INNOVATION CAPACITIES OF MEXICAN STATES

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ABSTRACT

Objective: The objective of this study is to investigate the innovation performance of Mexican states to identify the factors that explain the unequal performance of Mexican states in terms of innovation generation.

Theoretical Framework: The study design is based on the regional innovation capabilities (RICs) proposed by Muller et al (2008).

Method: The impact of the RICs on the generation of innovations in Mexican states is analyzed using 17 indicators under a multiple regression model based on data from official Mexican sources for each of the 32 states.

Results and Discussion: The results show that regional technology absorption capacity is the factor that has the greatest impact on the innovation performance of Mexico’s states.

Research Implications: These results highlight the relevance of factors associated with technological learning for the patenting rate performance of Mexican states. These implications could include the designers and decision-makers of public policies on science and technology, as well as the institutions that produce research and development.

Originality/Value: This research can be a very particular reference for future research to address and propose new conceptual frameworks for the study of regional inequalities in the generation of innovations. In addition, this study evidences the need for greater availability of data related to innovation processes in the country.

Keywords: Innovation capabilities, innovation performance, factor analysis, regional innovation.

CAPACIDADES DE INOVAÇÃO DOS ESTADOS MEXICANOS

RESUMO

Objetivo: O objetivo deste estudo é investigar o desempenho inovador dos entidades federais do México, a fim de identificar os fatores que explicam o desempenho desigual na geração de inovações.

Referencial Teórico: O estudo baseia-se na conceituação de capacidades regionais de inovação (CRI), proposta por Muller et al (2008).

Método: O impacto do CRI na geração de inovações em entidades federativas é analisado através de 17 indicadores, sob um modelo de regressão múltipla, baseado em dados de fontes oficiais mexicanas para cada um dos 32 unidades federativas.

Resultados e Discussão: Os resultados mostram que a capacidade regional de absorção de tecnologia é o fator que tem maior impacto no desempenho inovador dos entidades federativas do México.

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Implicações da pesquisa: Estes resultados destacam a relevância dos fatores associados à aprendizagem tecnológica para o desempenho da taxa de patenteamento dos estados mexicanos. Estas implicações poderiam abranger os criadores e decisores de políticas públicas em torno da ciência e da tecnologia, bem como as instituições que produzem investigação e desenvolvimento.

Originalidade/Valor: Esta pesquisa pode ser uma referência muito particular para que pesquisas futuras possam abordar e propor novos marcos conceituais para o estudo das desigualdades regionais na geração de inovações. Além disso, este estudo específico mostra a necessidade de maior disponibilidade de dados relacionados aos processos de inovação no país.

Palavras-chave: Capacidades de inovação, desempenho inovador, unidades federativas.

LAS CAPACIDADES DE INNOVACIÓN DE LOS ESTADOS MEXICANOS

RESUMEN

Objetivo: El objetivo de este estudio es investigar el desempeño en innovación de los estados mexicanos, con el fin de identificar los factores que explican el desempeño desigual de las entidades federativas de México en cuanto a la generación de innovaciones.

Marco Teórico: El diseño del estudio se basa en las capacidades regionales de innovación (CRI), propuestas por Muller et al (2008).

Método: Se analiza el impacto de las CRI sobre la generación de innovaciones de los estados mexicanos mediante 17 indicadores, bajo un modelo de regresión múltiple a partir de datos en fuentes oficiales mexicanas para cada una de las 32 entidades federativas.

Resultados y Discusión: Los resultados muestran que la capacidad regional de absorción de tecnología es el factor que en mayor grado impacta en el desempeño en innovación de las entidades federativas de México.

Implicaciones de la investigación: Estos resultados destacan la relevancia que tienen los factores asociados con el aprendizaje tecnológico para el desempeño en tasa de patentamiento de las entidades federativas de México. Estas implicaciones podrían abarcar a los diseñadores y decisores de políticas públicas alrededor de ciencia y tecnología, así como a las instituciones productoras de investigación y desarrollo.

Originalidad/Valor: Esta investigación puede ser una referencia muy particular para que futuras investigaciones puedan abordar y proponer nuevos marcos conceptuales para el estudio de las desigualdades regionales en la generación de innovaciones. Además, este estudio particular evidencia la necesidad de una mayor disponibilidad de datos relacionados a los procesos de innovación en el país.

Palabras clave: Capacidades de innovación, desempenho en innovación, análisis de factores, innovación regional.

INTRODUCTION

Technological innovation has become a crucial factor for the economic development and social well-being of nations and regions, such that their “innovative capacity” is a critical factor. Especially if one takes into account that an important part of the productive growth and socioeconomic development of advanced nations corresponds to innovation, so we can consider it as one of the key factors of development, growth and employment (Fagerberg, Srholec and
Therefore, academic research is especially important on which components of an R&D&I system are most decisive as drivers of innovation and which are the factors that determine the innovative capacity of the systems. Some years ago, a prestigious analyst of innovation systems observed that we, as a society, still have limited systematic knowledge about the determinants of innovation at the territorial level and highlighted the relevance of undertaking comparative studies of the different types of innovation systems, as well as the determinants of the innovation processes within them (Edquist, 2005). Therefore, as observed by Buesa et al. (2010) these issues are receiving special attention today from both academics and those responsible for public policies.

This is the topic that is addressed in this work, in the case of the federal entities of Mexico. For which we start from an approach that we have called “regional innovation capabilities”.

Although today there is a significant amount of academic, theoretical and empirical contributions on the subject, a critical and in-depth analysis of the basic concepts of innovation capacity and innovation performance is still scarce. Similarly, little attention has been paid, conceptually, to the proper definition, operationalization and measurement of the input or capability side of innovation compared to the output or performance side (e.g., Janger et al., 2018)

This work aims to be a contribution to this debate from two perspectives. First, from a conceptual point of view, both the conceptual bases of the constructs of regional innovation capacity and innovation performance are critically discussed, as well as the limitations faced in their operationalization and measurement, also in light of the implications that the complexity of these dimensions (theoretical and empirical) can have for the design and implementation of policies. Second, we complement the theoretical discussion with a simple but relevant empirical exercise aimed at deepening the association between innovation capacity, i.e., the input side of innovation, and innovation performance, i.e., the input side innovation exit.

In the case of the second objective of this work, we focus on the regional context of Mexico (32 federal entities), based on the importance of innovation as a key driver for the economic development and well-being of the populations of these territories. To this end, we draw on the official data set for 2017 and 2018 in order to empirically clarify the concepts of innovation capacity and performance, and to evaluate the role of the different dimensions of the input side of the innovation process as determinants of territorial performance in innovation, taking into account its high heterogeneity: from public spending on research and development...
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(R&D), population dedicated to R&F&D&I activities, the population with higher education, etc. Also we explicitly account for regional differences in the context to identify different best-fit sets of innovation inputs, which also sheds light on the apparent inability of some regions to translate their input endowment into a maximized innovation output.

The rest of the paper is organized as follows. Section 2 theoretically analyzes the concepts of innovation capacity and performance extracted from the literature on innovation at the regional level. Section 3 presents the method elements of the empirical research carried out, while Section 4 presents the empirical results. Section 6 concludes the work by discussing the empirical evidence and outlining some policy implications.

2 THEORETICAL FRAMEWORK

2.1 PREVIOUS STUDIES ON DETERMINANTS OF THE GENERATION OF INNOVATIONS IN REGIONS AND ENTITIES

In the last 2 decades, a series of studies have been published that have worked on the line of research on the determinants of the productivity of innovations at the regional and sub-national levels (Piergiovanni and Santarelli, 2001; Fritsch, 2002; Riddel and Schwer, 2003; Li (2009; Buesa et al., 2010; German-Soto and Gutiérrez, 2015; Sánchez Tovar et al., 2014). countries (provinces or federal entities), or, they are economic regions. In all these studies, secondary data at a macro level are used as indicators of the production of innovations in the regions, specifically those concerning patents requested or granted, coming from government agencies in charge of registering them. However, in the case of the variables considered to explain regional differences in the productivity of innovations, the differences are notable. The oldest studies in this selection focused almost exclusively on factors related to the resources and capabilities to carry out R&D activities (infrastructure, financial resources, dedicated personnel, private and government spending on R&D). Another aspect that also stands out in older studies is the presence in the regions of high-tech companies (which have greater R&D capabilities) as a key determinant of the regions' innovation capacity, and a very important role adduced to R&D carried out in universities and research centers located in the territories.

Towards the mid-2000s, an important shift occurred in these studies, since the exclusive focus on R&D and its inputs was insufficient to understand regional divergences in economic growth and technological development. Studies begin to base their analyzes on multidimensional conceptual schemes, since from then on they begin to talk about capabilities...
other than regional R&D capacity, a phenomenon driven by the recognition of the insufficiency of approaches based on the new theory of growth and in the “stocks of R&D infrastructure. This shift was also influenced by the appearance of compendiums of more diverse indicators on the innovation capacities of European regions (Innovation Scoreboards), on the one hand, as well as a very influential publication by Furman, Porter and Stern (2002) on the national innovation capabilities.

In the case of studies on the regions of Mexico, the analysis trends described above can also be confirmed, since in the study by Sánchez Tovar et al. (2014) it is possible to see an inflection towards the incorporation of new dimensions when the study of innovation capabilities is addressed, which is verified in the inclusion of factors such as the economic and productive structure.

2.2 LIMITATIONS OF COMPOSITE INNOVATION INDICES

Also over the last two decades, many authors have addressed the problem of how to measure national or regional innovation capacity and have captured the intrinsic systemic complexity of the construct by avoiding representing it with a single global measure. To this end, evaluation systems have been developed based on a more or less high number of variables. However, several contributions have represented the national or regional innovation capacity with a set of variables, but the problem is that these composite indices mix indicators located “on the input side” with other indicators that are located “on the input side”, exit side” (e.g., Capello and Lenzi 2013: De Marchi and Grandinetti 2017).

The same combination of input and output variables is found in the various national or regional innovation indices that have been developed to support innovation policies, and which are then also used in scientific research (Hauser et al. 2018). Two of the most used composite indices are the European Innovation Index, developed at the initiative of the European Commission as a key element of the Lisbon Process (Schibany and Streicher 2008), and the Regional Innovation Index (RII), derived from the previous one, but based on a more limited number of indicators (Trippl, Asheim and Miörner 2016). In the regional innovation literature, the RII has been used to assess both the innovative performance of regions (e.g., De Noni, Orsi, and Belussi 2018) and their innovative capacity (e.g., Pavão, Couto, and Natário 2019). However, since the index is a combination of indicators of innovative capacity and innovation performance, it is actually not suitable to represent either the first or the second dimension (Edquist et al. 2018).
2.3 THE CRI APPROACH

With the objective of identifying the factors that determine the unequal regional dynamics of the generation of innovations, this work adopts the approach of Regional Innovation Capacities (RIC), a concept that is derived from that originally developed by Furman, Porter and Stern (2002) for national contexts, and which was later developed and adapted to sub-national/regional contexts by some European authors (Radosevich 2004; Muller 2006). In this section a description of this approach is made.

The study of “innovation capabilities” has largely been based on the set of contributions derived from the national innovation systems approach carried out by Lundvall (1992), Nelson and Winter (1982) and Edquist (1997). Recent literature highlights that science and technology are strongly linked to innovation capabilities. According to this approach, it is considered that countries or regions that invest in their innovation capabilities are those that have a cumulative and competitive advantage over their rivals. Furthermore, this approach emphasizes that technological knowledge is not distributed homogeneously, but depends on their previous efforts and capacity development (Lall, 1992).

The concept of innovation capacity has the characteristic of being a multidimensional concept, which authors such as Furman et al. (2002), Porter (1999), Radosevic (2004), Muller et al. (2006), Castellacci and Natera (2012) have approached it from different approaches. Despite being considered a highly stylized concept, it provides us with a first key definition to study the evolution of Regional Innovation Systems (Castellacci and Natera, 2012).

Innovation capacity represents the total efforts and investments made by countries (or regions) to carry out R&D activities, as well as innovation activities. It is an expression of the result of research and innovation activities. This is the total production of technological and innovative activities.

Socio-economic development, both national and regional, is driven by the capacity for innovation (Furman et al., 2002). In this proposal, the capacity for innovation should not be reduced to investment in R&D and related activities, but rather through the understanding of (i) absorption capacity, (ii) capacity for diffusion of new knowledge, (iii) demand for its generation and use. This means that R&D activities constitute the core of innovation processes and the understanding of innovation capabilities, particularly when a regional perspective is adopted, should not be reduced to this limitation or be a general observation of knowledge creation.

Furman et al. (2002) define innovation capacity as a country's ability to produce and commercialize a long-term flow of innovative technology. Similarly, Porter et al. (2002) point...
out that innovation capacity is the result of different factors, such as skilled labor and the physical quality of infrastructure.

Radosevic (2004) mentions that to understand innovation capacity we must go beyond R&D, which is why he proposes a classification of indicators based on the national innovation system approach. Radosevic (2004) takes as a guide the conceptual model of the National Innovation Capacity (NIC) from Furman et al (2002), which explains the relationship between the different elements that make up the innovation capacity framework. In Figure 1 you can see the dimensions that make up the Regional Innovation Capacities (RIC) model, which is an adaptation of Radosevich's CNI model developed by Muller et al. (2008) for the sub-national context, in which the CRI are grouped into: a) R&D supply, b) absorption capacity, c) diffusion capacity, and d) demand.

Returning to Radosevich (2004), the different dimensions that make up the regional innovation capacity are briefly defined below. CRI (adopted from Muller et al, 2008).

**Figure 1**

*Dimensions of Regional Innovation Capacity*

![Diagram of Regional Innovation Capacities](source: Own elaboration based on Muller (2006).)

a) The knowledge creation capacity (KCC) is important not only to generate new knowledge, but also as a mechanism to absorb it (Cohen and Levinthal, 1990). This is a crucial element of innovation capacity which can be described with indicators such as: expenditures on R&D and human capital, the concentration of patent inventors, as well as publications in the field of bioscience and nanotechnology. R&D capacity is important, since in addition to generating knowledge it is also a mechanism to absorb this knowledge;
b) Absorptive capacity (ACC) is a concept used to describe the capacity of a territory to recognize the value of new external knowledge, to assimilate it and apply it for commercial purposes (Cohen and Levinthal, 1990; Zahra and George, 2002). According to Abramovitz (1986, 1996), absorptive capacity can be defined as the techno-economic characteristics (resource endowment, supply of factors, technological capabilities, market scales and consumer demands), as well as the socio-institutional conditions (level of education, technical competencies of institutions), which influence the ability to acquire, assimilate, transform and exploit knowledge to strengthen the competitiveness of a region or country;

c) The knowledge dissemination capacity (CDC) of a region is the resources, capabilities and competencies of a region to launch knowledge dissemination processes. According to Lan and collaborators, the diffusion of knowledge is the “process in which knowledge spreads from its origin to the outside or from its producers to its users, through the market or other distribution channels.” Knowledge diffusion is a process of learning and the social and spatial dissemination of knowledge in a broader space” (Lan et al., 2009: 1). This capacity is closely related to ICTs, these being tools for activities related to science, technology and innovation (STI), since they allow scientists and technologists to be in contact and work with different people who are in different parts of the world, which increases their productivity and allows the generation of new knowledge and technologies (Ruiz Durán, 2008);

d) Demand/market capacity for new technologies and knowledge (CDT). The realization of innovation involves the commercialization of products and services generated by research and development. This means that part of the success of innovations lies in having an adequate market in terms of demand for the products and services generated. Furthermore, considering the difficulties that geographical distance entails linked to transaction costs, transportation costs or the availability of adequate distribution channels, the regional market will generate the greatest opportunities for the majority of companies involved in the regional innovation system. This dimension seeks to reflect the potential of the demand that exists for the innovations generated in the region, through the indicators of GDP, population density and per capita income (Miles et al., 2009; Valdez-Lafarga and León-Balderrama, 2015).
3 METHODOLOGY

In the existing literature, the innovation performance of territories has been widely measured by patent productivity, although there are many disadvantages in using this measure (Acs, Anselin and Varga 2002; Hagedoorn and Clooedt 2003). For example, not all technologies are patentable, and not all patents are technologically advanced and have the same economic value. However, patents are used in most research as an output indicator of the capacity to generate innovations, which measures the performance of territorial units (states) in terms of generation of innovations (Buesa, Heijs and Baumert, 2010). Therefore, in this study the number of patent applications in a federal entity is used as a proxy for the productivity or innovation performance of the regions or entities of Mexico. Table 1 summarizes the variables used in the present study, as well as their respective indicators.

Table 1

Definition and sources of the entities’ Innovation and IC performance indicators

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Definition and source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dependent variable: Innovation performance</td>
<td></td>
</tr>
<tr>
<td>Patents applied for</td>
<td>No. of patents requested per 10 thousand inhabitants. IMPI and INEGI (2017)</td>
</tr>
<tr>
<td>Independent variables: Indicators of innovation capabilities</td>
<td></td>
</tr>
<tr>
<td>Capacidad de Creación de Conocimiento (CCC)</td>
<td></td>
</tr>
<tr>
<td>Researchers at the SNI (CCC_SNI)</td>
<td>Number of Researchers members of the National System of Researchers (SNI) per 10,000 of the PEA. CONACYT, INEGI (2017)</td>
</tr>
<tr>
<td>Companies and institutions with S&amp;T activities (CCC RENIECYT)</td>
<td>No. of member organizations of RENIECYT per 10 thousand inhabitants. CAIINO and INEGI (2017)</td>
</tr>
<tr>
<td>Scientific publications (CCC_PUBLICATIONS)</td>
<td>No. of internationally indexed publications per 10 thousand inhabitants. Scopus-Scimago Research Group (Main Scientometric Indicators of Mexican Scientific Production, 2018; and INEGI (2017).</td>
</tr>
<tr>
<td>Knowledge Absorption Capacity (CAC)</td>
<td></td>
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<tr>
<td>Postgraduate students (CAC_Posgrados)</td>
<td>No. of students enrolled at the postgraduate level per 10 thousand inhabitants. ANUIES and INEGI (2017)</td>
</tr>
<tr>
<td>National scholarships (CAC_Becas)</td>
<td>No. of current national CONACYT scholarship holders per 10 thousand inhabitants. CONACYT (2017)</td>
</tr>
<tr>
<td>PNPC Postgraduate Courses (CAC_PNPC)</td>
<td>% participation in the total PNPC postgraduate courses in the country. CONACYT (2017)</td>
</tr>
<tr>
<td>Per capita spending on education (CAC_GastoEducacion)</td>
<td>Expenditure on education per capita in millions of pesos. CIEP (2017)</td>
</tr>
<tr>
<td>Knowledge Diffusion Capacity (CDC)</td>
<td></td>
</tr>
<tr>
<td>Internet access (CDC_AccInternet)</td>
<td>% of households that have an Internet connection in urban-rural areas. INEGI-ENDUTIH (2018)</td>
</tr>
<tr>
<td>Computer access (CDC_AccComputer)</td>
<td>% of households that have a computer in urban-rural areas. INEGI-ENDUTIH (2018)</td>
</tr>
<tr>
<td>Cellular telephony (CDC_TelCelular)</td>
<td>Mobile cell phone subscriptions per 100 inhabitants. SENIEG (2016)</td>
</tr>
<tr>
<td>Fixed telephony (CDC_TelFija)</td>
<td>Landline telephone subscriptions per 100 inhabitants. SENIEG (2016)</td>
</tr>
</tbody>
</table>
Empresas con ISO (CDC_EmpresasISO) % de las empresas estatales que cuentan con certificación ISO 9000 o 14000. INEGI-DENUE (2015)

Technology Demand Capacity (CDT)
GDP per capita (CDT_PIBE) GDP per capita in millions of pesos in 2013. INEGI-SCN (2017)
Employed population aged 14 and over (CDT_PobOcupada) P.O. 14 years or older, as a % of the total population. INEGI-ENOE (2017)
Schooling (CDT_GradoEscolar) Average years of studies. SEP (2016)
Population density (CDT_DensPoblacion) No. of inhabitants per square kilometer (transformed with log 10). INEGI (2017)


3.1 INDICATORS OF THE INNOVATION CAPACITIES OF FEDERAL ENTITIES

For the analysis, 17 indicators were selected with information obtained from official sources in regular publications. This information was classified into the four CRI categories that have been identified in the previous section. As noted, this analysis adopts as its central conceptual reference the innovation capabilities approach proposed by Radosevich (2004) and Muller et al. (2006). In the case of the CCC, in order to have an indicator on the population dedicated to R&D&I activities, the number of researchers assigned to the National System of Researchers (SNI) was selected. In relation to the monetary resources invested in research, the budget allocated by CONACYT to the federal entities is taken; The number of member organizations of RENIECYT is also included here as an indicator of public and private infrastructure capabilities aimed at generating new knowledge through research. (Table 1). In the case of CCS, following Radosevich and Muller (2004), indicators were sought to reflect the population's competencies for learning, adoption and adaptation of new technologies. The population with postgraduate degrees, the number of scholarship holders and the number of postgraduate courses considered to be of high quality are the indicators that were chosen for this purpose, as well as educational expenditure per capita, which we consider another indicator of this particular capacity. With respect to the CDC, indicators of infrastructure linked to ICT, the level of implementation of ICT in homes, and the penetration of new forms of management in companies were selected. Finally, the indicators were selected for measuring the CDT, which would allow us to appreciate how the states differ in terms of market size and the characteristics of the population as consumers of new technologies.

3.2 STATISTICAL PROCEDURES

• Data purification and standardization. As a first procedure, normalization or standardization of the database was carried out. This transformation of variables was
carried out in order to facilitate the comparison between variables with different units, as well as to allow obtaining weighted values when two or more variables are added into a single factor;

• Exploratory analysis of the database. Exploratory data analysis (EDA) aims to identify the most appropriate theoretical model to represent the population from which the sample data come. This analysis is based on graphs and statistics that allow the distribution to be explored by identifying characteristics such as: outliers or outliers, jumps or discontinuities, concentrations of values, shape of the distribution, etc. (Komorowski et al., 2016);

• Analysis of correlation between variables. In order to have an initial appreciation of the degree of relationship between the variables included in the study, a correlation analysis was carried out. The Pearson correlation coefficient was calculated, which is a measure of the linear relationship between two quantitative random variables.

Generación del modelo de regresión. Se procedió después a realizar la selección de un modelo de regresión lineal múltiple, con el fin de estimar la relevancia de los distintos indicadores de las denominadas capacidades regionales de innovación como predictores del desempeño de las entidades como generadoras de innovaciones. Para este fin se empleó el método conocido como Criterio de Información de Akaike (AIC). El AIC es una medida de la calidad relativa de un modelo estadístico, para un conjunto dado de datos.

4 RESULTS AND DISCUSSIONS

4.1 EXPLORATORY ANALYSIS OF CRI INDICATORS

This analysis was carried out based on graphs that allowed exploring the distribution of the indicators, identifying characteristics such as: atypical values or outliers, jumps or discontinuities, concentrations of values, shape of the distribution, etc.

Figure 2 shows the level of symmetry/asymmetry of the CRI indicators for the case of the Mexican states. It can be seen that only one group of indicators observes a symmetrical distribution, this is the case of the indicators of the population's access to information and communications technologies, which we have conceptualized as innovation capabilities belonging to the dimension "knowledge dissemination capabilities", as well as the average years of study of the population and the employed population as a percentage of the total population, which we consider indicators of the demand capacity for new technologies. On the
other hand, 13 of the 18 indicators observe a positive asymmetric distribution. We say that there is positive (or right) asymmetry if the "tail" to the right of the mean is longer than that to the left, that is, if there are values further away from the mean to the right. This turned out to be the case. case of the indicators linked to the knowledge creation capacity of the entities, such as the number of SNI researchers, the Conacyt budget assigned to the entity, the number of companies and organizations that carry out R&D activities and the number of publications by entity.

Figure 2

Symmetry of the CRI indicators (Mexican states)

Also, most indicators of knowledge absorption capacity present a positive asymmetric distribution, such as the number of postgraduate students, the number of quality postgraduate programs and the number of national Conacyt scholarship holders. The same happens with the distribution of the dependent variable in the study. In these indicators, some indicators corresponding to the most important entities due to their population and economic activity, such as CDMX, Jalisco, Nuevo León, are quite different from the national average, which denotes a high degree of concentration or unequal distribution of the capabilities.

Figure 3, on the other hand, was also part of the exploratory analysis of the data and shows the dispersion of the CRI indicators of the federal entities. In this graph, in order to
observe the dispersion between the predictor and response variables, the data were transformed ($\mu = 0$) to make them comparable between them.

**Figura 3**

*Dispersion of CRI indicators*

![Figure 3: Dispersion of CRI indicators](source: self made)

4.2 CORRELATION ANALYSIS

In the correlogram (Figure 4) there are 63 non-significant correlations ($\alpha=0.01$) - blank boxes. Regarding the significant correlations, strong correlations are observed between the predictor variables, especially between the variables belonging to the same category of innovation capacity, as is the case of the CCCs, where the scientific publications per capita of an entity are highly correlated with the budget that Conacyt allocates to it, the number of researchers assigned to the SNI and the number of national scholarship holders per entity. Likewise, the number of SNI academics in an entity is closely correlated with the budget that Conacyt allocates to the entity. An interesting correlation is the one that exists in a high way between the population density of an entity, which can be interpreted as its degree of “metropolization”, and the concentration of public resources destined for scholarships, the budget assigned by Conacyt and being a beneficiary of the program. PNPC.
What is most relevant for our empirical analysis is that in the case of the variable to be predicted, innovation performance measured by patent productivity at the state level, all correlations are above 0.21, with a proportion of 11/17 significant (α=0.01). The correlation coefficients obtained show a positive and significant association between the level of patent generation of the federal entities and regional innovation capabilities.

In the case of the knowledge creation capacity indicators (CCC), the correlation is high and very significant with the number of companies and institutions with S&T activities (CCC_RENIECYT) and number of publications (CCC_Publications); while it is high for the number of SNI investigators and the Conacyt expenditure assigned to the entity per inhabitant.

On the other hand, the correlation between the patents variable and the indicators of the knowledge absorption capacity (CAC) is high and very significant, particularly with the postgraduate population and the number of scholarship holders, while it is more moderate with respect to the quality postgraduate courses, and there is definitely a reduced correlation with per capita education spending.

The requested patents also have a medium-high correlation with 1 of the variables of the diffusion capacity of new technologies and innovations (CDC), which is the case of fixed
telephony. The correlation is medium-low with the variables related to the population's access to ICTs (internet access, cell phone access and computer access); while it is low for the percentage of state companies that have ISO 9000 or 14000 certification.

In contrast, the degree of correlation between patents and the indicators of the demand capacity for new technologies (CDT) is low and not significant, with the exception of the population density variable.

4.3 GENERATION OF THE REGRESSION MODEL

To prepare the explanatory model of the level of production of innovations of the entities based on the innovation capabilities, a multiple linear regression model was developed using the method of successive steps. This method allows the selection of variables one by one, to arrive at a model that guarantees a higher level of “goodness” of fit. Finally, a normality analysis of the residuals is performed in order to test the resulting model.

To obtain the regression model, the 17 indicators of innovation capabilities were used as predictor variables of the behavior of patent applications (response). To select the best explanation model, the stepwise variable selection strategy was used through the double or mixed method ("both"). The mathematical criterion for the incorporation or extraction of variables was the AIC (Akaike's Information Criterion). The summary of these results is provided in Table 2.

From the value of the adjusted completion coefficient (R2-adjusted = 0.859) it is possible to explain that the model explains 85% of the variability since the F ratio test is significant at 99.99% confidence. It also validates that the number of observations per independent variable is sufficient, which according to Hair (1999), the minimum of these per predictor is four.
Table 2
Selected regression model

<table>
<thead>
<tr>
<th>Coefficients:</th>
<th>Standardized BETA coefficient</th>
<th>Typical error</th>
<th>Parametric contrasts t</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Intercept)</td>
<td>0.0155</td>
<td>0.0421</td>
<td>0.368</td>
<td>0.7162</td>
</tr>
<tr>
<td>CCC_GastoID</td>
<td>-0.0007</td>
<td>0.0001</td>
<td>-5.513</td>
<td>9.93E-06</td>
</tr>
<tr>
<td>CCC_RENICYT</td>
<td>0.0870</td>
<td>0.0242</td>
<td>3.602</td>
<td>0.001366</td>
</tr>
<tr>
<td>CAC_Becas</td>
<td>0.0326</td>
<td>0.0040</td>
<td>8.175</td>
<td>1.58E-08</td>
</tr>
<tr>
<td>CAC_PNPC</td>
<td>0.0013</td>
<td>0.0003</td>
<td>4.041</td>
<td>0.000446</td>
</tr>
<tr>
<td>CDC_AccInternet</td>
<td>0.0015</td>
<td>0.0009</td>
<td>1.649</td>
<td>0.1117</td>
</tr>
<tr>
<td>CDC_TelCelular</td>
<td>-0.0017</td>
<td>0.0009</td>
<td>-1.873</td>
<td>0.0728</td>
</tr>
</tbody>
</table>

Meaning codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1. Residual standard error: 0.03931 on 25 degrees of freedom; Multiple R-squared: 0.8867, Adjusted R-squared: 0.8595; F-statistic: 32.62 on 6 and 25 DF, p-value: 1.177e-10

Source: self made.

The regression model shows five variables significant with at least 90% confidence, and four of them with at least 99% confidence. It should be noted that the variable “CDC_AccInternet Access” tends to be significant since with 88% confidence this would be significant. On the other hand, according to the coefficients of the variables in the model CCC_RENICYT is the variable that contributes the most to the growth of the response (Patents requested by federal entity), followed by CAC_Becas, CDC_AccInternet and CAC_PNPC, while the variables CDC_TelCelular and CCC_GastoID show an inverse behavior to the growth of patent applications, in the same order of importance.

5 CONCLUSION

The objective of this research was to identify the factors that can explain or predict the productivity of federal entities in the generation of innovations, measured by patents. The first conclusion that emerges from this work is that, through this empirical analysis, it has been possible verify that the conceptual framework of innovation capabilities has an important “explanatory power” to know what the forces or factors are behind the unequal performance that the federal entities of Mexico have in terms of the production of innovations.

The results for the case of Mexico suggest that the main predictors of the productivity of the states in the generation of patents are, on the one hand, the capacity to create new knowledge, especially the magnitude and number of the CCC-RENIECYT indicator, which expresses the presence of institutions, centers, organizations, companies and natural or legal persons from the public, social and private sectors that carry out activities related to research and development of science and technology; and budget allocated by CONACYT to the federal...
entities (per capita). On the other hand, the so-called knowledge absorption capacity also turned out to be a relevant predictive factor of the productivity or innovation performance of the federal entities. Particularly, the indicators of the number of current CONACYT national scholarship holders per 10 thousand inhabitants, and the percentage participation of the entity in the total number of PNPC postgraduate courses in the country, turned out to be predictor variables of the productivity of innovations. The capacity to absorb knowledge is essential for the “updating” or technological updating of regional economies and populations. Therefore, postgraduate education in entities not only generates human capital and new knowledge, but also facilitates and stimulatess the incorporation of knowledge generated outside the region.

It is very interesting that the differences in the number of SNI researchers and public educational spending per capita are not factors that determine significant differences in the performance of states as generators of patents. In the second case, it should be considered that in recent years it has been oriented towards meeting policy objectives linked to compensating for inequalities in terms of development that exist between the country's entities: that is, greater spending has been directed to the most backward entities in order to lay the foundations for a more equitable (convergent) development in territorial and social terms.

The results imply that it is necessary to continue with public policies that reinforce these capacities, especially with regard to the promotion of a greater incidence of institutions, companies and various organizations in R&D activities, the exercise of a budget growing audience aimed at regions and entities, the training of young researchers and technologists through postgraduate scholarship programs, mainly.

This research can be a very particular reference so that future research can address and propose new conceptual frameworks for the study of regional inequalities in the generation of innovations. One of the limitations of this research work was the limited availability and difficulty of collecting data for the STI indicators of the federal entities of Mexico. This meant that several indicators on innovation capabilities could not be applied, due to the practically zero availability of statistical information on resources and capabilities for science and technology at this level. This results in a lag in research, since different themes and methodologies that are currently being applied in the analysis of the innovative potential of countries and regions cannot be addressed; For this reason, in Mexico this type of analysis has been focused or limited to the development of rankings for federal entities.
REFERENCES


