applicators or article authors; therefore, they are also applicable for the present analysis.

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[1] The availability of information in English or Spanish languages in official websites was an additional criterion for the selection of the analyzed countries.

[2] Statistics Canada (http://www.statcan.gc.ca), Instituto Nacional de Estadística y Geografía – Mexico (http://www.inegi.org.mx/), Statistics South Africa (www.statssa.gov.za), Australian Bureau of Statistics (www.abs.gov.au), Ministry of Statistics – India (http://mospi.nic.in), Federal Statistics Office – Germany (www.destatis.de), National Bureau of Statistics of China (www.stats.gov.cn/english), US Bureau of Economic Analysis (www.bea.gov) e IPEADATA-Brazil (www.ipeadata.gov.br).

[3] http://data.worldbank.org.

Those data are used herein to evaluate the patterns of regional concentration of science, technology and innovation – S,T&I – activities in the above mentioned countries. This paper is divided in five more sections. In the second regional aspects of NSI are discussed. In the third general characteristics of the nine countries analyzed are presented. In the fourth section, the regional concentration of income is matched to regional distribution of scientific and technological activities in those countries. In the fifth section development patterns for S,T&I structures and economic performance are evaluated for the sub-national regions in the nine countries analyzed. The last section presents the conclusions of this paper.

2 THE REGIONAL ASPECTS OF THE NSI

The influence of regional space over technological innovation has been a matter of research for a long time. Many authors have found that spatial amenities improve the technological performance of the firms (Asheim and Gertler 2005; Cooke 1998; Jaffe 1989). Factors as the embeddedness of firms and agents, the learning infrastructure, agglomeration economies and the spatial spillovers were described as fundamental regional aspects for the innovative activity of industrial firms (Cooke 2001; Florida 1995; Granovetter 1985). This field of analysis asserted the importance of spatial proximity for the improvement of the intangible aspects related to innovative processes, such as the information flows and trust-based relationships between the agents (firms, universities and research centers) in technological projects.

Most of this literature was influenced by neoschumpeterian research, including the NSI's literature, and was performed by an eclectic group of regional analysts, including regional economists, social scientists and geographers. Its contribution improved old regional concepts by adding to them a neoschumpeterian approach, such as the concept of Marshallian industrial districts (Harrison 1992; Marshall 1983), and introduced new concepts such as the Regional Innovation System (Cooke 1992). All of the coined or re-coined concepts arose mainly during the 1980s and the 1990s and tried to explain both the regional aspects in the innovative performance of firms and the importance of technological activity for regional development in the global economy (Cooke 1998).

In the NSI agenda, however, the major focus was on the institutions and organizations established to promote learning relationships for innovation (Freeman 1987, 1995; Lundvall 1995; Nelson and Rosenberg 1993). The importance of regional space was ignored for most of the scholars in this field during the shaping of the NSI concept and its later developments. Freeman (1987; 2002) was the author in the NSI's agenda who most gave attention to regional aspects for the innovation process and economic development. In his memorable book about Japanese catch up, Freeman (1987) pointed to the use of regional policy in the construction of the Japanese system of innovation. This policy prompted the central government to create municipal research centers and laboratories to develop R&D activities and give technical assistance to local industry.

Fifteen years later, the same author challenged the innovation systems researchers to determine the relationships between innovative structures in different regional scales. In this paper, the author considered the existence of sub-national, national and continental systems of innovation that relate to each other in the promotion of the scientific and technological knowledge. For Freeman (2002), those different scales for innovation systems are complementary rather than concurrent. Freeman (2002) also calls for a better understanding of the relationships between sub-national innovative structures and the NSIs to advance research in economic development.

This paper follows Freeman (2002) in calling for a better understanding of innovative policies at regional and national levels instead of separating them in two opposite or unrelated spheres. In addition, the preponderance of federal or national policy over regional action reinforces the difficulty of isolating sub-national and national levels in terms of innovation systems (Edquist 2005). Therefore, it is proposed here that NSIs influence and are also influenced by regional development and inequalities within the country. Thus, each one of the NSI actors is related to a regional environment being influenced and, at the same time, influencing it (Cooke 1998). Those mutually interacting and cumulative influences might determine both the innovative activity of the local firms and, as a consequence, the level of regional development. Imbalances in regional development within a specific country may result, therefore, from a concentration in the regional distribution of the NSI agents as well as from problems in regional distribution of economic activities. Thus the technological trajectory of the regions is a response to specific historical events that shaped the regional location of S,T&I assets around national space (Cooke 2001).

On the other hand, a highly concentrated distribution of NSI actors along national territory might narrow it, since sub-national regions that could contribute to improving national scientific and technological productions would not have the necessary assets for this. As a result, the NSI gets stuck below its potential level of technological and scientific development. This might be a characteristic of NSIs in developing countries, where the regional concentration of economic activities and infrastructural assets is very common (Furtado 1967a). This possible higher concentration of the NSI assets in less developed countries is the subject of analysis in the following sections of this paper.

3. ECONOMIC DEVELOPMENT AND REGIONAL CONCENTRATION OF INCOME

Table 1 shows general features about the nine countries examined. According to the per capita GDP, it is clear that there is a huge gap between the developed and the developing countries. Considering population and territorial extension, it is possible to determine that even in the geographically larger countries and in the more populous for the developed countries the per capita income is still very large. It can be seen in a comparison involving US and China or India. Even though these three countries are very large geographically and have large populations, the US has a very superior per capita GDP in comparison with the two others. In the case of China and India, despite their large GDPs they are not able to generate enough per capita income for their populations, as seen by their very low per capita GDP indexes.

TABLE 1
General characteristics of the evaluated countries – 2010

Country	Per Capita GDP (US$)	Population 2010	Territoral Extension Km2	Number of sub-national divisions
Brazil	10,978.09	195,210,154	8,515,767	27
China	4,433.36	1,337,705,000	9,596,961	31
India	1,419.11	1,205,624,648	3,287,590	32
Mexico	8,780.24	117,886,404	1,958,201	32
South Africa	7,266.08	49,991,300	1,221,037	9
Australia	51,586.09	22,065,300	7,692,024	8
Canada	46,211.53	34,126,547	9,984,670	13
Germany	40,163.82	81,776,930	357,051	16
USA	46,615.51	309,326,225	9,371,175	51

Source: Author's own elaboration. Data from World Bank.

The nine countries show very different sub-national divisions. Although most of them are federalized and divided into states or provinces, some of these countries have specific sub-national divisions, especially India and China. India is comprised of 28 federal states and 7 territories from which only 4 were considered in the present analysis due to the limited availability of information[4]. In China, the regional sub-divisions of the territory comprise 22 provinces, 4 municipalities, 5 autonomous regions and 2 special administrative regions. The municipalities, like Beijing and Shanghai, have the same status as the provinces. The autonomous regions, such as Tibet and Mongolia, also have similar status to the provinces, but hold larger legislative rights because they are constituted predominantly by ethnic minority groups. The special administrative regions have greater administrative independence from the Chinese central government. The two special administrative regions, Hong Kong and Macau, are not included in this analysis because of their dispersed character in relation to the other Chinese regions and the unavailability of data from official Chinese sources. Thus 31 sub-national regions are considered for China in this work. The other seven countries of this study are divided into states or provinces and territories, which can be compared without major methodological problems.

Data pertaining to the scientific articles published and to patent applications per million of inhabitants for the evaluated countries are presented in Table 2. It is possible to determine that the number of articles per million of inhabitants in the less developed countries is much smaller than the one verified in developed countries. Even countries with great number of publications in absolute numbers, as Brazil, China and India, show scientific production below the possibilities offered by their population scales. This aspect points to the necessity of increasing the scientific activity in less developed countries. Looking at the sub-national regions with the highest number of articles per million of inhabitants in their countries, a special case is Beijing (China). This region has a number of articles per million of inhabitants as high as that observed in the top regions in developed countries like Canada

[4] Information available in Indian Government official website: http://india.gov.in.

and Germany. Comparing the performance of Beijing with all the country it is possible to observe evidence of geographical concentration of scientific production in that municipality.

TABLE 2
Scientific Articles and Patents per 1 million of inhabitants by country – 2010

	Articles	Patents
Brazil	153.465	0.174
China	100.671	1.610
India	34.866	0.092
Mexico	73.613	0.331
South Africa	169.529	0.580
Australia	2,375.857	25.696
Canada	1,469.618	52.950
Germany	1,012.437	47.789
USA	966.245	348.386

Source: Author's own elaboration. Data from Statistics Canada, INEGI – Mexico, Statistics South Africa, Australian Bureau of Statistics, Ministry of Statistics – India, Federal Statistics Office – Germany, National Bureau of Statistics of China, US Bureau of Economic Analysis, IPEADATA – Brazil and USPTO.

Table 3 shows some homogeneity among the developed countries. All of those countries have CVs below 0.2, which is a sign of little variability between their regional per capita GDPs. In the case of the Theil index, a very similar scenario was found. On the other hand, for developing countries, CVs and Theil index values are higher, suggesting a larger variation between the regional GDPs within these countries. In other words, those results suggest that developed countries have more homogeneous regions in terms of income than developing countries. In the case of developing countries, there was a tendency toward greater income inequality between regions.

TABLE 3
Theil Index and Williamson's Coefficient of Variation for regional income (GDP) – 2010

	Theil Index	Williamson's Coefficient of Variation
Brazil	0.112	0.463
China	0.082	0.423
India	0.120	0.496
Mexico	0.130	0.707
South Africa	0.045	0.298
Australia	0.014	0.184
Canada	0.017	0.199
Germany	0.018	0.188
USA	0.014	0.191

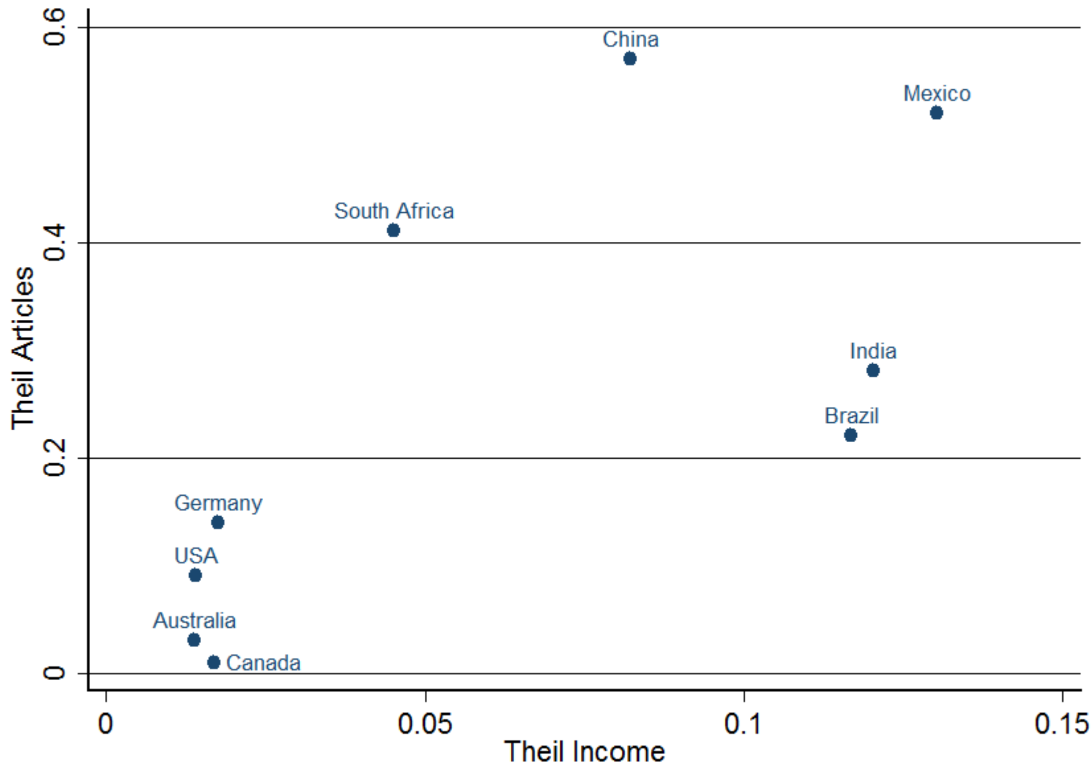
Source: Author's own elaboration. Data from Statistics Canada, INEGI – Mexico, Statistics South Africa, Australian Bureau of Statistics, Ministry of Statistics – India, Federal Statistics Office – Germany, National Bureau of Statistics of China, US Bureau of Economic Analysis and IPEADATA – Brazil.

This analysis of CV and Theil index points to the existence of major sub-national disparities in developing economies compared to the developed ones. It is known that those results cannot be generalized due to the small number of observed countries, but the high contrast between the two groups (developed and developing countries) seen in Table 3 allows hypothesizing about such a tendency. Moreover, these results have already been predicted and confirmed by the literature on economic development and regional economy. In terms of theory, important authors in the Latin American Structuralist school, such as Pinto (2000) and Furtado (1967a, 1967b), drew attention to the relationship between structural/regional heterogeneity and underdevelopment. In terms of empirical contributions, the original work of Williamson (1965) compared various countries and noted that the existence of dual sub-national economies would be related to an incomplete development trajectory for national economy.

Table 3 indicates, therefore, that the hypothesis of greater regional concentration of income in the developing economies is confirmed for the set of countries used here. The threshold difference with respect to the Williamson's CV and the Theil index among developed and developing countries points to this as well as the fact that Williansom (1965) has already observed this phenomenon in the 1960s.

Following the Theil Index is used to provide clearer evidence about patterns of regional distribution of scientific activity in developed and developing countries. Here the variable regional GDP was replaced by the number of articles per region in the Theil Index formula. The results are presented in the Chart 1, which is a graph that shows in its horizontal axis the Theil Index for Income (GDP) and in the vertical axis the Theil Index for scientific production as a way to compare the regional behavior of those variables for the evaluated countries.

CHART 1
Theil Index for Income and Regional Scientific Production in the Analyzed Countries – 2010



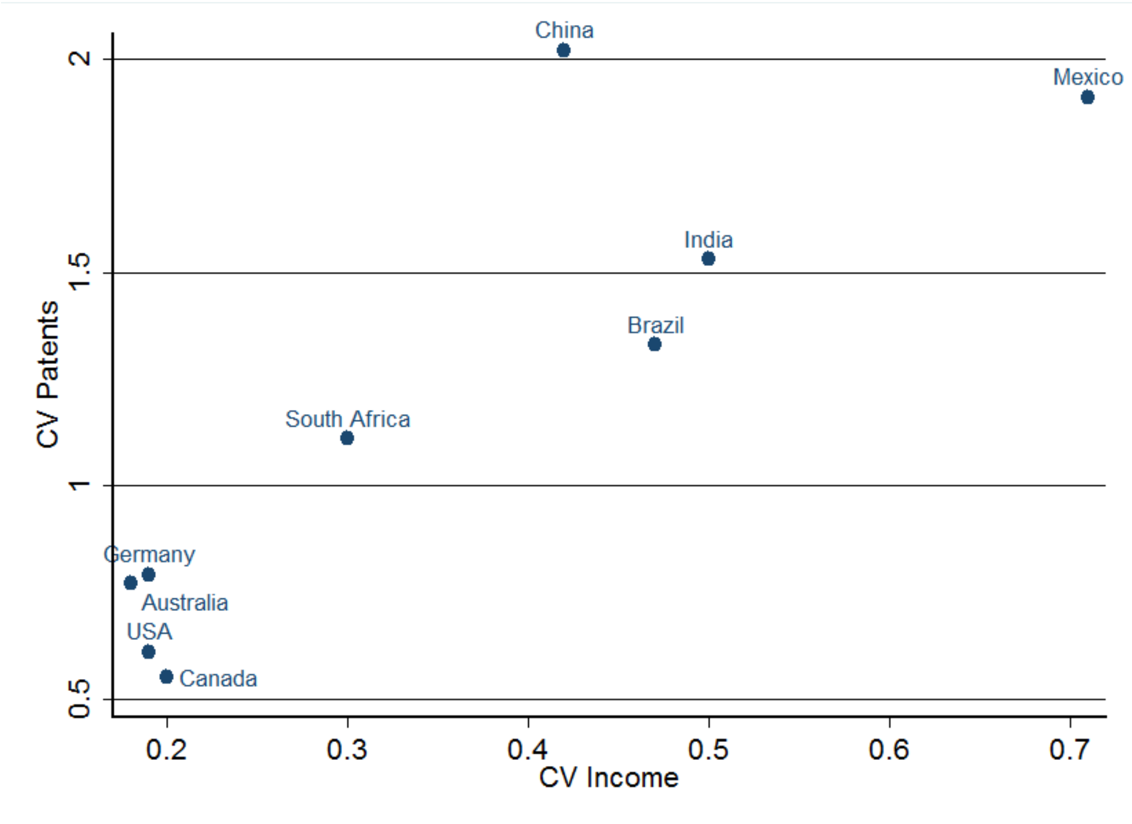
Source: Author's own elaboration. Data from Statistics Canada, INEGI – Mexico, Statistics South Africa, Australian Bureau of Statistics, Ministry of Statistics – India, Federal Statistics Office – Germany, National Bureau of Statistics of China, US Bureau of Economic Analysis and IPEADATA – Brazil

Chart 1 shows high homogeneity among the most developed countries in terms of regional distribution of internal scientific production and income. Australia, Canada, Germany and USA have the lowest levels of regional concentration for income. Similarly, the levels of regional concentration of scientific activity are lower in these countries. Among them, Germany is the one with the highest Theil Index value for scientific activity, 0.16.

Among the less developed countries, there is no homogeneity in terms of the regional distribution of income or scientific activity, since their Theil index values are more dispersed on the chart. The results observed show that the less developed countries are more likely to demonstrate a regional concentration of scientific activity than the developed ones. It would suggest a possible imbalance in the regional distribution of the national scientific actors within these economies. So it is possible to relate the regional distribution of income with the regional distribution of NSI institutions based on the scientific activity within the sub-national regions.

In the following analysis of regional concentration of technological activity is based in an index weighted by regional populations. In this analysis of technological activity, the Williamson Weighted Coefficient of Variation - CV - is used. In this way, the high number of zeros in the dataset disrupts the calculation of the Theil index. However, CV is a classical index used for the analysis of regional imbalances in income, first presented by Williamson (1965) in a study comprising regions of developed and developing countries. The CV substitutes the Theil index in this section given the great number of sub-national regions with no patent applications identified in USPTO data set for 2010.

CHART 2
Williamson's Coefficient of Variation for Income and Technological Production in the Evaluated Countries – 2010



Source: Author's own elaboration. Data from Statistics Canada, INEGI – Mexico, Statistics South Africa, Australian Bureau of Statistics, Ministry of Statistics – India, Federal Statistics Office – Germany, National Bureau of Statistics of China, US Bureau of Economic Analysis and IPEADATA – Brazil.

Chart 2 shows the CVs of regional income (horizontal axis) to technological production (vertical axis). As for scientific production, it is possible to test if there is a more homogeneous pattern for the developed countries. Among them, Germany is the one with the highest level for regional concentration of technological activity, according to the CV index, 0.79. On the other hand, South Africa is the less developed country with the lowest level of regional concentration for technological activity; the CV is 1.11. A higher heterogeneous pattern of regional distribution of income and patent applications for the developing countries was identified again, in contrast to the homogenous pattern observed among the developed countries.

In this way, it is observed a trend toward higher regional concentration of regional technological activity within less developed economies. This result allows associating the regional concentration of patents applications to the underdevelopment stage of Brazil, China, India Mexico and South Africa. In addition, this result must be associated with the regional distribution of scientific activities, since science and technology have a close relationship (Nelson and Rosenberg 1993).

Thus, it is possible to establish a connection between the regional distribution of the NSI actors, based on scientific and technological activities, and the development level for the nation. The analysis performed here suggests that most developed countries tend to have a more equitable regional distribution of NSI agents across their sub-national regions than the developing ones. In this way, seeking a more equitable territorial distribution of NSI actors may be a strategy to overcome the problems related to the underdevelopment.

5. AN EVALUATION OF ANALYZED REGIONS ACCORDING TO S,T&I INDICATORS

In this section, the performance of the analyzed sub-national regions is evaluated based on their scientific and technological activities and their economic level. Introducing this analysis Table 4 shows the number of regions that manifested technological activity in 2010 for the nine countries. All of the regions with technological activity also performed scientific activity. This result reinforces the importance of science for technological development. Moreover, it suggests possible positive effects of physical closeness between the agents related to scientific activities and the ones related to technological development, independently of the national development level (Jaffe, 1989).

TABLE 4
Number of sub-national regions with scientific and technological activities by country – 2010

	Regions with patents and articles	Regions only with articles	Regions with no patents and no articles	Total of Regions
Brazil	4	23	0	27
China	20	11	0	31
India	9	22	1	32
Mexico	9	23	0	32
South Africa	5	4	0	9
Australia	7	1	0	8
Canada	10	3	0	13
Germany	16	0	0	16
USA	51	0	0	51
Total	**131**	**87**	**1**	**219**

Source: Author's own elaboration. Data from USPTO and ISI.

In the developed countries, most of the regions showed both scientific and technological activities. The exceptions are one sub-national region in Australia and three sub-national regions in Canada, but all of the sub-national divisions in these countries have scientific activity.

Among the developing countries, only China and South Africa have most of their regions showing technological activity. For the other developing countries, most of the sub-national regions performed only scientific activities. This is one of main problems of less advanced NSIs, the disconnection of scientific and technological activities. As happens in Brazil, for example, there is relevant scientific production that is underused by the internal industries to create technological improvements. (Albuquerque 1999). India was the only country of the nine with one of its sub-national region without any patent application and scientific article for the year of 2010.

Based on the difference among regions located in developed countries and regions located in developing, a grouping covering all the 219 regions is presented in this section. The regions are divided into four groups differentiated by the development level of the countries they belong to and by its technological performance. Thus, the criterion by which regions from developing countries are categorized is based upon whether they performed patent applications in the USPTO.

For the developed countries, in their turn, since almost all the regions had technological activity in 2010, the criteria used to group the regions is the number of patents per million of inhabitants. A first group covers regions with at maximum 30 patents per million of inhabitants. The other group is comprised by regions of developed countries with more than 30 patents per million of inhabitants. It was observed that regions with more than 30 patents per million of inhabitants tend to be more homogeneous in terms of S,T&I indicators. On the other hand regions of developed countries with less than 30 patents per million of inhabitant are less homogeneous to other regions in similar situation. The four groups are described as follow:

1. Regions from the five developing countries that had no patents identified in 2010 in USPTO;
2. Regions from the five developing countries that had patents identified in 2010 in USPTO;
3. Regions from the four developed countries that had up to 30 patents per million of inhabitants identified in USPTO in 2010;
4. Regions from the four developed countries that had more than 30 patents per million of inhabitants identified in USPTO in 2010.

Table 5 shows the number of sub-national regions per country in each of the four groups. Group 1 is the larger among the four, formed by a great number of regions without patents from mainly Brazil, India and Mexico. As noted above, in these countries most of the sub-national regions did not have patents identified in 2010. Group 2, formed by the regions from developing countries with technological activity is predominantly composed by Chinese localities. In this group 43% of the regions are in China which may explain the recent economic success of that country. Brazil is the country with the smallest number of regions in Group 2, although it has three times more states than South Africa.

TABLE 5
Distribution of the regions among the groups by country

	Categories				
Country	**1**	**2**	**3**	**4**	**Total**
Brazil	23	4	0	0	**27**
China	11	20	0	0	**31**
India	23	9	0	0	**32**
Mexico	23	9	0	0	**32**
South Africa	4	5	0	0	**9**
Australia	0	0	7	1	**8**
Canada	0	0	8	5	**13**
Germany	0	0	11	5	**16**
USA	0	0	0	51	**51**
Total	**84**	**47**	**26**	**62**	**219**

Source: Author's own elaboration. Data from USPTO and ISI.

For developed countries, with regions in groups 3 and 4, it is determined that most of the regions are in the last group. This result is a consequence of the presence of all USA sub-national regions (states) in the group 4. This demonstrates USA technological leadership in the world. In their turn, Canadian, Australian and German regions in this group have similar technological performance to USA regions.

Some variables are used to evaluate the characteristics of each group. These variables with their average values are displayed on Table 6. The development level differences between the regions in the four groups are clear. For the regions of less developed countries classified in groups 1 and 2, it is possible to confirm that scientific activity is greater in regions with technological activity. This is further evidence of the importance of scientific structure to technological performance in sub-national regions. This result suggests that regions with well-established scientific infrastructure tend to be more likely to have innovations than others, representing evidence in favor of the learning regions approach (Asheim 1996; Florida 1995). In this approach, the information channels among scientific and technological actors would be enhanced given the physical proximity and the sharing of same social and cultural environments by the agents (Cooke, 1998; Jaffe, 1989).

TABLE 6
Average values for evaluated regional variables for the groups

	Groups				Total
	1	2	3	4	
Articles/million of inhabitants	72.230	151.660	1,109.470	1,447.510	601.770
Regional per capita GDP	8,905.260	10,238.260	38,440.220	48,262.750	23,840.070
Share in national GDP	0.020	0.070	0.050	0.040	0.040
Share in national population	0.020	0.060	0.050	0.040	0.040
GDP per capita deviations from national (National=100)	101.800	119.420	97.030	106.940	106.470
Number of observations	84	47	26	62	219

Source: Author's own elaboration. Data from Statistics Canada, INEGI – Mexico, Statistics South Africa, Australian Bureau of Statistics, Ministry of Statistics – India, Federal Statistics Office – Germany, National Bureau of Statistics of China, US Bureau of Economic Analysis and IPEADATA – Brazil.

Considering the regions of developed countries, is it also possible to identify differences in terms of scientific production for the groups 3 and 4. The group with the highest technological activity is also the one with the highest scientific activity level. So regions that have a larger amount of articles are likely to have also a larger amount of patent applications. As observed for the developing countries, this result leads to conclusion that sub-national regions with good scientific assets are likely to be more innovative, as the literature has already shown for countries (Bernardes and Albuquerque 2003). Another point is related to the distance between the regions classified in groups 3 and 4 in terms of scientific production. The average amount of articles per million of inhabitants published by residents in the regions in group 3 represents 77% of the amount observed in group 4. Among the less developed countries, the average number of articles per million of inhabitants for group 1 is 48% of the value for group 2. This situation stresses that regions in most developed countries tend to be more homogeneous than regions in developing countries, since the difference in scientific production between groups 3 and 4 is not that high.

Additionally, there is a high difference between average scientific activity between developed and developing countries. The average amount of scientific articles published by residents in regions of group 2 represents only 15% of the total observed in group 3 and 10% of the observed value in group 4. It illustrates the backwardness of innovation systems in developing countries compared to the most developed countries. Even in the richest regions in developing countries have scientific activities in a very lower level compared to those performed by regions in developed countries. This condition might be related to the high regional concentration of NSI actors in peripheral economies, as noted above. So the small number of sub-national regions with developed S,T&I infrastructures reduces the scientific possibilities along national territory, which also happens to technology activity. In this way the absence of scientific scale narrows the development opportunities including for the richest regions in developing countries. As a result, these less developed countries have scientific activity in smaller scales in the aggregate.

According to this interpretation, a concentration of the S,T&I assets in the most dynamic sub-national regions in peripheral economies will not be sufficient to enable them to push the rest of country to a scientific and technological level close to that performed by developed countries. Hence, most dynamic regions need the rest of the country to advance national development. Furthermore, structural improvements in depressed areas might make them more likely to develop their regional economies. Such measures might generate benefits for the richest regions through the establishment of scientific and technological networks and the opening of new and more diverse markets within the same country, i.e., internal economic integration. In this context, imbalances in regional distribution of development and S,T&I assets are not expected to disappear, but they might be smaller as already checked in the developed countries analyzed here. Thus, the catch up process might also be affected by spreading S,T&I assets over the national territory, since it presupposes an increase in national scientific and technological activities.

It is given here that high regional concentration of NSI actors inhibits the national catch up process in reason of the restrictions caused over the development of richest and poorest sub-national regions. As a consequence, the developing countries analyzed here demonstrate a reduced scale for national scientific and technological activities. This idea is clearly related to the differences in the level of regional distribution of scientific and technological activities among developed and developing countries analyzed above. Therefore, a better distribution of S,T&I assets across sub-national regions might be a policy argument for national catch up process, since it increases the scientific and technological scales and generates new technological opportunities across the national territory.

Table 6 also shows that regions in group 2 tend to have per capita GDP in average numbers superior to regions in group 2. Those regions also exhibit average per capita GDP higher than the overall country. This result confirms that the regions with patents applications tend to be the most developed ones in their respective countries. These regions possess higher shares of the national GDP and populations. So regions with technological activity in less developed countries are more developed than the other sub-national regions and concentrate larger shares of economic activity and population. In the Brazilian case, for instance, the state of Sao Paulo is responsible for 30% of national GDP, 22% of the populations and 70% of the national patent applications in USPTO in 2010. Taken together the four Brazilian states that had patent applications in USPTO in 2010 are responsible for 60% of Brazilian GDP.

In India, nine of thirty-two regions had patent applications, and those nine represent together 70% of the national GDP. The state of Maharashtra has the major regional GDP in India and is responsible for one third of the patent applications from the country in USPTO. In China, most of the regions had patent applications in 2010, nevertheless only five had more than one patents per million of inhabitants. The state of Guangdong concentrates 67% of Chinese patents in USPTO and also is the state in the country with the highest number of patents per million of inhabitants. Moreover, Guangdong is the province with major shares in national GDP and population. However, the sub-national region with the highest scientific production in the country is the municipality of Beijing.

These results associate the better performance in technological and scientific aspects to the regions that are more representative in national economy and population for developing countries. This association is not manifested in the developed countries. Even though the national scientific and technological leaders are also the regions with highest per capita GDP, these regions are not the most representative in national populations or GDPs. That is, in developed countries the economic scale of the regions is not a prerequisite for their scientific or technological activity. Another important result is related to the regional per capita GDP deviations from the national value. While group 3 regions are on average below the national per capita GDP, the regions in group 4 are above it. Thus, the technological performance of regions in developed countries is related to regional development level. Nevertheless regional development in this case is not a synonymous of high participation in national GDP or population as it is in less developed countries. This demonstrates another structural difference among developed and developing countries. For the developing countries most dynamic regions concentrate technological and scientific activities as well as income. On the other hand, in developed countries even regions with small shares in national income and population are able to have great scientific and technological positions.

In the USA, for example, the state with the largest shares in national GDP and population is California, which is also the state with the greater number of patents in the country. However, if technological production is weighted by the regional population, then the state with the best result is Vermont, even representing only 0.18% of national GDP. States like Washington and Massachusetts, with a share of almost 2% of the USA GDP, also overcome California in terms of patents per million of inhabitants. In Germany, the state with the largest share of national GDP, North Rhine-Westphalia, neither is the one with the largest number of patents. That state is Bavaria. North Rhine-Westphalia has only the sixth largest number of patents per million of inhabitant in the country, even though it is responsible for 22% of German GDP. This state is overcome by other states, such as Hamburg that represents 3% of national GDP and Rhineland-Palatinate with 4%.

Therefore, while in developing countries only regions with most representative economies are able to develop technological innovations, in developed countries even regions with small scale economies have great technological activity relative to their populations. This difference might be a consequence of the relatively strong concentration of S,T&I assets in the richest sub-national regions in developing countries. In this way states, provinces or cities with the largest GDPs in these countries tend to host the major part of NSIs in these countries. This condition seems to be a natural consequence of market forces since the regional economic development for these regions demands and induces the building of scientific and technological structures there. It is a result of a cumulative causation process, as described by Myrdal (1957) and by Furtado (1967a) and accentuates the regional imbalances in developing countries in the absence of national state's intervention. As a consequence, the existence of concentrated NSI structures for some regions is related to the regional income concentration in those countries. On the other hand, in developed countries the broader geographical distribution of NSI agents across national territory allows all of the regional economies to attain a higher technological performance.

6. CONCLUSION

In this paper, a comparison between sub-national regions located nine different countries was performed to evaluate the validity of the hypothesis that developing countries demonstrate higher regional concentrations of NSI assets. The analysis of the data for income and scientific and technological activities suggests that this hypothesis is correct, at least for the nine selected cases.

Regions within developed countries demonstrated a more homogeneous pattern of NSI assets between sub-national regions. On the other hand, it was possible to identify profound differences among sub-national regions both intra- and extra-country. The most important one is the fact of while in developing countries technological activities were restricted to a small number of sub-national regions, in the developed countries almost overall sub-national regions performed technological activity.

The performance shares of the regions in groups according to their technological activity showed the existence of regional patterns for both developed and developing national economies. First of all, the association between technological and scientific activities is clear for the regions. The regions with higher technological performance, independent of the country they belong to, are also among the regions with highest scientific activity. This result indicates that the regional improvements in technological activity demand the local establishment of a scientific structure. In addition there are regional aspects that make easier the relationship involving science and technology. Even though knowledge is a global asset in the information era, the physical proximity of the agents favors its transfer from universities and research institutes to industry, making innovation more likely. Thus, regional scientific structures are required for all sub-national regions and those regional assets require integration within the NSI institutions and agents to improve regional development possibilities. But this requirement is not met in the less developed countries, as data suggests here.

Another important issue in this analysis is related to the regional share of economic activity and the concentration of S,T&I activities in less developed countries. In these economies, there is tendency for only regions with the highest shares of national GDP to produce the relevant scientific and technological activities. This process is probably related to the previous economic development in those regions. As a result, the richest regions in peripheral economies are naturally driven to concentrate national income and most parts of NSIs in the absence of counter-concentration politics from national governments. This process tends to lead to the maintenance and to the reinforcement of regional income concentration in developing countries.

It is also important to note that the high degree of regional inequalities in developing countries can restrict the overall national scientific and technological productions. The evidence for this is the performance of the richest regions in those countries that is still very below that of the performance of regions of developed countries. This is a consequence of the strong imbalances among sub-national regions in terms of S,T&I structures. Hence, the innovative institutions in the richest regions cannot interact with surrounding areas that do not have similar institutions. This condition inhibits the development of S,T&I activities in the richest regions, which in turn inhibits the national catch up process. By contrast, the developed countries are comprised of more homogeneous sub-national regions. In these countries even the regions with smallest economies have consistent S,T&I structures and are important to the NSI. Each region is able to develop its own technological improvements and push surrounding areas with similar S,T&I by the regional spillovers created.

The results of this study are indicative rather than definitive since they refer to only a small group of countries. Nevertheless, the results found here are important and innovative given the lack of international comparisons regarding to sub-national regions. The main contribution of this paper is to show a tendency toward a higher regional concentration of NSI actors in developing countries. A comparison with developed economies suggests the need to spread NSI institutions across the national territory in developing economies as a means of attaining higher homogeneity among sub-national regions. This effort might have beneficial effects not only across less developed regions but also over the richest sub-national regions and, as a consequence, over the all of the NSI.

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