www.cya.unam.mx/index.php/cya

Contaduría y Administración

Accounting & Management

Contaduría y Administración 66 (4), 2021, 1-22

Spatio-temporal dynamics of the regional production of industrial designs in Mexico

Dinámica espacio-temporal de la producción regional de diseños industriales en México

Víctor Hugo Torres Preciado*, Dony Vázquez Olmos, Juan José Moreno Cuevas

Universidad de Colima, México

Received November 6, 2019; accepted February 25, 2021
Available online August 23, 2023

Abstract

The aim of this investigation consists on analyzing the spatial-temporal distributional evolution of industrial designs among states in Mexico. The contribution to the empirical literature on innovation strives on studying, with a new database, a widely ignored form of innovation in international studies as are industrial designs, and its distributional evolution conditioned to spatial interaction. Based on the spatial Markov chain approach proposed by Rey (2001), results suggest the presence of a diverging process in the regional production of industrial designs characterized by a multimodal distribution and drove by neighboring regions located at very low, low or medium classes.

JEL Code: C02, O33, R10
Keywords: regional technological innovation; industrial designs; spatial Markov chains; México

*Corresponding author.
E-mail address: tpreciado04@gmail.com (V. H. Torres Preciado).
Peer Review under the responsibility of Universidad Nacional Autónoma de México.

http://dx.doi.org/10.22201/fca.24488410e.2021.2770

Resumen

El objetivo de esta investigación consiste en analizar la evolución de la distribución espacio-temporal de los diseños industriales en los estados de México. La contribución a la literatura empírica sobre innovación estriba en estudiar, con una nueva base de datos, una forma de innovación ampliamente ignorada en los estudios internacionales como son los diseños industriales, y por otro, su evolución distributiva condicionada a la interacción espacial. A partir del enfoque de cadenas de Markov espaciales propuesto por Rey (2001), los resultados sugieren la presencia de un proceso de divergencia en la producción regional de diseños industriales caracterizado por una distribución multimodal impulsado por las regiones vecinas ubicadas en las clases muy bajas, bajas o medios.

Código JEL: C02, O33, R10
Palabras clave: innovación tecnológica regional; diseños industriales; cadenas de Markov espaciales; México

Introduction

One of the contributions of the theory of economic growth proposed by Solow (1956 and 1957) was to establish the importance of technological change for economic progress. Although his theory has been severely criticized due to the exogenous nature of the technology, it has also led to different research studies focusing on clarifying its economic effect. In this direction, the work of Griliches (1979 and 1980), who laid the foundations for empirically measuring the effect of technological innovation on economic performance, specifically on business productivity, stands out. His research made it possible to analytically visualize the creation of new ideas through innovation production functions and to incorporate an element of endogeneity by focusing on the innovative behavior of companies. Nonetheless, it was Romer (1990) who once again placed technological innovation at the center of the study of economic growth. His contribution produced new technological knowledge through research and development processes based on human capital dedicated to research and access to a pool of pre-existing technological knowledge.

The function of public good Romer (1990) attributed to technological knowledge, based on the assumption of non-rivalry and partial exclusivity, although it represented an advance in understanding the process of technological diffusion, also leaves pending the study of its channels and scope, among them the territorial one. In this regard, recent research has identified the need to focus attention on the spatial nature of technological innovation. For example, Fingleton (2003) has stressed the importance of recognizing and measuring the dissemination of technological knowledge from a spatial perspective. In this approach, the geographical location and scope of the information flow are important to understand the presence of technological externalities that cross geographical boundaries and affect the economic performance of adjacent regions. Some advances in this direction are the works of Varga, Anselin, and

Acs (2003) and Parent and LeSage (2012), who incorporate the spatial dimension in innovation production functions using spatial econometric methods to measure the spatial dissemination of technological knowledge.

On the other hand, more recent studies, which agree with incorporating the spatial dimension in the study of innovation processes, consider the production function approach insufficient to understand the different ways innovation occurs. To this end, Capello and Lenzi (2013) acknowledge that scientific advances represent a significant source of innovation; nevertheless, they reject the assertion that it is the only form of innovation. Instead, they propose viewing regional innovation processes as the result of different modes of innovation that, subject to contextual conditions (internal or external to the region), lead to specific innovation patterns. In particular, the authors point out that innovation does not only result from research and development processes within companies or territories, which are subsequently codified in patents. Rather, they can present themselves as innovation patterns endogenous to the region with access to scientific networks, innovation patterns based on technological knowledge external to the region (Foray, 2009), or even innovation patterns based on technological imitation.

This feature is particularly significant in countries that systematically devote low levels of public and private investment to research and development and consequently produce comparatively lower numbers of patents. In such cases, it is crucial to analyze alternative forms and products of innovation. In Mexico, economic research studying technological innovation mainly addresses its effect on regional economic performance (Díaz-Bautista, 2003; Torres, Polanco, & Tinoco, 2014) and even the determinants of some measures of regional innovation (Germán-Soto, Gutiérrez, & Tovar, 2009; Germán-Soto & Gutiérrez, 2013). Except for the study by Torres, Polanco, and Tinoco (2014)—who analyze alternative measures of innovation—studies in Mexico frequently focus on patents. Nevertheless, as with international research, analyzing the distributive evolution of the regional production of innovations in Mexico is practically absent.

This research recognizes the importance of analyzing alternative forms of innovation, as Capello and Lenzi (2013) pointed out, to focus on a measure largely ignored in economic analysis: industrial designs. Although the reason for omitting its study seems to be associated with its functional character apparently limited to an aesthetic type of innovation, as Feeney and Rogers (2001) point out, industrial designs are considered a product innovation linked to the market. Like patents, industrial designs represent the possibility of creating new businesses and even influencing the creation of new competitive products.

In Mexico, the production of industrial designs follows a regional concentration pattern, with four states accounting for nearly 70 percent of the national total, a feature that, from a dynamic perspective, could have differentiated effects on regional economic performance. Therefore, analyzing the territorial distributive evolution of industrial designs would provide insight into the general patterns of regional mobility in inventive activity and the expectation of moving toward higher (or lower) production levels. This research aims to analyze the distributive evolution of the regional production of innovations measured by the number of industrial designs in the 32 states of the country. To this end, the study resorts to the Markov chain approach, specifically the one proposed by Rey (2001), which extends the classical Markovian approach to condition it to the spatial interaction between states. An advantage of this methodological strategy is that it facilitates the investigation of the distributional evolution of the innovation measure of this research by considering the complete temporal information. In this context, the research questions posed are: What have been the dynamics of the regional production of industrial designs in Mexico? Is there any tendency toward convergence or divergence in the production of innovations? Does the interaction between regions condition these dynamics?

The document is organized as follows. The first section provides a review of the literature, followed by an overview of regional patent production in the second section. The third section explains the methodology, followed by an analysis of the results and finally, the conclusions are presented.

Review of the literature

The study of technological innovation has focused mainly on its role as a determinant of economic progress. Indeed, Schumpeter's (1934) work represents one of the first efforts to systematically understand the relation between entrepreneurship and technological innovation and its relation to long-term economic change. In his conception, technological innovation results from an endogenous effort by companies seeking to adapt to market changes to preserve their competitiveness, which leads to discontinuous economic change. Nevertheless, Solow's later works (1956 and 1957) motivated the resurgence of the study of technological change and its effect on production growth. His measurements of the contribution of technological change to economic progress, although based on an aggregate and exogenous conception of innovation, were crucial to understanding its importance and promoting new research efforts. Other studies in this area are those of Arrow (1962), who introduced experiential learning, and Baumol (1968), who sought to reintegrate the innovative entrepreneur into economic analysis.

Subsequent research took up the study of innovation as a source of growth with a predominantly empirical approach; among these are the contributions of Griliches (1979, 1980) and Griliches and Mairesse (1984), among others, who found evidence of the favorable effect of research and development on business productivity. Nevertheless, Romer (1980) formally introduced the production of new ideas as a result of research and development work. In his model, a sector dedicated to producing new technological knowledge for economic gain represents an advance over previous contributions that preserved exogenous technological change.

Although previous works recognized the presence of technological knowledge externalities, a recent branch of studies highlights the importance of incorporating the spatial dimension. Among these is Fingleton (2003), who stresses the importance of recognizing the local character of technological information and the possibility of spatial dissemination. Similarly, Varga, Anselin, and Acs (2003) and Parent and LeSage (2012) seek to identify the presence and extent of spatial and technological externalities using the production output approach. Nevertheless, Capello and Lenzi (2013), while recognizing that research and development are relevant as a form of innovation, state that there are also specific regional innovation patterns, such as innovation endogenous to the region but with access to scientific networks. These innovation patterns depend on technological knowledge external to the region (Foray, 2009) and innovation based on technological imitation.

Nonetheless, most of the international empirical studies mentioned above have used patents as an indicator of technological innovation, possibly motivated by the reliability attributed to this purpose (Griliches, 1990), although little attention has been paid to the production of industrial designs. On this topic, some reports have delved into explaining the economic importance of industrial designs, the forms of their legal protection, and found through surveys the reasons why companies decide to protect their industrial designs (Europe Economics, 2016); notwithstanding, there is no analysis of their spatial distribution or even their implications for economic progress in the international literature.

In the case of Mexico, a similar situation occurs; most studies focus on researching the effect of technological innovation on economic growth. For example, Marroquín and Ríos (2012) estimate a model that follows Romer's (1990) theory, whose results show that the R&D stock would positively affect the production of innovations. Díaz-Bautista (2003) finds a positive effect on regional growth from education, although inconclusive for research and development spending. Velázquez and Salgado (2016) find evidence of a positive impact of technological variables on Mexico's economic growth. Recently, Torres, Polanco, and Tinoco (2014) have incorporated spatial interaction effects to investigate the effects of technological dissemination on regional growth stemming from some innovation measures, including the number of industrial designs. On the other hand, the works of Germán-Soto, Gutiérrez, and Tovar (2009) and Germán-Soto and Gutiérrez (2013) take up the approach of the innovation production function to study the determinants of technological progress, measured utilizing patents.

Regional production of industrial designs in Mexico

The production of industrial designs as a form of innovation has experienced a notable increase in Mexico. With an average growth rate of 6.5 percent between 1993 and 2016, its production level has quadrupled to 1650 industrial designs (Graph 1), surpassing the production of patents, whose level was 1310 in the last year. This dynamic reflects, on the one hand, the intensification of Mexican inventive activity and, on the other, the increase in the use of instruments for the legal protection of industrial property in the country.

The importance of the increase in this form of innovation is manifested in its relation to other types of innovation and its economic implications. On the one hand, industrial design, which constitutes a set of peculiar features incorporated into an industrial product for aesthetic purposes (IMPI, 2018), fulfills a complementary function regarding other innovations, such as patents, utility models, and even trademarks, contributing to strengthening their legal protection. From an economic perspective, it is a form of innovation endogenous to the company that, by giving a special and particular appearance to a product, contributes to its positioning and validity in the market, corresponding to the product differentiation typical in monopolistic competition market structures.

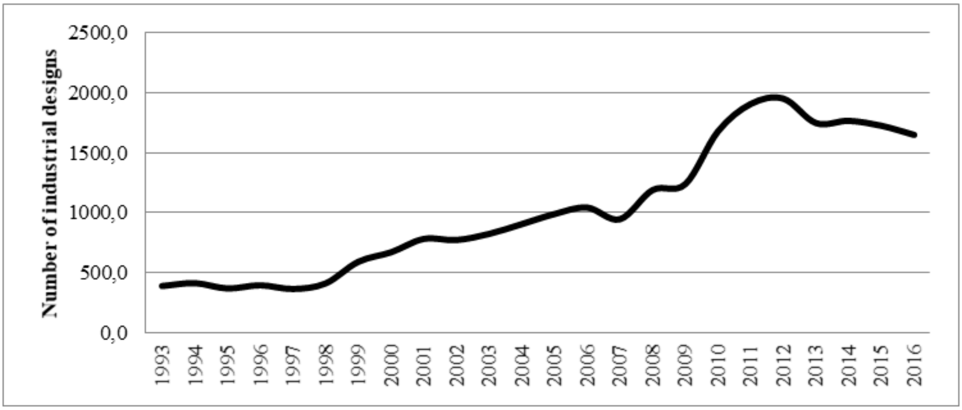

Figure 1. Evolution of the number of industrial designs in Mexico, 1993-2016
Source: created by the authors with data from the Mexican Institute of Industrial Property

The increase in industrial designs during this period is far from homogeneous when observing their spatial distribution. In this regard, Figure 2 shows some characteristics of the geography of industrial designs in Mexico, highlighting, for example, that most production is concentrated in the states in the North and some in the central zone. On the other hand, the states in the South generally have a relatively lower level of industrial design production than those in the North, along with greater variation over time. Particularly, although it can be observed that some states, such as Mexico City, State of Mexico, Jalisco, and Nuevo Leon, have significantly concentrated the regional production of industrial designs over time in the country, it can also be noted that some states, such as Coahuila, Queretaro, Guanajuato, and Puebla have significantly increased their production levels in this type of innovation. Nevertheless, the disparity in innovation between states has led to spatial polarization with the southern states.

http://dx.doi.org/10.22201/fca.24488410e.2021.2770

An additional feature of this spatial distribution is an apparent positive spatial association between states. Figure 2 shows that states with higher levels of industrial design production are surrounded by states that share similar levels of innovation, a characteristic that also seems to emerge when looking at states with lower production levels.

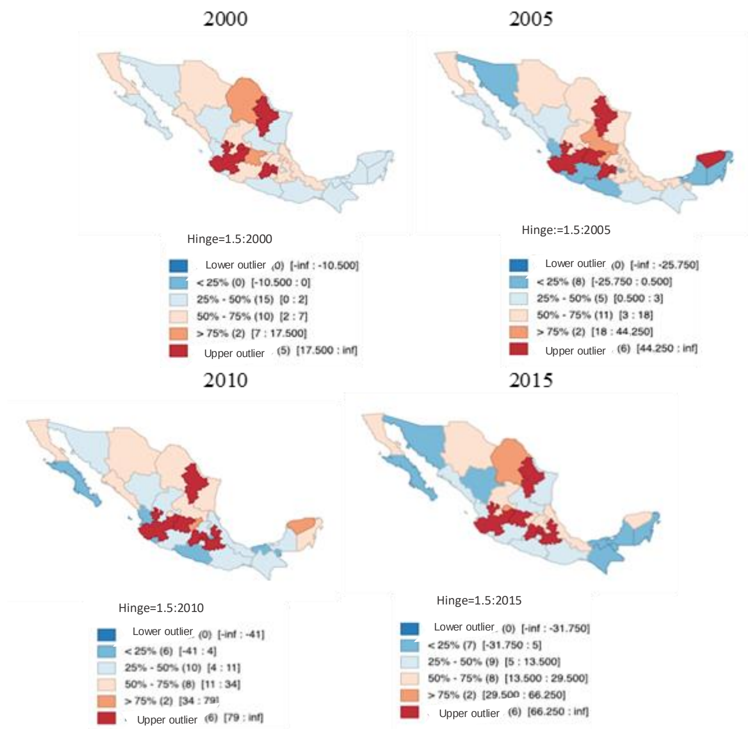

Figure 2. Spatial distribution of industrial design production in Mexico
Source: created by the authors with data from the Mexican Institute of Industrial Property
Note: Box plots were created using a quartile distribution

One way of observing changes in spatial distribution is through their dispersion over time. In this case, Graph 2 shows a remarkable increase in the interregional dispersion of industrial design production in Mexico. Specifically, the upward shift of the median reflects the overall increase in industrial design production. Nevertheless, this increase has been accompanied by a widening of the third quartile, indicating an increase in dispersion due to some states intensifying their industrial design production, as indicated in Figure 2. In general, the evolution of the interquartile range that measures the difference between the third and first quartile of the distribution reflects the increase in interregional inequality in this form of innovation.

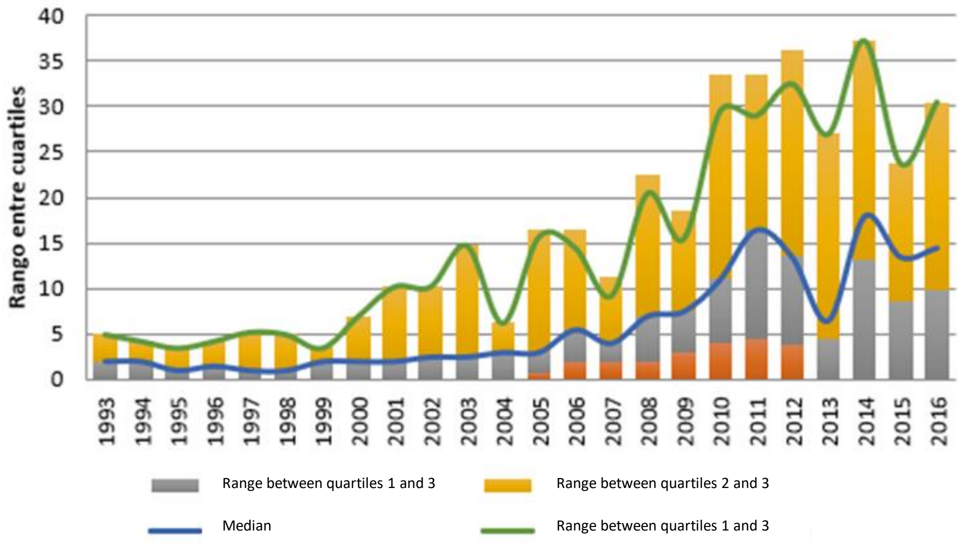

Figure 3 Evolution of interregional dispersion in the production of industrial designs in Mexico, 1993-2016
Source: created by the authors with data from the Mexican Institute of Industrial Property

Concerning the above, although the dispersion analysis suggests a widening of interregional inequality in the production of industrial designs in Mexico, with a tendency toward a bimodal distribution at the extremes, it is still insufficient to identify how spatial proximity and interaction could determine the evolution of the regional distribution of industrial designs in the country. The possibility of corroborating a significant spatial association, as seen in Figure 3, may not only result in different distributional evolution of industrial designs but opens the possibility of identifying policies for developing this type of creative activity and regional growth from spatial interaction patterns.

Methodology

The study of the distributional evolution of the regional production of industrial designs in Mexico is conducted using the Markov chain approach. This approach offers several analytical advantages over standard methods, such as, for example, the calculation of interregional variance over time. Another advantage is using a complete sample of data, which clarifies how the entire distribution evolves (Quah, 1996). The classical Markovian approach states that a stochastic process has the Markov property if its distribution at a given time t+1 only depends on its distribution present at t:

$$\text{Prob}\ (x_{t+1}|x_t, x_{t-1}, \ldots, x_{t-k}) = \text{Prob}\ (x_{t+1}|x_t) \quad (1)$$

A Markov chain consists of a transition matrix P of size nxn that records the transition probabilities from one state to another in one period and a vector "π" _"0" of size nx1 that indicates the probability of being in state i in the initial period 0. Among the relevant assumptions of Markovian processes are the stochastic and time-invariant nature of the transition matrix P. In the first case, the sum of the probabilities along column j for each row i in the matrix P equals 1. From the assumption of time invariance, two properties of the same matrix P are derived; on the one hand, it calculates the average time in which a region can transit from one class to another, and on the other hand, it is possible to identify the ergodic or steady state vector in the long term. According to Rey (2001), the ergodicity property of the probabilistic transition matrix P implies that PTb = A, where Tb represents the time it takes for the matrix P to converge to the steady-state matrix A.

In order to analyze the distributional dynamics of the regional production of industrial designs conditioned to spatial interaction, the spatial Markov chain approach proposed by Rey (2001) is used. This approach recognizes that the evolution of regional distribution may show a different behavior if the possibility of interaction between a specific region and its neighboring regions is considered. This methodological approach enables, on the one hand, to empirically approximate the presence of spatial externalities of technological knowledge and, on the other hand, to elucidate more realistic distributional dynamics compared to standard Markovian analysis.

Specifically, according to Rey (2001), the explicit incorporation of spatial interaction shows the probability that a specific region will move to a different class in the following period, conditioned to the location of its neighboring regions in one of these classes during the initial period. The methodology generates a number k of probabilistic transition matrices equal to the number of classes, so it is possible to determine the influence neighboring regions have on the transition probability of a specific region.

In order to clarify the above, Table 1 presents the characterization of a spatially conditioned hypothetical transition matrix with five classes that are defined as follows: very low (MB), low (B), medium (Med), high (A), and very high (MA). Each class corresponds to a level of production calculated as mutually exclusive quintiles. For example, the notation PMBMA/MB indicates the probability of a region transitioning to a very low class (MB) in the following period, conditioned to whether its neighboring regions are initially in a very low class (MB). The rest of the transition probabilities are interpreted similarly.

http://dx.doi.org/10.22201/fca.24488410e.2021.2770

Table 1
Characterization of the spatial transition matrix

Spatial lag	Class	MB	B	Med	A	MA
	MB	$P_{MBMB\mid MB}$	$P_{MBB\mid MB}$	$P_{MBMed\mid MB}$	$P_{MBA\mid MB}$	$P_{MBMA\mid MB}$
	B	$P_{BMB\mid MB}$	$P_{BB\mid MB}$	$P_{BMed\mid MB}$	$P_{BA\mid MB}$	$P_{BMA\mid MB}$
MB	Med	$P_{MedMB\mid MB}$	$P_{MedB\mid MB}$	$P_{MedMed\mid MB}$	$P_{MedA\mid MB}$	$P_{MedMA\mid MB}$
	A	$P_{AMB\mid MB}$	$P_{AB\mid MB}$	$P_{AMed\mid MB}$	$P_{AA\mid MB}$	$P_{AMA\mid MB}$
	MA	$P_{MAMB\mid MB}$	$P_{MAB\mid MB}$	$P_{MAMed\mid MB}$	$P_{MAA\mid MB}$	$P_{MAMA\mid MB}$
	MB	$P_{MBMB\mid B}$	$P_{MBB\mid B}$	$P_{MBMed\mid B}$	$P_{MBA\mid B}$	$P_{MBMA\mid B}$
	B	$P_{BMB\mid B}$	$P_{BB\mid B}$	$P_{BMed\mid B}$	$P_{BA\mid B}$	$P_{BMA\mid B}$
B	Med	$P_{MedMB\mid B}$	$P_{MedB\mid B}$	$P_{MedMed\mid B}$	$P_{MedA\mid B}$	$P_{MedMA\mid B}$
	A	$P_{AMB\mid B}$	$P_{AB\mid B}$	$P_{AMed\mid B}$	$P_{AA\mid B}$	$P_{AMA\mid B}$
	MA	$P_{MAMB\mid B}$	$P_{MAB\mid B}$	$P_{MAMed\mid B}$	$P_{MAA\mid B}$	$P_{MAMA\mid B}$
	MB	$P_{MBMB\mid Med}$	$P_{MBB\mid Med}$	$P_{MBMed\mid Med}$	$P_{MBA\mid Med}$	$P_{MBMA\mid Med}$
	B	$P_{BMB\mid Med}$	$P_{BB\mid Med}$	$P_{BMed\mid Med}$	$P_{BA\mid Med}$	$P_{BMA\mid Med}$
Med	Med	$P_{MedMB\mid Med}$	$P_{MedB\mid Med}$	$P_{MedMed\mid Med}$	$P_{MedA\mid Med}$	$P_{MedMA\mid Med}$
	A	$P_{AMB\mid Med}$	$P_{AB\mid Med}$	$P_{AMed\mid Med}$	$P_{AA\mid Med}$	$P_{AMA\mid Med}$
	MA	$P_{MAMB\mid Med}$	$P_{MAB\mid Med}$	$P_{MAMed\mid Med}$	$P_{MAA\mid Med}$	$P_{MAMA\mid Med}$
	MB	$P_{MBMB\mid A}$	$P_{MBB\mid A}$	$P_{MBMed\mid A}$	$P_{MBA\mid A}$	$P_{MBMA\mid A}$
	B	$P_{BMB\mid A}$	$P_{BB\mid A}$	$P_{BMed\mid A}$	$P_{BA\mid A}$	$P_{BMA\mid A}$
A	Med	$P_{MedMB\mid A}$	$P_{MedB\mid A}$	$P_{MedMed\mid A}$	$P_{MedA\mid A}$	$P_{MedMA\mid A}$
	A	$P_{AMB\mid A}$	$P_{AB\mid A}$	$P_{AMed\mid A}$	$P_{AA\mid A}$	$P_{AMA\mid A}$
	MA	$P_{MAMB\mid A}$	$P_{MAB\mid A}$	$P_{MAMed\mid A}$	$P_{MAA\mid A}$	$P_{MAMA\mid A}$
	MB	$P_{MBMB\mid MA}$	$P_{MBB\mid MA}$	$P_{MBMed\mid MA}$	$P_{MBA\mid MA}$	$P_{MBMA\mid MA}$
	B	$P_{BMB\mid MA}$	$P_{BB\mid MA}$	$P_{BMed\mid MA}$	$P_{BA\mid MA}$	$P_{BMA\mid MA}$
MA	Med	$P_{MedMB\mid MA}$	$P_{MedB\mid MA}$	$P_{MedMed\mid MA}$	$P_{MedA\mid MA}$	$P_{MedMA\mid MA}$
	A	$P_{AMB\mid MA}$	$P_{AB\mid MA}$	$P_{AMed\mid MA}$	$P_{AA\mid MA}$	$P_{AMA\mid MA}$
	MA	$P_{MAMB\mid MA}$	$P_{MAB\mid MA}$	$P_{MAMed\mid MA}$	$P_{MAA\mid MA}$	$P_{MAMA\mid MA}$

Source: created by the authors based on Rey (2001)

Databases

The statistical information used consists of the number of industrial design applications for the 32 federal entities of Mexico with an annual frequency from 1993 to 2016. This database was provided by the Mexican Institute of Industrial Property (IMPI) and is new since it has not yet been published in any official report. The methodology Rey (2001) proposed requires a simple transformation of the information before calculating the transition probabilities. First, the number of industrial designs relative to the average value was calculated. Subsequently, five classes representing the transition states were calculated.

The spatial interaction is modeled through the spatial lag corresponding to each of Mexico's states according to a first-order Queen-type spatial matrix. This type of interaction follows the method of Rey (2001), capturing the possible spatial dependence of a particular region on its neighboring regions whenever they touch any boundary or vertex. In particular, the matrix W shows the interaction between a region i and its neighboring regions j where j = 1, . . ., N, with $i \neq j$, assuming that $0 \leq wij \leq 1$ with wij =

0 if i = j. Since a standardized spatial matrix is used, where it is found that $\sum wij = 1$, the spatial lag corresponds to a weighted average of the production of industrial designs in neighboring regions.

Results

Table 2 presents the results of calculating the global probabilistic transition matrix, which, according to the Markov property, indicates the probability that a region in Mexico has of remaining in a class with a certain production level of industrial designs or moving to a different class in the following period. The calculations show that the global matrix's main diagonal probabilities are generally higher than the rest. This result shows a significant persistence of regions to remain in the same class. For example, regions in the class with the lowest industrial design production (MB) level would have a 58 percent probability of remaining in the same class in the following period. Although the regions located in the rest of the classes share similar dynamics, those belonging to the classes denoted as high (A) or very high (MA) have high probabilities; in particular, the regions located in the class with the highest level of production (MA) with 83 percent respectively.

Table 2
Probabilistic global transition matrix for the number of industrial designs in Mexico

State	MB	B	Med	A	MA	VPEE
MB	0.58	0.23	0.13	0.04	0.01	0.20
B	0.27	0.31	0.27	0.12	0.03	0.18
Med	0.12	0.26	0.36	0.23	0.02	0.20
A	0.05	0.10	0.21	0.53	0.11	0.21
MA	0.01	0.01	0.04	0.11	0.83	0.21

Source: created by the authors with information from the Mexican Institute of Industrial Property
The absolute figures can be found in Table A1 in the appendices
Note: VPEE stands for vector of steady-state probabilities

The analysis of the global transition matrix seems to indicate a promising outlook for the regions that, during the study's sample period, have reached the highest levels of design production, while the opposite situation would characterize the regions located in the lower classes, mainly in the MB class. Nevertheless, Table 2 also shows the feasibility of moving to different classes. For example, regions in the very low production class could move to the next class, defined as low (B) with a probability of 23 percent, and even to a medium level of industrial design production, with a lower but still significant probability of 13 percent. Similarly, the possibility of moving to other production levels, even lower, in the next period is a fact. In this regard, although the regions located in the highest class (MA) have the highest probability of remaining the regional leaders in the production of industrial designs, there is also

http://dx.doi.org/10.22201/fca.24488410e.2021.2770

a non-negligible 11 percent probability of being able to fall back to a lower class (A). In addition, the vector of steady-state probabilities (VPEE) indicates that the observed dynamics would lead to a multimodal regional distribution in the long term, characteristic of a divergent process.

The probabilistic global transition matrix shown in Table 2 enables the observation of important features of the spatio-temporal dynamics of the regional distribution of industrial designs in Mexico. Nevertheless, in the presence of a pattern of spatial dependence that conditions these dynamics, it is necessary to explicitly include the spatial dimension to find the changes in their long-term distribution and the presence of regional technological externalities. In order to identify the presence of any spatial interaction pattern and determine whether it should be incorporated into the analysis, the indicator known

as Moran's *I* was calculated. The calculation produces a Moran's *I* of 0.451 with a probability of 0.0, thus corroborating the presence of positive spatial autocorrelation[1].

Table 3 shows the stochastic transition matrix for the number of industrial designs conditioned to the spatial interaction with neighboring regions, as explained in the methodological section. In order to corroborate the statistical significance of the presence of spatial effects, a Markov homogeneity test was applied (Table A2). The probabilities calculated for the likelihood ratio (LR) and chi-square statistics indicate the rejection of the null hypothesis proposing equality between the overall transition matrix and each of the spatially conditioned matrices. Therefore, it is concluded that conducting a Markov chain analysis is appropriate, conditional on the presence of spatial effects. The first set shows the spatio-temporal dynamics of industrial design production in regions spatially associated with neighboring regions with the lowest industrial design production (MB). A general feature in this set is the high probability of remaining in their class of origin. In particular, a region's probability of remaining in the class with the lowest design output (MB) level is remarkably high, at 66 percent, if it interacts spatially with regions initially located in that class (MB). Regions located in the highest class (MA) that also interact spatially with regions located in the class with the lowest production (MB) have a 56 percent probability of remaining in their same class; Nevertheless, the probability of moving to a lower class (A) is also high at 44 percent. This statistic contrasts with the 20 percent probability for regions to move from

[1]Moran's *I* is a statistic that enables the measurement of the presence of global spatial association between values in specific spatial units and the weighted average of values in neighboring spatial units. A positive value indicates the presence of spatial association between similar values of the geographic units forming a spatial agglomeration pattern, while a negative value indicates the presence of heterogeneous spatial association characterized by dissimilar values between the geographic units.

MA to the B level. In the case of regions located in the middle class (Med), it is striking that the probability of moving to the lower class (B) is greater than the probability of remaining in their initial location.[2]

Table 3
Spatially conditioned probabilistic transition matrix for the number of industrial designs in Mexico

Spatial lag	State	MB	B	Med	A	MA
	MB	0.66	0.20	0.15	0.00	0.00
	B	0.16	0.43	0.24	0.11	0.05
MB	Med	0.18	0.32	0.29	0.18	0.04
	A	0.00	0.10	0.30	0.57	0.03
	MA	0.00	0.00	0.00	0.44	0.56
	MB	0.56	0.29	0.09	0.06	0.00
	B	0.23	0.43	0.27	0.07	0.00
B	Med	0.16	0.24	0.38	0.22	0.00
	A	0.05	0.05	0.33	0.52	0.05
	MA	0.00	0.00	0.00	0.07	0.93
	MB	0.67	0.27	0.03	0.03	0.00
	B	0.30	0.20	0.30	0.15	0.05
Med	Med	0.13	0.30	0.35	0.22	0.00
	A	0.11	0.04	0.14	0.54	0.18
	MA	0.00	0.05	0.00	0.10	0.85
	MB	0.40	0.29	0.17	0.11	0.03
	B	0.59	0.00	0.18	0.18	0.06
A	Med	0.00	0.22	0.28	0.39	0.11
	A	0.10	0.17	0.10	0.52	0.10
	MA	0.00	0.00	0.07	0.07	0.85
	MB	0.65	0.12	0.19	0.00	0.04
	B	0.20	0.30	0.35	0.15	0.00
MA	Med	0.10	0.23	0.45	0.23	0.00
	A	0.00	0.11	0.21	0.50	0.18
	MA	0.03	0.00	0.06	0.11	0.80

Source: created by the authors with information from the Mexican Institute of Industrial Property

A similar spatio-temporal dynamic is observed in the regions that interact with neighboring regions with the highest level of production of industrial designs (MA). In Table 3, the calculations also indicate that the probability of remaining in the initial class is relatively higher, except for the regions originally located in the middle level of industrial design production. For example, the probability of a region remaining in the group with the lowest production of industrial designs (MB) is 65 percent, 45 percent if they are located in the middle level, and 80 percent for the highest class (MA); nevertheless, the

[2] Table A5 in the appendix shows the classes to which the spatial lags associated with each of the 32 regions have belonged in the period between 1993 and 2016. Similarly, Table A6 identifies the classes to which the 32 regions have belonged during the same period.

probabilities of moving to a different class are significant. In the case of médium-level regions, they have a probability of 23 percent of reaching a higher level or falling in the next period.

This information suggests that regions that interact with neighboring regions located in the high and very high classes have the potential to increase their production of industrial designs through dissemination processes or externalities resulting from spatial interaction in taking advantage of geographic proximity. On the other hand, although regions that produce a very low amount of industrial designs and interact with neighbors with similar characteristics also seem to benefit from positive spillover effects, the boost they would receive would be considerably smaller compared to those regions that interact with highly innovative neighbors. Furthermore, it is observed that regions located in the middle or higher classes that also interact with neighboring regions located at the lowest production level are at risk since the probability of decreasing their levels of innovation and moving toward lower classes is high.

Table 4 presents the spatio-temporal distribution of the regional production of industrial designs in the steady state for each spatially conditioned transition matrix. The multimodal distribution[3] observed when regions interact with neighbors with the lowest production level (MB class) describes a process of divergence in the long run with a higher probability of belonging to the very low, low, medium, and even high classes. In this case, the Shorrocks index[4] is the second highest at 0.63, suggesting moderate mobility but accompanied by a process of divergence (Table A3). On the other hand, the regions that interact with neighbors located in the low class (B) also face a divergence process as indicated by the trimodal distribution in the steady state toward the MB, B and Med classes. The Shorrocks index shows moderate regional mobility, with 0.54 in this case. Regarding the regions that interact with neighbors located in the middle class (Med), a process of polarizing divergence toward the extremes of the distribution is observed in the very low or high classes, which the Shorrocks index captures with a magnitude of 0.60.

On the other hand, regions that interact spatially with neighboring regions in the high (A) or very high (MA) classes present a convergence process described by a unimodal distribution in the steady state. In particular, regions that interact with neighbors in the high class (A) present a unimodal distribution centered on the very high class, suggesting the significant presence of spatial, technological externalities. Regarding the regions associated with neighbors in the very high class, although the highest probability indicates a unimodal distribution centered on the medium class (Med), the probabilities of staying in the very high class or transitioning to the high class in the long run are not negligible (Table 4).

---

[3] Quilis (1997) states that the ergodic vector must have a unimodal distribution in order not to reject the convergence hypothesis. If it is multimodal, it is claimed that there is no convergence. In particular, the bimodal case indicates the presence of local attractors in regions, which define convergence clubs formed by polarized regions as mentioned by Quah (1996), but this result does not show a trend toward convergence

[4] The mobility index proposed by Shorrocks (1978) offers a global measure of the global mobility of a specific economic variable. The index takes values between zero and one, with a value close to one (zero) indicating high (low) regional mobility.

Table 4
Spatially conditioned long-run steady-state probability matrix for the number of industrial designs in Mexico

Class	MB	B	Med	A	MA
MB	0.24	0.25	0.23	0.22	0.07
B	0.23	0.23	0.23	0.18	0.13
Med	0.25	0.16	0.13	0.19	0.28
A	0.16	0.12	0.14	0.24	0.35
MA	0.17	0.14	0.26	0.21	0.22

Source: created by the authors with information from the Mexican Institute of Industrial Property

Conclusions

This research argues that industrial designs as a form of innovation have been largely ignored in economic studies, perhaps due to their purely aesthetic character, as opposed to innovations, focused on technological and technical aspects such as patents and utility models, respectively. It is noted that industrial designs should be considered as a market innovation that complements, rather than substitutes, technological and technical innovations. Concerning its economic contribution, it does not only occur from the creation of an industry made up of companies that provide industrial design services, but it is even broader, since with its function of providing a special and unique external image, it also contributes to the differentiation of products and services, to their positioning in the market, and even to the creation of new markets.

A contribution of this research is the use of a new database that compiles the number of industrial designs for the 32 states of Mexico to analyze the evolution of their spatio-temporal distribution. Through the application of spatial Markov chains and statistical contrast tests, spatial interaction is observed as a significant condition in the distributive evolution of the regional production of industrial designs in Mexico. One feature that characterizes the regional dynamics is a high probability of preserving their location in the original class and a significant probability of moving to different classes. In particular, regions that interact with neighboring regions that produce high levels of industrial designs have, in general, high probabilities of moving into higher classes. Nevertheless, regions that interact with neighbors with the lowest design production levels may even move toward production levels in lower classes. This transitional dynamic implies that, in the long run, regions that interact with neighbors that are high producers of industrial designs will converge to equal or higher levels of innovation. In contrast, those regions that interact with less innovative neighbors face a process of divergence characterized by a multimodal distribution.

These results, while offering a novel perspective on the geography of innovation, also complement the empirical findings of several studies that have identified the heterogeneous spatial distribution of innovation in Mexico regarding patenting (Mendoza & Torres, 2003), brand production (Torres *et al.*, 2013), and industrial designs themselves (Torres *et al.*, 2014), as a potential factor in the economic divergence processes observed in the long run.

In this regard, the empirical evidence obtained from the analysis of the distributive evolution of the regional production of industrial designs suggests that the design of the general guidelines for technological development and innovation policy in the country should incorporate a regional component that considers the type of spatial interaction identified. In particular, regions whose innovation dynamics and spatial association with other regions enable them to take advantage of cross-border knowledge externalities should be the target of measures that contribute to preserving and even strengthening such innovative dynamism. The main challenge, however, seems to lie in the design of a set of regional technological development and innovation policies focused on those regions with low levels of industrial design production but which also find it difficult to take advantage of cross-border knowledge externalities that enable them to advance in the production of industrial designs. Technological development and innovation policies with a regional focus are essential to address the divergence in regional innovation observed in Mexico and contribute to regional economic growth. In this regard, it is necessary to strengthen the presence of local programs that promote the creative activity of industrial design and its protection through access to the existing industrial property protection system in the country and promote public and private interregional cooperation.

References

Arrow, K. (1962). The economic implications of learning by doing. The Review of Economic Studies 29(3), 155- 173. https://doi.org/10.2307/2295952

Baumol, W (1968). Entrepreneurship in economic theory. The American Economic Review 58(2), 64-71.

Capello, R. & Lenzi, C. (2013). Territorial patterns of innovation and economic growth in European regions. Growth and Change 44(2), 195-227. https://doi.org/10.1111/grow.12009

Díaz-Bautista, A. (2003). Capital humano y crecimiento económico en México (1970-2000). Comercio Exterior 53(11), pp. 1012-1023.

Europe Economics (2016). The economic review of industrial design in Europe. London: Europe Economics. Disponible en: shorturl.at/mqy36. Consultado: 15/09/2019.

Fingleton, B. (2003). Externalities, economic geography and spatial econometrics: conceptual and modelling developments. International Regional Science Review 26(2), 197-207. https://doi.org/10.1177/0160017602250976

Feeney, S. & Rogers, M. (2001). Innovation and performance: benchmarking Australian firms. Melbourne Institute, Working Paper number 7/01. https://doi.org/10.1111/1467-8462.00285

Germán-Soto, V., Gutiérrez, L. y Tovar, S. (2009). Factores y relevancia geográfica del proceso de innovación regional en México, 1994-2006. Estudios Económicos 24(2), pp. 225-248.

Germán-Soto, V. y Gutiérrez, L. (2013). Assesing some determinantes of the regional patenting: An essay from the Mexican states. Technology and investment, 4, pp. 1-9. https://doi.org/10.4236/ti.2013.43b001

Foray, D. (2009). Understanding smart specialization. In The question of R&D specialization, ed. D. Pontikakis, D. Kyriakou & R. van Bavel. Brussels: European Commission.

Griliches, Z. (1979). Issues in Assessing the Contribution of R&D to Productivity Growth. The Bell Journal of Economics 10(1), 92-116. https://doi.org/10.2307/3003321

Griliches, Z. (1980). Returns to Research and Development Expenditures in the Private Sector. In J. Kendrick and B. Vaccara eds New Developments in Productivity Measurement, 419-462, USA: Chicago University Press. https://doi.org/10.2307/1058637

Griliches Z. & Mairesse, J. (1984). Productivity and R&D at the firm level. In: Griliches Z ed R&D, patents and productivity. US: University of Chicago Press. https://doi.org/10.3386/w0826

Griliches Z. (1990). Patent statistics as economic indicators: a survey. Journal of Economic Literature 28(4), 1661- 1707.

IMPI (2018). ¿Qué son los diseños industriales? Disponible en: https://www.gob.mx/impi/articulos/que-son-los-disenos-industriales?idiom=es. Consultado: 01/08/2019.

Jungmitage, A. (2004), Innovations, technological specialization and economic growth in the EU. International Economics and Economic Policy 1(2-3), 247-273. https://doi.org/10.1007/s10368-004-0018-5

Marroquín, J., & Ríos, H. (2012). Inversión en investigación y crecimiento económico: un análisis empírico desde la perspectiva de los modelos de I+D. Investigación Económica, LXXI (282), 15-33. https://doi.org/10.22201/ fe.01851667p.2012.282.37362

Mendoza, E., & Torres Preciado, V. (2003). Globalization and technological growth: a model of technology diffusion in Mexico, 1996-2000. Momento Económico, Diciembre, no. 129-154.

Parent, O. & LeSage, J. (2012). Determinants of knowledge production and their effects on regional economic growth. Journal of Regional Science 52(2), 256-284. https://doi.org/10.1111/j.1467-9787.2011.00732.x

Quah, D. (1996). Regional convergence clusters across Europe. European Economic Review, 40(3-5), 951-958. https://doi.org/10.1016/0014-2921(95)00105-0

Quilis, Enrique (1997). Convergencia de la productividad en España, un análisis dinámico de su distribución regional. Instituto Nacional de Estadística, Madrid, http://www.ine.es/daco/daco42/daco4214/cbtc13.pdf.

Rey, S. (2001). Spatial empirics for economic growth and convergence. Geographical Analysis, 33(3), 195–214. https://doi.org/10.1111/j.1538-4632.2001.tb00444.x

Romer, P. (1990). Endogenous Technological Change. Journal of Political Economy 98(5), 71-102. https://doi. org/10.3386/w3210

Sener, S. y Saridogan, E. (2011). The effects of science-technology-innovation on competitiveness and economic growth. Procedia Social and Behavioral Sciences 24, pp. 815-828. https://doi.org/10.1016/j.sbspro.2011.09.127

Shorrocks, A.F. (1978). The measurement of mobility. Econometrica 46(5), 1013-1024.

Schumpeter, J. (1934). Theory of economic development. Cambridge: Harvard University Press.

Solow, R. (1956). A contribution of the theory of economic growth. Quarterly Journal of Economics 70(1), 65–94. https://doi.org/10.2307/1884513

Solow, R. (1957). Technical change and the aggregate production function. Review of Economics and Statistics 39(3), 312–320. https://doi.org/10.2307/1926047

Torres-Preciado, V., Polanco, M. & Tinoco, M. (2013). Marcas, efectos de difusión espacial y crecimiento económico regional en México. En I. Perrotini ed. Política económica: análisis monetario, regional e institucional, 265-292, México: BUAP.

Torres-Preciado, V., Polanco, M. & Tinoco, M. (2014). Technological innovation and regional economic growth in Mexico: a spatial perspective. The Annals of Regional Science 52(1), 183-200. https://doi.org/10.1007/s00168- 013-0581-1

Varga, A., Anselin, L. & Acs, S. (2003). Regional innovation in the US over space and time. Discussion papers on Entrepreneurship, Growth and Public Policy no. 1804. https://doi.org/10.1007/3-211-27175-9_5

Velázquez, G., & Salgado, J. (2016). Innovación tecnológica: un análisis del crecimiento económico en México (2002-2012: proyección a 2018). Análisis Económico, XXXI (78), 145-170.

http://dx.doi.org/10.22201/fca.24488410e.2021.2770

Annex

Table A1
Global transition matrix for the number of industrial designs in Mexico

Clase	MB	B	Med	A	MA
MB	97	39	21	7	2
B	33	39	33	15	4
Med	17	36	49	32	3
A	7	13	29	72	15
MA	1	2	5	16	117

Table A2
Markov homogeneity test

Test	RV	ch2
Statistic	113.503	103.489
G. de L.	80	80
Prob.	0.008	0.04

P(H0)	MB	B	Med	A	MA
MB	0.58	0.24	0.13	0.04	0.01
B	0.27	0.32	0.27	0.12	0.03
Med	0.12	0.26	0.36	0.23	0.02
A	0.05	0.10	0.21	0.53	0.11
MA	0.01	0.01	0.04	0.11	0.83

Source: created by the authors

Table A3
Regional mobility based on the Shorrocks Index

Transition matrix	Index Value
Global matrix	0.60
Spatial transition matrix	
Neighbor in first quintile	0.63
Neighbor in second quintile	0.54
Neighbor in third quintile	0.60
Neighbor in fourth quintile	0.74
Neighbor in fifth quintile	0.57

Source: created by the authors with information from the Mexican Institute of Industrial Property
Note: The Shorrocks index was calculated with the formula: $\widehat{M}(P) = n - trace(P)/n - 1$ where n is the number of classes, and P is the transition matrix

Table A4
Matrix of average duration of the first transition for the number of industrial designs in Mexico

	State	MB	B	Med	A	MA
MB	MB	4.2	4.89	5.60	11.64	35.17
	B	9.47	4.02	4.68	8.92	31.94
	Med	9.40	4.57	4.41	8.43	32.63
	A	12.11	6.11	3.86	4.50	32.27
	MA	14.36	8.36	6.11	2.25	15.34
B	MB	4.42	4.71	6.28	10.64	110.58
	B	6.94	4.32	4.97	10.06	110.00
	Med	8.20	6.04	4.36	8.32	108.26
	A	11.15	9.22	5.25	5.47	99.94
	MA	26.15	24.22	20.25	15.00	7.66
Med	MB	4.00	4.62	11.47	10.91	23.48
	B	8.43	6.38	9.03	8.91	20.98
	Med	9.73	5.89	7.96	7.87	21.26
	A	12.78	10.30	12.48	5.36	15.73
	MA	18.16	13.70	18.16	9.8024565	3.56
A	MB	6.42	6.37	7.52	6.34	14.27
	B	5.97	8.60	7.64	6.09	13.86
	Med	11.66	8.29	7.38	4.67	12.52
	A	10.55	8.47	8.82	4.14	12.76
	MA	17.94	15.21	11.24	9.17	2.85
MA	MB	5.80	8.74	5.36	10.19	21.44
	B	12.10	6.99	4.30	7.74	21.19
	Med	13.93	7.66	3.90	6.81	20.67
	A	17.30	10.42	6.26	4.79	15.40
	MA	18.87	14.39	9.34	8.40	4.55

Source: created by the authors with information from the Mexican Institute of Industrial Property

Table A5
Location of spatial lags in the five quintiles between 1993 and 2016

Spatial Lag	Quintile
Spatial Lag Aguascalientes	[4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 3, 3, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
Spatial Lag Baja C.	[1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0]
Spatial Lag Baja C. S.	[0, 0, 2, 1, 1, 2, 0, 1, 0, 0, 0, 0, 0, 2, 0, 0, 1, 1, 1, 1, 2, 1, 1]
Spatial Lag Campeche	[0, 1, 1, 0, 1, 1, 0, 0, 0, 1, 0, 1, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1]
Spatial Lag Chiapas	[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 1, 0, 0, 1, 0]
Spatial Lag Chihuahua	[2, 2, 1, 0, 1, 1, 1, 1, 0, 0, 1, 0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1]
Spatial Lag Mexico City	[4, 4, 4, 4, 4, 3, 4, 4, 3, 4, 4, 3, 3, 4, 4, 4, 4, 4, 4, 3, 3, 3, 3]
Spatial Lag Coahuila	[2 2 2 2 2 2 2 1 2 3 3 2 3 2 2 2 2 2 2 3 3 3 3

http://dx.doi.org/10.22201/fca.24488410e.2021.2770

Spatial Lag Colima	[4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 3, 3, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
Spatial Lag Durango	[1, 1, 0, 1, 1, 1, 1, 1, 1, 2, 1, 1, 1, 1, 1, 1, 1, 1, 1, 2, 1, 2, 1]
Spatial Lag México	[3, 3, 4, 4, 4, 4, 4, 4, 3, 3, 3, 3, 3, 3, 3, 4, 3, 3, 3, 3, 3, 3, 3]
Spatial Lag Guanajuato	[3, 3, 2, 2, 2, 3, 3, 4, 4, 3, 2, 3, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3]
Spatial Lag Guerrero	[3, 3, 2, 3, 4, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 3, 2, 2, 2, 2, 2]
Spatial Lag Hidalgo	[2, 2, 2, 3, 3, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 3, 2, 3, 2, 2, 2, 2, 2]
Spatial Lag Jalisco	[1, 1, 1, 2, 1, 2, 1, 1, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 3, 3, 2]
Spatial Lag Michoacán	[4, 4, 3, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
Spatial Lag Morelos	[4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
Spatial Lag Nayarit	[4, 4, 3, 3, 3, 3, 4, 4, 4, 3, 2, 2, 2, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3]
Spatial Lag N. León	[2, 2, 1, 2, 0, 0, 0, 1, 2, 2, 1, 0, 2, 1, 1, 2, 1, 2, 2, 1, 1, 2, 1]
Spatial Lag Oaxaca	[1, 1, 0, 2, 1, 0, 0, 0, 1, 1, 1, 0, 0, 1, 1, 1, 1, 2, 1, 1, 1, 1, 2]
Spatial Lag Puebla	[2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2]
Spatial Lag Querétaro	[3, 3, 2, 3, 3, 3, 2, 2, 2, 3, 3, 4, 4, 4, 3, 3, 3, 4, 4, 3, 4, 3, 3]
Spatial Lag Q. Roo	[0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 2, 3, 1, 1, 1, 1, 2, 1, 1, 1, 1, 1]
Spatial Lag S. L. Potosí	[3, 3, 3, 3, 2, 3, 3, 3, 3, 3, 4, 4, 3, 3, 3, 3, 3, 3, 3, 3, 4, 3, 4]
Spatial Lag Sinaloa	[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 1, 1, 0, 1, 1]
Spatial Lag Sonora	[1, 0, 1, 1, 2, 1, 2, 1, 0, 1, 1, 1, 1, 1, 0, 0, 1, 2, 2, 2, 2, 2, 1]
Spatial Lag Tabasco	[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0]
Spatial Lag Tamaulipas	[2, 3, 3, 3, 2, 3, 3, 2, 2, 4, 4, 3, 4, 3, 3, 3, 3, 3, 3, 3, 4, 4, 4]
Spatial Lag Tlaxcala	[3, 4, 3, 4, 4, 2, 3, 3, 3, 3, 3, 2, 3, 3, 3, 3, 3, 4, 3, 2, 3, 3, 3]
Spatial Lag Veracruz	[1, 1, 0, 1, 1, 0, 0, 0, 1, 0, 1, 0, 1, 1, 1, 1, 1, 2, 1, 1, 1, 1, 1]
Spatial Lag Yucatán	[0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0, 0, 0, 0]
Spatial Lag Zacatecas	[3, 3, 3, 3, 2, 3, 3, 3, 4, 4, 4, 4, 4, 3, 3, 3, 4, 3, 3, 4, 4, 4, 4]

Source: created by the authors

Note: codifications 0, 1, 2, 3, and 4 correspond to classes MB, B, Med, A, and MA, respectively

Table A6
Location of the regions in the five quintiles between 1993 and 2016

State	Quintile
Aguascalientes	[4, 3, 3, 1, 2, 3, 4, 4, 4, 4, 4, 2, 2, 3, 1, 1, 3, 3, 3, 3, 3, 4, 3]
Baja C.	[1, 1, 4, 3, 3, 3, 2, 2, 1, 2, 1, 2, 2, 3, 2, 1, 3, 3, 3, 3, 3, 3, 3]
Baja C. S.	[2, 1, 0, 1, 0, 0, 1, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 0, 1, 1, 1, 0, 1]
Campeche	[0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 2, 0, 1, 0, 0, 1]
Chiapas	[0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1, 2, 2, 1, 1, 1, 1, 1, 1, 1, 1]
Chihuahua	[2, 0, 0, 3, 2, 0, 2, 2, 1, 3, 1, 2, 3, 3, 3, 2, 3, 3, 3, 3, 2, 3, 3]
Mexico City	[4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
Coahuila	[4, 4, 3, 2, 2, 3, 2, 3, 1, 2, 3, 2, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3, 3]
Colima	[2, 0, 0, 1, 0, 0, 1, 0, 0, 0, 0, 1, 0, 1, 1, 1, 1, 0, 2, 1, 1, 1, 2]
Durango	[0, 3, 0, 0, 0, 0, 0, 1, 1, 0, 1, 2, 1, 1, 2, 2, 2, 2, 1, 2, 2, 2, 1]
México	[4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
Guanajuato	[3, 3, 4, 4, 4, 4, 4, 3, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
Guerrero	[3, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 1, 0, 3, 0, 0, 0, 1, 1, 2, 2],
Hidalgo	[0, 1, 0, 0, 0, 1, 1, 3, 0, 2, 2, 1, 2, 3, 3, 2, 2, 1, 2, 2, 1, 3, 3]
Jalisco	[4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
Michoacán	[0, 0, 0, 3, 4, 0, 2, 2, 2, 1, 2, 1, 0, 2, 1, 2, 1, 2, 2, 2, 2, 2, 2]
Morelos	[0, 2, 3, 2, 3, 3, 2, 2, 3, 3, 2, 2, 3, 3, 3, 2, 2, 2, 1, 2, 2, 3, 2]
Nayarit	[0, 0, 0, 0, 0, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 0, 1, 0, 2]
N. León	[4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4, 4]
Oaxaca	[1, 2, 0, 0, 0, 0, 2, 0, 0, 0, 1, 0, 1, 3, 2, 0, 2, 2, 2, 1, 1, 1, 2],
Puebla	[3, 4, 1, 4, 4, 1, 3, 3, 4, 3, 4, 3, 3, 3, 3, 3, 4, 4, 3, 3, 3, 4, 4]
Querétaro	[2, 3, 3, 0, 0, 3, 1, 2, 1, 1, 3, 4, 3, 1, 3, 3, 2, 3, 3, 3, 4, 3, 3]
Q. Roo	[2, 2, 3, 1, 2, 3, 2, 0, 0, 2, 1, 2, 0, 1, 2, 2, 3, 2, 2, 2, 1, 1, 1]
S. L. Potosí	[3, 0, 3, 2, 2, 1, 0, 0, 2, 1, 0, 0, 4, 4, 2, 4, 3, 3, 3, 3, 3, 4, 2]
Sinaloa	[2, 0, 2, 1, 4, 3, 4, 3, 2, 2, 3, 2, 1, 2, 0, 2, 3, 3, 3, 3, 3, 3, 2]
Sonora	[2, 1, 1, 1, 0, 0, 0, 0, 1, 1, 0, 0, 0, 1, 1, 2, 2, 2, 3, 1, 2, 2, 1]
Tabasco	[0, 1, 2, 0, 0, 0, 0, 0, 0, 1, 0, 1, 2, 1, 1, 1, 1, 1, 1, 0, 0, 0, 1]
Tamaulipas	[3, 2, 1, 3, 0, 0, 0, 1, 0, 0, 0, 0, 2, 0, 2, 2, 2, 3, 3, 3, 3, 3, 3]
Tlaxcala	[0, 0, 0, 0, 2, 0, 0, 0, 1, 0, 1, 0, 0, 2, 1, 4, 3, 1, 3, 1, 1, 2, 3]
Veracruz	[0, 2, 2, 3, 2, 3, 2, 2, 2, 0, 2, 0, 2, 2, 1, 3, 2, 1, 2, 2, 2, 3, 3]
Yucatán	[2, 3, 1, 3, 3, 2, 2, 1, 1, 3, 2, 4, 4, 3, 3, 3, 3, 4, 3, 3, 3, 3, 3]
Zacatecas	[0, 3, 0, 4, 2, 0, 0, 2, 4, 4, 2, 2, 2, 1, 2, 3, 1, 2, 1, 3, 2, 3, 3]

Source: created by the authors
Note: codifications 0, 1, 2, 3, and 4 correspond to classes MB, B, Med, A, and MA, respectively