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Articles

Spatial diffusion of economic growth and externalities in Mexico

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Abstract:

Economic growth and externalities are rooted in spatial dynamics, however, their spread over space is not unlimited. In this document it is estimated the strength spatial externalities from capital on output and the spatial spillover of the economic growth for Mexican municipalities at different distances. The estimation is carried out implementing a Spatial Durbin Model with distance-based spatial weight matrices in a panel data structure from 1988 to 2013. The results show evidence of weak spatial externalities from capital on output at short distances, say 20 or 60 km. Additionally, it is found that the diffusion of economic growth is directly related to distance, moreover, there is evidence in favor about the convergence hypotheses, finding out that distance between stationary states is insufficient to explain differences among municipalities' growth rates, but geographical distance matters as well.

Keywords: Economic growth; Externalities; Spatial Convergence.
JEL Classification: R11; R12.

Difusión espacial del crecimiento económico y de las externalidades en México

Resumen:

El crecimiento económico y las externalidades están vinculados a la dinámica espacial, sin embargo, su difusión sobre el espacio no es ilimitada. En este trabajo es estimada la fuerza de las externalidades espaciales del capital físico en la producción, así como la difusión del crecimiento económico en los municipios de México a diferentes distancias. La estimación es llevada a cabo a través de un Modelo Espacial Durbin con matrices de peso espaciales basadas en la distancia con una estructura de datos panel, de 1988 a 2013. Los resultados muestran evidencia de débiles externalidades espaciales del capital sobre la producción en cortas distancias, por ejemplo 20 o 60 km. Por otro lado, se encuentra que la difusión espacial del crecimiento económico está relacionada directamente con la distancia, más aún, existe evidencia en favor de la hipótesis de convergencia, encontrando que la distancia entre estados estacionarios es insuficiente para explicar las diferencias en las tasas de crecimiento, sino que también la distancia geográfica importa.

Palabras clave: Crecimiento económico; externalidades; Convergencia espacial.
Clasificación JEL: R11; R12.

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1. Introduction

Regional economic growth is a topic that has attracted increasing attention over the last three decades. One of the early works is Richardson (1973), who studies economic growth at a disaggregated level within a regional framework. Theoretical advances on knowledge interdependence, technological spillovers, and human capital by Arrow (1962); Romer (1986); Lucas (1988); just for mention a few, became the foundations for modern regional analysis.

The underlying idea behind those documents, which combine the so-called engine of growth with the regional approach, is that human or physical capital externalities are transmitted from one region to another, under the fact that territories are not isolated and they interact with one another (Isard, 1960).

Despite a significant number of papers analyzing output and output growth rate from many perspectives in Mexico, no one has pointed out the role of the spatial externalities from capital on output at municipality level. On the other hand, the spatial effects of the economic growth in Mexico is wide covered in the literature using all aggregation levels available, although the role of distance on the dimensions like output or output growth rate is null. The goal of this document is to estimate and to analyze the spatial externalities from capital on output, and the output growth rate diffusion over space. To that end, it is taken the model from Romer (1986) and add elements of the model developed in Vayá et al. (2004) to measure the strength of the spatial externalities from capital on output and the spillover of economic growth for the Mexican municipalities.

The structure of the document is as follows; Section 1 presents relevant literature on the externalities of economic growth. Section 2 describes the theoretical models used to carry out the analysis. The econometric exercise is conducted in Section 3 where the specifications are presented. In Section 4 are presented and discussed the results. The document ends with some concluding remarks and suggestions for future research.

2. Economic growth and spatial externalities

One of the early works addressing spatial effects on economic growth is Bernat (1996). The author evaluates Kaldor's laws for the U.S. economy considering the states as units of analysis. A key assumption is the existence of spatial effects not only in the manufacturing sector but by geographical location as well. The analysis shows clear support for the first two Kaldor's laws and marginal evidence in favor of the third one.

There are factors rooted in the physical space that were virtually ignored by earlier authors who worked on growth and convergence, Rey and Montouri (1999) overcomes this shortcoming. The authors tackle the question of regional income convergence from a spatial econometric perspective. They were pioneers on the analysis of this issue utilizing spatial econometric techniques. Beyond corroborating the convergence hypotheses for U.S. states, they find strong evidence of spatial autocorrelation across states on the economic growth rate. This means that, in the path of economic growth along with the diminishing income gap, states do not exhibit independence from one another, but instead converge like their regional neighbors.

Based on Romer (1986), López-Bazo et. al. (1998) develop a theoretical and empirical model, later extended in Vayá et al. (2004). In this last, the authors take a regional context and decompose the internal and external effects of physical and human capital. They use spatial econometrics techniques to show that intraregional returns on human capital and intraregional returns on physical capital are significant enough to raise the growth rate in an entire region.

Ertur and Koch (2007), on the other hand, study the impact of physical capital externalities at steady states. They develop a spatially augmented Solow model to assess the spatial effects on production and the growth rate. Their results show evidence in favor of conditional convergence. The authors also replicate the exercise for each country in the sample and obtain an individual convergence speed rate; and find evidence that knowledge interdependence generates spatial externalities in neighboring countries. Furthermore, they highlight the relevance of distance and the role that plays when externalities extend over space. They also confirm that the intensity of those externalities declines as the distance between two countries increases. This result is consistent with benefits of agglomeration and the existence of increasing returns.

In the same vein of analysis, Rodríguez-Pose and Villarreal (2015) study the impact of investment on innovation on economic growth in Mexico using states as units of analysis. They find that, although innovation has veered in the right direction in recent years, it is not enough to tow the Mexican economy faster than current levels of growth, which implies the absence of externalities. The analysis shows high concentration of investment in knowledge, but only a few states benefit with this kind of capital flows.

Dall'erba and Llamosas-Rosas (2015) approach the externalities issue by dividing capital into human, private and public to assess its impact on economic growth in the U.S. states. Their approach combines neoclassical, endogenous growth, and new economic geography theories which in the past were considered separately. One of the main findings, among others, is the impact that private capital has on income; which is two or three times higher than public capital.

Recently, Jung and López-Bazo (2017) introduce the absorptive capacity of regions on the capital accumulation and spatial spillovers across economies for the case of Europe. They focus on the externalities derived from the physical and human capital in European regions. Their results confirm that neighborhood matters and find that local externalities lead to economic growth and increase the capacity of the surrounding neighbors.

The literature about spatial externalities and growth for the case of Mexico is scarce. Most of the literature focuses on growth and convergence.[1] The bulk of documents use states as observation unit; hence, the analyses ignore multiple socio-demographic and economic processes at local level and does not necessarily consider factors like regional specialization, planning, and natural resources. One way to overcome these shortcomings is to consider a lower level of data aggregation, like municipalities. At this aggregation level is possible to capture inter-state relationships as well as local productivity characteristics, among other.

Valdivia (2007) for instance, focuses on the growth dynamics of municipalities from 1993 to 2003. He considers the spatial heterogeneity of municipalities which is split into core and periphery categories. His results provide evidence in favor of unconditional convergence between 1993 and 2003. These results are in contrast of the findings in previous works that consider states as unit of analysis like Esquivel (1999) or Ruiz (2000). Carmeño et al. (2009) study manufacturing value added per worker in northbound border municipalities and southbound border U.S. counties. Their results contrast with Validia (2007) as they find divergence. However, it is important address that Carmeño, *et. al.* (2009) focus on a sample of municipalities without considering spatial interactions, whereas Valdivia (2007) employs spatial econometric techniques to capture the spatial dimension.

Recently, Díaz, Fernández, Garduño and Rubiera (2017) show the existence of club convergence in the border municipalities of Mexico, which appear to be associated with Mexico City's loss of competitiveness following the implementation of the North America Foreign Trade Agreement (NAFTA). These authors use a panel data model with a spatial lag to assess the convergence from 1980 to 2010, they conclude that, trade openness has generated regional divergence in the country.

[1] See for example Esquivel (1999), Ruiz (2000), Carrillo (2001), Carmeño (2001), Rodríguez-Benavides, Mendoza-González and Venegas Martínez (2016), Ocegueda (2007), Díaz-Bautista (2008), among others.

Rodríguez-Gámez and Cabrera-Pereyra (2019) develop a study where it is addressed upon the absolute as well as the conditional convergence hypotheses with spatial econometric techniques, using the municipalities as observation unit. These authors find evidence that corroborates the fact that poor municipalities grow faster than rich ones, furthermore, from 2009 to the last, municipalities depend on their own productive characteristics more than spatial interactions for developing, pointing out that, geographic location has become irrelevant for the municipalities' economic growth in recent years.

It is important to recognize that externalities are not randomly distributed in space, these are located and rooted to a specific place (Marshall, 1920) (Muñiz, 1998). Territories obtain benefits from other because of geographic location. Even their position in space plays a role when externalities exist.

A common assumption is that externalities are transmitted to the nearby locations, but, what does 'nearby' mean? Clearly, diffusion of externalities across space is not unlimited, it is reasonable the existence of a distance threshold for their influence. If this were not the case, we would not observe economic activities agglomeration around the world. The same reasoning is true for economic growth; if a territory experiences growth, its closest neighbors shall too.

Based on this rational, it should be the case that, as distance between territories increases, the benefits between them diminish. Hence, nearby territories should be associated with high externality levels, whereas distant territories should be associated with low externality levels. The last, is the underlying hypothesis to test in the present study, the goal is to determine the distance threshold where externalities from capital are present on output among territories and how the output growth rate affects the output growth rate of their neighbors.

3. The model

Consider a production function where output (Y) in territorial units *i* and time *t* depends on capital (K), labor (L) and technology (A):

$$Y_{it} = F(K_{it}, A_{it}L_{it}) \tag{1}$$

Notice that technology is an endogenous variable and interacts with labor. Technology is defined as the set of knowledge and skills that workers have developed during their life; therefore, technology is not associated with capital initially, tough, later it is shown that it depends on this factor as well.

The productive factors interact via a Cobb-Douglas function as follows,

$$Y_{it} = F(K_{it}, A_{it}L_{it}) = K_{it}^{\alpha}A_{it}L_{it}^{1-\alpha} \text{ with } 0 < \alpha < 1 \tag{2}$$

Where K is the stock of capital, A is the technology, L is the Labor, subscripts denote territorial unit i and time t. Parameter α represents the share of each productive factor on output.

The diffusion idea comes from Romer (1986, p. 1003) *"the creation of new knowledge by one firm is assumed to have a positive external effect on the production possibilities of other firms"*. But instead firms, territorial units are considered. Technology, which is available in any territorial unit i, is also available in the nearby territories j, because workers move within a geographical area to reach their jobs. Even when they move from one firm to another, they typically do so within the surrounding area. Workers carry knowledge and skills with them. The model description that follows comes from López-Bazo, et. al. (1998) with modifications adapted for the present study.

For a finite number of territorial units which define a neighborhood delimited by a distance, technology is defined as:

$$A_{it} = \Delta k_{it}^{\alpha}A_{jt}^{\rho} \tag{3}$$

In equation (3), Δ represents an exogenous level of technology that may arise from historical accidents (Krugman, 1991), which shifts the direction of economic activity. A_{jt} refers to the technological level in territorial units j and ρ represents the spatial interdependence between territories, this parameter also reflects the strength with which the ups and downs from territorial units *j* impact on a territorial unit *i*. When there is no spatial interdependence, this means that $\rho=0$, then, technology is only determined by its own capital per worker. In summary, equation (3) reflects how the technology depends on its own capital and the neighbors' technology too.

Technology is dynamic, the knowledge and skills change throughout time, they obey the economic dynamics as they are related to capital flow. The stock of capital corresponds to the set of capital flows held in any territorial unit. Therefore, the set of knowledge and skills are equivalent to the capital flows accumulated over the entire time. It is a function of investment *I,* which depends on saving (*s*):

$$A_t = \int_{-\infty}^{t} I(s)ds = K_t \tag{4}$$

Although workers own the knowledge and skills, they are restricted to learning only the required skills for their specific job, e.g. the arrival of a new machine requires the worker to update his knowledge and skills in order to use the machine efficiently. If the machine never arrives, update is unnecessary, "*learning only takes place through the attempt to solve a problem and therefore only takes place during activity"* (Arrow, 1962, p. 155). Given this set up, it is assumed that the technology growth rate is proportional to the capital growth rate per worker for all territorial units:

$$\dot{A}_t = \dot{k}_t \tag{5}$$

When any territorial unit increases, its stock of capital, the capital for neighboring territories also increase, thus, the knowledge and skills available in any territorial unit are also available for all workers.

$$A_{it} = \Delta k_{it}^{\gamma} A_{jt}^{\rho} \tag{6}$$

Where $\gamma = \alpha + \eta$, η represents the share on capital from neighbors, considering that every territory *j* has its own η. When $\eta=\rho=0$, i.e. either neighbors' capital is zero or there is no spatial interdependence, the own capital of unit *i* determines the technology level.

Economic activity is not restricted by administrative delimitations, these boundaries are nonexistent to the flows of knowledge whose vehicle is, mainly, the workers. It is, however, restricted by physical capital flows.

To normalize the production function, given in the equation (2), and make the comparison between territorial units reliable, it is multiplied by $1/L$, and rewrite the equation as:

$$y_{it} = A_{it} k_{it}^{\alpha} \tag{7}$$

Where y_{it} and k_{it} are output and capital per worker respectively in the unit *i* in time *t*. Each territorial unit that belongs to the neighborhood has a similar production function which is determined simultaneously, the territorial unit *j* has a production function equal to

$$y_{jt} = A_{jt} k_{jt}^{\eta} \tag{8}$$

Technology is substituted into the production function of the territorial unit *i* to get the next equation:

$$y_{it} = \Delta k_{it}^{\gamma} \left[\frac{y_{jt}}{k_{jt}^{\eta}}\right]^{\rho} \tag{9}$$

If this expression is log-linearized, we obtain the steady state level of output,

$$\ln y_{it} = \ln \Delta + \gamma \ln k_{it} + \rho(\ln y_{jt} - \eta \ln k_{jt}) \tag{10}$$

The last function indicates that output depends on the exogenous level of technology, on the physical capital per worker and on the difference between both output and physical capital per worker of the neighbors. Equation (10) allows for the existence of physical capital externalities on output through spatial interaction.

Equation 10, however, is insufficient to evaluate the output growth diffusion over space. To address this shortcoming a growth equation is introduced. Following Vayá, et.al. (2004) Consider a Solow-Swan's fundamental equation in expression (7) and assume that $\dot{A} = \dot{k}$. The result is equation (11) which is appropriate to estimate the variation of physical capital in territorial unit *i*

$$\dot{k}_i = s\Delta k_i^{\gamma} k_j^{\rho} - (d+n)k_i \tag{11}$$

Where d and n are the depreciation and population growth rates respectively. Notice that physical capital variation is a function of capital per worker in territorial unit i and capital per worker in neighboring territorial units j. Thus, the growth rate of capital accumulation in unit i is as follows

$$\frac{\dot{k}_i}{k_i} = s\Delta k_i^{-(1-\gamma)} k_j^{\rho} - (d+n) \tag{12}$$

To obtain the rate of capital accumulation throughout the economic growth path, consider that, at any point in time, all units that belong to a neighborhood have the same rate, i.e., all territorial units behave at any point in time as one. At this point, all units of the neighborhood share the same growth rate. In the long run, territorial units conform a larger territorial unit, as actually happens on the composition of metropolitan areas where administrative boundaries are irrelevant for interactions. This implies that territorial units adhere to the dynamics where positive and negative exogenous shocks affect all units in the same way, therefore, it is plausible that in the long run all the territorial units accumulate physical capital at the same rate, formally, $k_i^* = k_j^* = k^*$. Moreover,

$$g_k \equiv \frac{\dot{k}}{k} = s\Delta k^{-(1-(\gamma+\rho))} - (d+n) \tag{13}$$

The rate of capital accumulation is a decreasing function of capital per worker. The magnitude of the rate depends on how far a given unit is from the steady state. That is, in the territorial units with low capital levels, capital is accumulated at higher rates. Furthermore, it depends positively on the saving rate which in this case is assumed exogenous for simplicity. The accumulation process follows a dynamic that makes sense when territorial units interact across space. In fact, it is expected that territorial units with low capital levels, if they are isolated in space, show low accumulation rates, so that, space and neighborhood matter.

From (13) it is easy to obtain the level of the stock of capital for the neighborhood. As in Sala-i-Martin (2000) it is assumed that in steady state $g_k = 0$. It is substituted the result into the production function to obtain:

$$\ln y_{it} = \left(\frac{1-\rho+\eta}{1-(\gamma+\rho)}\right)\ln\Delta + \left(\frac{\gamma+\eta}{1-(\gamma+\rho)}\right)\ln s - \left(\frac{\gamma+\eta}{1-(\gamma+\rho)}\right)\ln(d+n) + \rho\ln y_{jt} \tag{14}$$

Equation 12 log-linearized around $\ln k_i^*$ leads to the next expression:

$$g_k = (1-\gamma)s\Delta e^{-(1-\gamma)\ln k^*}(\ln k^* - \ln k_{i0}) \tag{15}$$

In a steady state $s\Delta e^{-(1-\gamma)\ln k_{i0}} = (d+n)$, such that, equation 15 can be rewritten,

$$g_k = (1-\gamma)(d+n)(\ln k^* - \ln k_{i0}) \tag{16}$$

Then $\beta = -\frac{\partial g_k}{\partial \ln k_i} = (1-\gamma)(d+n)$, which is the classical speed of convergence. In the steady state, if endogenous variables growth at the same rate, then equation (16) can be rewritten as:

$$\ln y_{it} = \left(1 - e^{-\beta t}\right)\ln y^{*} + e^{-\beta t}\ln y_{i0} \tag{17}$$

From equation (14) and (17) the following expression is defined:

$$\psi = (1 - e^{-\beta t})\left[\left(\frac{1-\rho+\eta}{1-(\gamma+\rho)}\right)\ln\Delta + \left(\frac{\gamma+\eta}{1-(\gamma+\rho)}\right)\ln s - \left(\frac{\gamma+\eta}{1-(\gamma+\rho)}\right)\ln(d+n)\right] \tag{18}$$

Ertur and Koch (2006, p. 5) assume that all territories have the same steady state and the difference between territories is captured by θ such that,

$$\ln y_{it} - \ln y_{i0} = \theta(\ln y_{jt} - \ln y_{j0}) \tag{19}$$

Where θ is the spatial interdependence between the growth rates on territorial units within a neighborhood. Combining (17), (18) and (19), the next growth equation is obtained,

$$(\ln y_{it} - \ln y_{i0}) = \psi - \left(1 - e^{-\beta t}\right)\ln y_{i0} + \left(1 - e^{-\beta t}\right)\rho\left(\ln y_{jt} - \ln y_{j0}\right) + \left(1 - e^{-\beta t}\right)\theta \ln y_{j0} \tag{20}$$

This expression implies that the average growth rate in the long run on territorial unit i depends on starting level of output, on the growth rate of neighbors and the starting level of output of neighbors.

4. Empirical models

Consider equations (10) and (20) as the base models. The first model captures the externalities diffusion on output and determines a distance threshold where they are significant. The second model is a growth equation used to test the convergence hypothesis.

Both theoretical models are consistent with a Spatial Durbin Model (SDM) structure. The SDM is an extension of the Spatial Autoregressive model (SAR) whose general form is as follows (LeSage & Pace, 2009). The SDM model used is as follows:

$$y = \rho W y + \alpha\iota_n + X\beta + WX\gamma + \varepsilon \tag{21}$$

This model includes spatial lags of the explanatory variables as well as the dependent variable and can be estimated with panel data. This specification solves the bias problem of omitted variables and allows for the inclusion of explanatory variables spatially lagged.

The econometric specification to measure the threshold distance of externalities on output is based on equation (10), which is the production function log linearized. The equation includes factors that reflect the heterogeneity between territorial units and elements associated with time shocks in the territorial units. These shocks may be interpreted as changes in public policy, and economic crises, among others. The econometric model specification is,

$$\ln y_{it} = c_i + \gamma \ln k_{it} + \rho\left(w_{ij}^{r}\ln y_{jt} - \eta w_{ij}^{r}\ln k_{jt}\right) + \delta_t + \varepsilon_{it} \tag{22}$$

Where ε_{it} is an idiosyncratic error $N(0, I\sigma^2)$. The equation shows how output in territorial unit *i* depends on its own capital, and on both output and capital on territorial units *j* within a neighborhood. The element w_{ij}^{r} is the spatial weight matrix, whose composition and role are explained below.

From equation (20) the next regression is specified:

$$g_y \equiv \ln\left(\frac{y_{it}}{y_{it-1}}\right) = c_i - \left(1 - e^{-\beta}\right)\ln y_{it-1} + \rho w_{ij}^{r}\ln\left(\frac{y_{jt}}{y_{jt-1}}\right) + \theta\left(1 - e^{-\beta}\right)w_{ij}^{r}\ln y_{jt-1} + \varepsilon_{it} \tag{23}$$

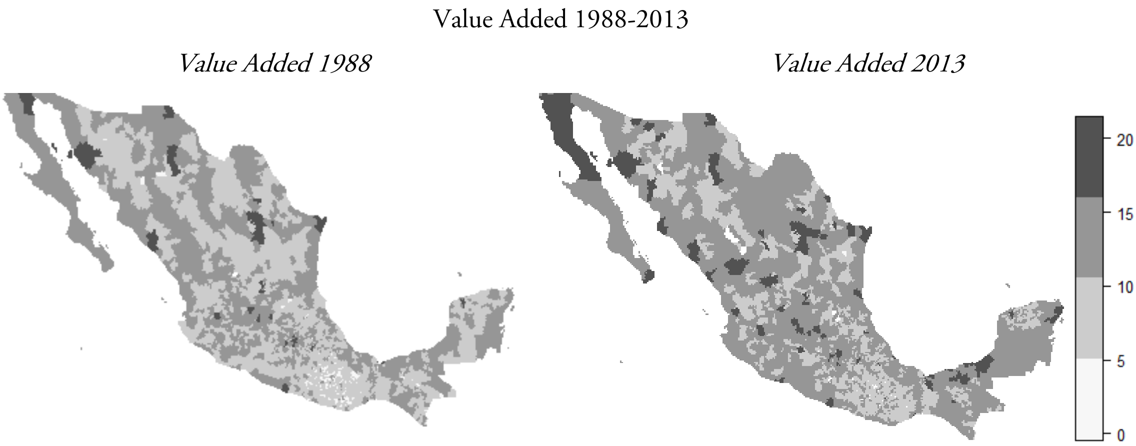
Where, g_y is the output growth rate per worker between year *t* and year *t-1*. In the production function, the terms $w_{ij}^r \ln\left(\frac{y_{jt}}{y_{j0}}\right)$ and $w_{ij}^r \ln y_{j0}$ are spatial lag variables. Notice that, the first two elements on the right side of equation (23) are the same as in the traditional convergence regression. In this study are included two more variables spatially lagged to assess the economic growth not only from the starting level of output but considering the growth rate of neighbors, as well as their starting level of output.

3.1. Data

The analysis considers the municipality level, since the spatial interactions between them ignore the state boundaries and capture accurately the dynamics of regional economies. Ideally, the empirical exercise would include the Gross Domestic Product (GDP) as a measure of output. However, GDP is not calculated at the municipal level. Following the empirical literature for the case of Mexico, Carmeño et al. (2009); Baylis, Garduño-Rivera and Piras (2012), among others, it is used the Gross Value Added (Y) as a proxy of output. Fixed-Capital Gross Formation (K) is used as a measure of capital. Total Employed Population (L) is the variable for population. These three variables are available in the economic census provided by the National Institute of Statistics and Geography (INEGI acronym in Spanish) with a periodicity gap of five years. The oldest economic census that may be compared with the preceding one is from 1989, and the most recent is from 2014. Each one contains information about one year before its publication, thus, the 1989 census contains information from 1988 and so on. The number of municipalities in the last census is 2,457, thus the sample size is 14,742 for the output equation and 12,285 for the growth equation.

The maps in figure 1 show the spatial distribution of the logarithm of the real value added in 1988 (left) and 2013 (right) for 2,457 municipalities. Some territories in the north and in the northwest shifted to a higher value added. Territories in the south, mainly in the state of Oaxaca, show no changes over time. Overall, there are more municipalities with higher value added in the north than in the south. Some outliers in the south like Campeche, Villahermosa, Coatzacoalcos, that belong to the states of Campeche, Tabasco and Veracruz respectively, show a high value added, however, it should be notice that these municipalities/states concentrate activities related to the oil extraction.

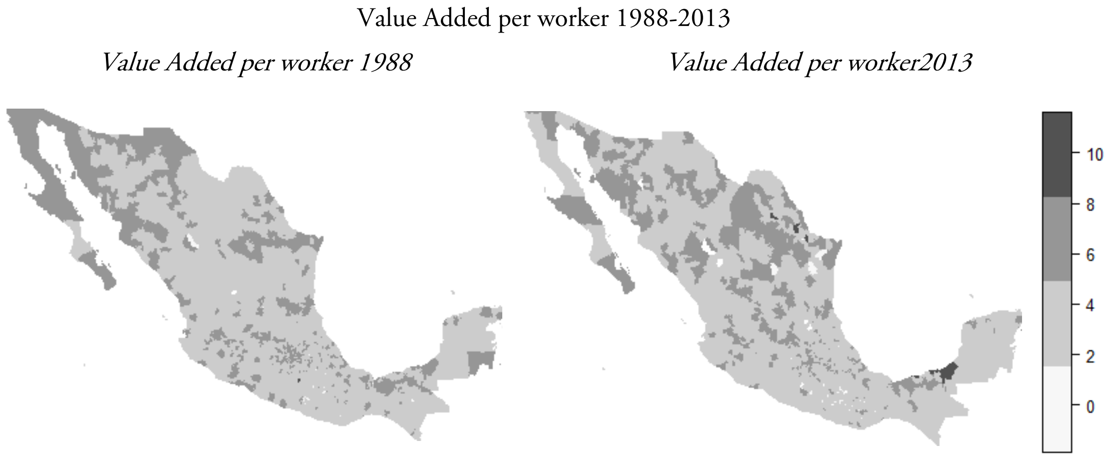
Figure 1.
Spatial distribution of Gross Value Added in 1988 and 2013



Source: Author's own elaboration with data from INEGI, 1989, 2014.

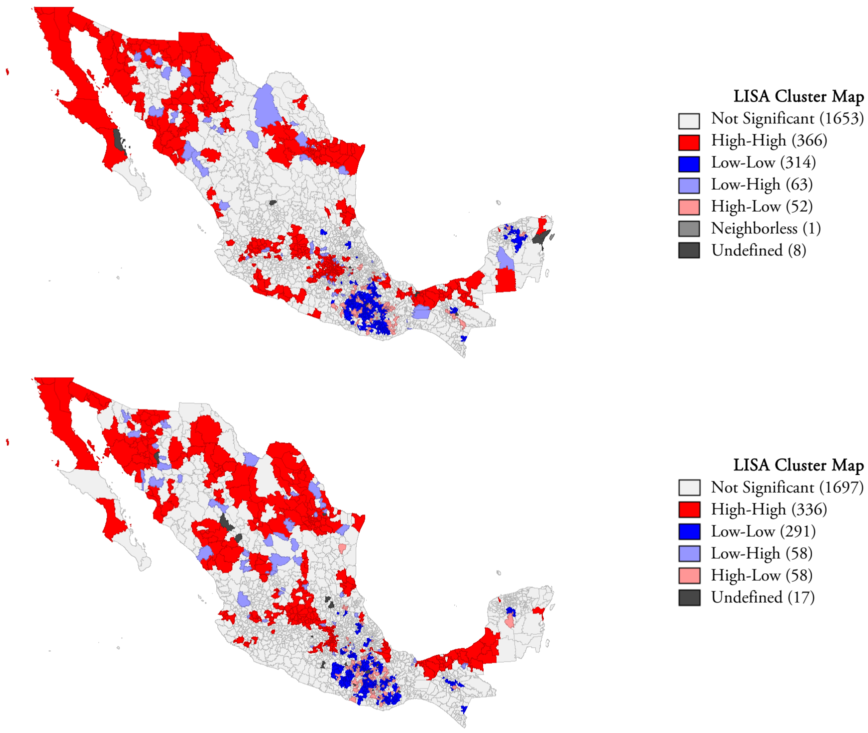
Notice, however, that there is a scale effect due to the size of municipalities, northern municipalities are bigger than southern municipalities. In order to more accurately compare municipalities, a relative measure should be used such as output per worker. Graphs in Figure 2 show this variable. In 1988, value added per worker is concentrated in the northwest, in municipalities that belong to the states of Baja California and Sonora, some other municipalities in states like Nuevo León and Tamaulipas. Overall, there are clear differences between northern and southern municipalities. Historically, low income municipalities are primarily located in the south (Chiquiar, 2005). This condition appears to worsen since the signing of the NAFTA, which arguably benefited northbound territories, in 2013 northern municipalities increase their presence with a higher value added per worker, whereas southern municipalities remain in the lower side of the distribution.

FIGURE 2.
Spatial Distribution of Gross Value Added per worker in 1988 and 2013



Source: Author's own elaboration with data from INEGI, 1989, 2014.

FIGURE 3.
LISA cluster maps of Value Added per worker, 1988-2013



Note: This analysis is performed with a first order contiguity spatial weight matrix.
Source: Author's own estimation with data from INEGI, 1989, 2014.

In addition, in figure 3 are shown two maps that reflect the cluster formation of the value added per worker in 1988 and 2013. These maps strengthen the statement about the differences between northern and southern municipalities. There is a clear and significant formation of clusters of rich municipalities in the north and in the center of the country, whereas in the south, municipalities that chiefly belong to Guerrero and Oaxaca remain in the Low-Low quadrant, which means that those municipalities have a value added per worker below the average and surrounded by municipalities with value added per worker below the average[2]. It must be addressed that in early 80's the country started a process of economic liberalization where the international trade stand as an engine of the economy. This process benefited the northern territories simply by their geographic location (Aroca, Bosch, & Maloney, 2005).

Regarding output growth, maps in Figure 4 show how the value added (left) and the value added per worker (right) grew between 1988 and 2013. There is no clear pattern on the spatial distribution of the growth rate at levels or per worker, the prompter increased from one period to another along many municipalities, however the growth of output per worker is around zero, just a few municipalities located in the north grew along with some others located in the states of Campeche and Tabasco, perhaps those specialized in the oil industry.

FIGURE 4.
Output growth and output growth per worker between 1988 and 2013

Growth of GVA and GVA per worker 1988-2013

Growth of GVA *Growth of GVA per worker*

Source: Author's own elaboration with data from INEGI, 1989, 2014.

3.2. Spatial Weight Matrix

A key step in spatial econometrics is to determine the spatial weight matrix (Anselin, 1988). As previously indicated, the interest of this work is to find the distance threshold where externalities from capital on output, as well as the output growth rate, are spread out over space. Hence, the model specification must also include a feature that allows to accomplish this purpose.

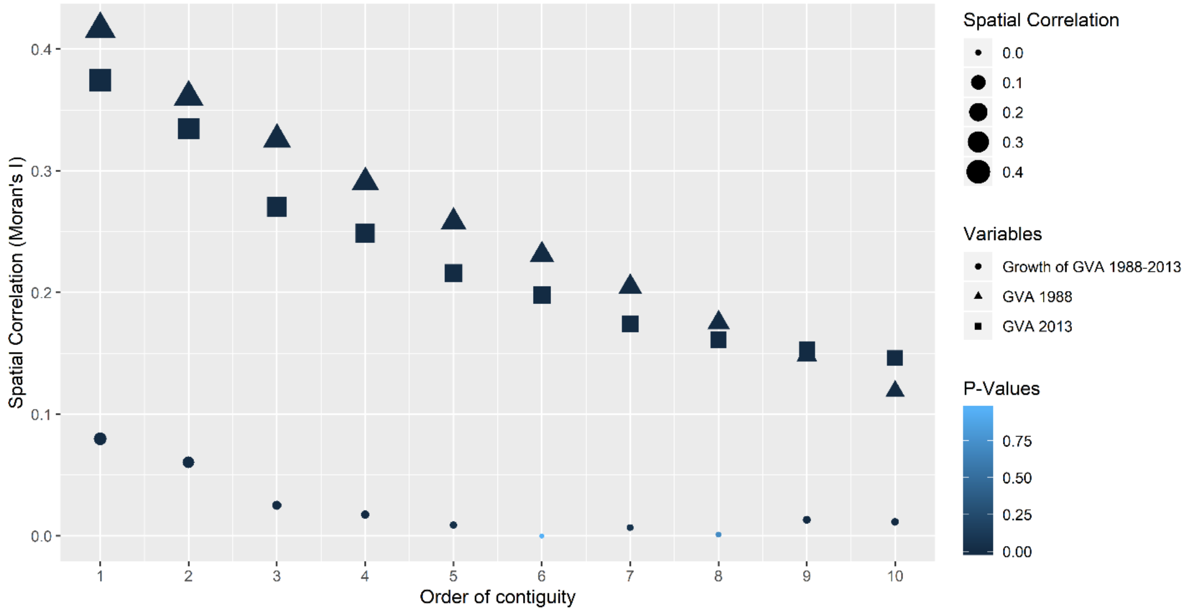
Before to define the spatial weight matrices, the spatial correlation is computed in order to address the spatial behavior of the dependent variables. To accomplish this purpose, it is performed the spatial correlogram through the Moran's Index using high-order contiguity spatial weight matrices.

In figure 5 is shown the spatial correlogram for the GVA per worker in 1988 and 2013, and for the growth of the GVA 1988-2013. The spatial correlation of the GVA in both years decreases as higher order contiguity is considered, however, these are statistically significant at 1% for all order contiguity.

[2] For a wider explanation about the meaning of the quadrants, see Anselin, (1995).

The spatial correlation of the GVA growth rate is below 0.1 for a first order contiguity and decreases from that point to the last. It is statistically insignificant for both sixth and eighth order.

FIGURE 5.
Spatial Correlation of GVA 1988, 2013 and Growth of GVA 1988-2013, for high-order contiguity spatial weight matrices



Source: Author's own estimation with data from INEGI, 1989, 2014.

As spatial correlation persists even for the tenth order of contiguity, there are delimited the distances that captures the spatial structure, let $r = \{20,60,100,140,180,220,260,300\}$ a collection of positive integers that define a distance threshold measured in kilometers[3]. The selection of every distance is arbitrary, however, in table 1 is shown a non-parametric test of spatial correlation considering the distance. Since the southern-central region of the country is highly interconnected, and municipalities are quite close to each other. Considering 20 or 60 km is enough to travel from one place to another; and two or more large or medium cities may be encompassed within that distance. The same cannot be argued for the northern region. Distinctive trends during the development of northern Mexico resulted in differences in the spatial structure. Territories are more spread out as well as distant from each other. Medium and large cities are generally far away as well, 20 or even 60 km is not enough to connect two medium or large cities, therefore a longer distance must be considered. In fact, Arbia (2014) identifies empirically a threshold distance of 380 km where spatial dependence takes place.

Most of the studies that use a spatial weight matrix based on distance, and the municipality is the observation unit, determine the elements of the matrix considering the euclidean distance between centroids of the municipalities, nevertheless, most of the times, these centroids are in the middle of nowhere. For instance, the centroid of Ensenada municipality is 300 km away from the city town (Ensenada) and relies in the middle of the desert. Overall, centroids of municipalities are unmatching with cities, reducing the accurate of the spatial structure represented in the spatial weight matrix. In order to improve the representation of the spatial structure, in this study are taken localities[4] instead of municipalities, only to create the spatial weight matrices. For every municipality, there is a main locality

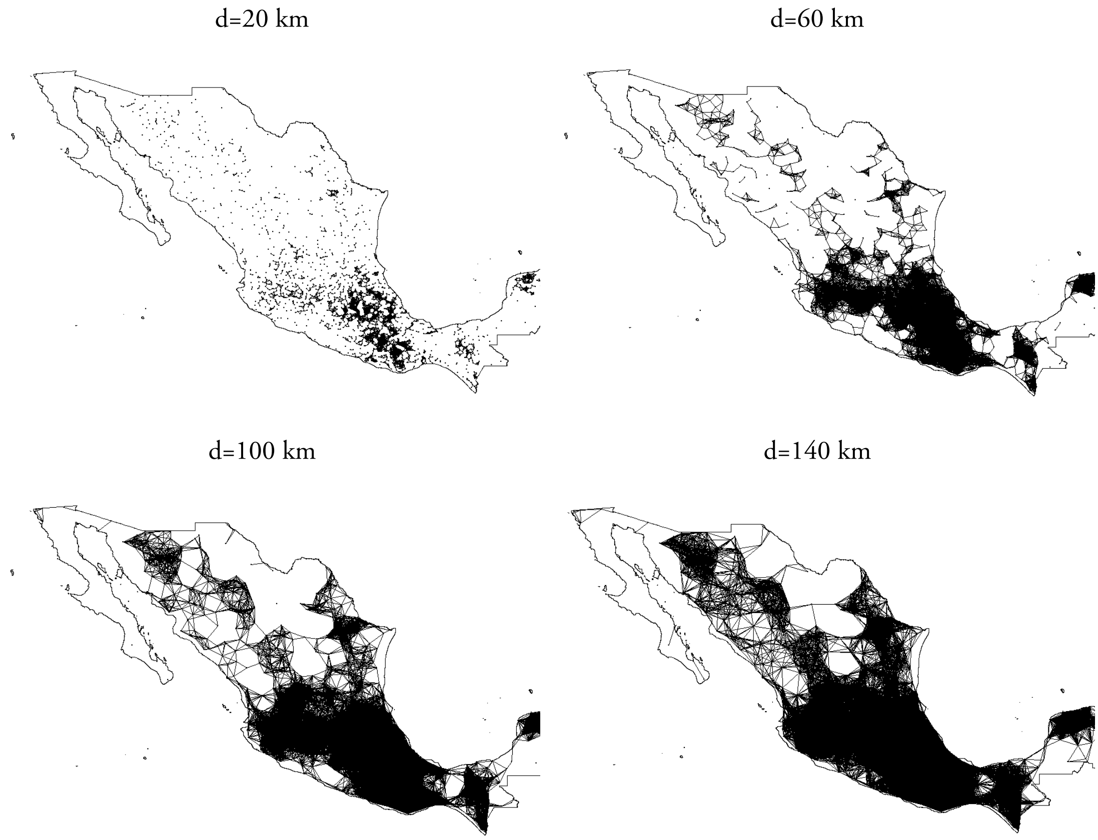
[3] It is used the distance in kilometers, not the euclidean distance.
[4] Localities are more disaggregated than municipality.

that match with the name of the municipality and in the 99% of the cases are urban areas (the main urban area). Choosing localities for creating the spatial weight matrices has two advantages over choosing municipalities 1) increases the accurate in the spatial structure and 2) justifies, *per se,* the using of the distance instead of contiguity as neighboring criteria, due to that localities are not contiguous[5].

Thus, the elements of the spatial weight matrices are defined by $w_{ij} = 1$ if $d_{ij} \leq r$ and $w_{ij} = 0$ if $d_{ij} > r$, Every matrix is row-standardized dividing its element by the row-sum.

The following maps show the spatial weight matrices representation for all distances considered in this work. The first map corresponds to threshold distance of 20 km. The connections between territories is scarce, this matrix just captures interactions between territories in the center of the country, mainly around Mexico City. Also, most of municipalities in Oaxaca are included because they are smaller than those located in other states.[6] The 60 km threshold distance map shows more connections between territories, most municipalities from the southern-central fraction of the country are interacting with each other. Some interrelations in northwestern and northeastern areas are captured with this spatial weight matrix.

FIGURE 6.
Distance-based matrix representations



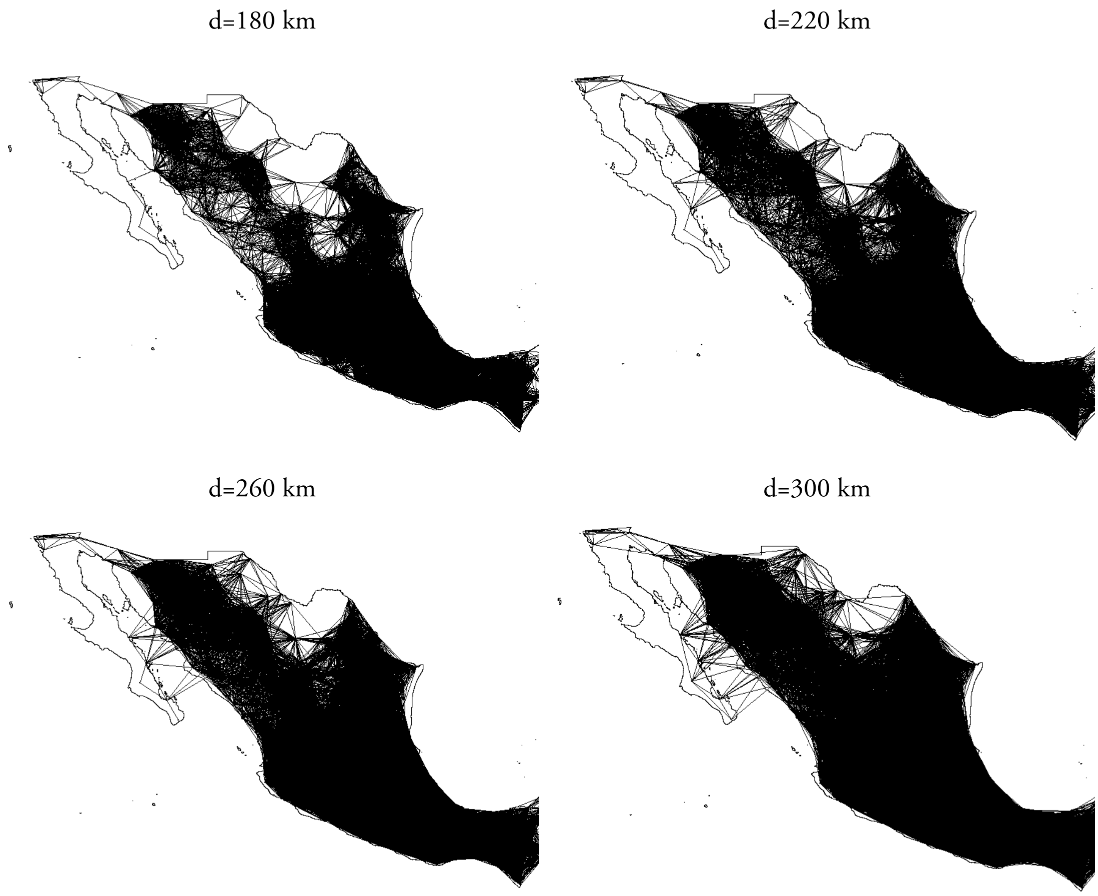
Source: Own elaboration.

The maps in Figure 7 illustrate the spatial weight matrix representations when distance is equal to 180, 220, 260 and 300 km. Notice that most of the municipalities are connected, as distance increases

[5] Data and analysis are still carried out by municipality.
[6] Oaxaca state owns 547 municipalities of 2,457 overall.

the number of interactions does as well. After 220 km, the whole country is connected but the number of links in the north is less than in the southern-central region; while distance increases, municipalities in the north are more connected. Also, after this distance the spatial autocorrelation becomes zero according with the test shown in table 1.

FIGURE 7.
Distance-based matrix representations



Source: Own elaboration.

The distance threshold of 300 km shows municipalities' wide connectivity which is not consistent with empirical evidence, given the number of interactions that each municipality has with others. Nonetheless, it is necessary to use this matrix for empirical work so that results with shorter distances in the matrices may be compared.

5. RESULTS

In a first step, it is performed the Lagrange Multiplier test upon the equations without spatially lagged variables to determine if there is evidence of spatial dependence. The Conditional Lagrange Multiplier (CLM) tests presented in table 1 are developed in Baltagi, Song and Koh (2003). One of these tests performs the null hypothesis that $\lambda = 0$, against the alternative that there is spatial autocorrelation. For all regressions, the null hypothesis is confidently rejected at 1% of significance, which shows evidence in favor of spatial autocorrelation. On the other hand, the second CLM test works under the alternative hypothesis that there are regional random effects (RRE) where the null hypothesis is that μ = 0. In this case, for all regressions the null hypothesis is rejected, thus, the alternative becomes true.

Following these criteria, RRE should be the most efficient assumption to carry out the estimations, however, the Spatial Hausman test (Mutl & Pfaffermayr, 2011) shows a contrary evidence. Following the Spatial Hausman test, alongside the assumption that there is an arbitrary correlation between c_i and the explanatory variables because there is an unobservable heterogeneity for each municipality that makes it unique in the sample, spatial fixed effects are the best option for estimating the equations.

For the output equation, which results are shown in table 1, time dummy variables are included to control for exogenous shocks that affect all municipalities in a similar manner[7]. They capture, for instance, the crisis effect during 2008, the coefficient associated to the dummy variable for 2008 at a distance threshold of 20 km suggests that expected output in this year is 10% less than in 1988, holding constant all other factors. Only for 1998 there is no statistical significance of any coefficient for any distance threshold. A relationship between time and space is found because dummy variables are statistically significant over short distances, beyond 140 km there is no evidence for exogenous shock related to time.

For all regressions, there is evidence of spatial dependence captured by the coefficient associated to the spatially lagged variable W ln y, this coefficient measures the global externalities in the neighborhood. The strength of global externalities from the output increases from 0.122 at 20 km to 0.530 at 300 km, also it is statistically significant at 1%. The spatial dependence coefficient indicates that the global externalities increase along with the distance. As the coefficient is increasing, it implies that production is highly concentrated in a few municipalities because every distance threshold considers more municipalities in the neighborhood, thus, when neighbors increase their production, it is not randomly distributed over space, but it follows a spatial pattern.

The coefficients of the variable $\ln k$ and its spatial lag shown in table 1 must not be interpreted because there are effects that are not part of the spatial interaction. A change in a single observation associated with any explanatory variable will affect the region itself (direct impact) and potentially affect all other regions indirectly (indirect impact) (LeSage & Pace, 2009). Thus, direct impact is a non-spatial effect, while indirect impact is the spatial effect or the spillover effect. These two effects are computed following the method proposed by LeSage and Pace (2009) and presented in Table 2.

In the same table 2 is reported the indirect impact, which represents the spatial diffusion or the spillover effect of capital on output. In contrast with the direct impact, indirect impact increases along with the distance. It is 0.015 for 20 km and it could be considered as weak effect relatively to the total effect. Total effect for 20 km is 0.125, where indirect effect represents 12%. The share of the indirect impact increases along with the distance as well, at 220 km it represents 49% of total effect. Beyond 220 km, indirect impact is higher than direct impact, also it represents more than 50% of the total effect.

The behavior of the indirect impact suggests that distant municipalities generate more externalities than closer ones. However, due to that capital is highly concentrated in a few municipalities, those that are closer compete each other for capital flows instead of mutually benefit, thus, distant municipalities do not represent a hazard for the capital flows on those municipalities located far away.

All impacts are statistically significant at 1%. It must be addressed that for 20, 60 and 180 km there is a very small feedback effect, 0.001, whereas for the rest of distances, there is none. Except for 180 km, it is reasonable that for short distances like 20 and 60 km a feedback effect is found, due to the geographic proximity that increase interaction among municipalities.

The direct impact is the effect of capital on municipality's itself output, it is 0.110 for every distance threshold and it is statistically significant at 1%. This effect is independent on the distance and on the number of neighbors.

[7] The model also was computed including a trend variable instead of year dummies, however, the last shown a better fit, based on AIC criteria.

TABLE 1.
Results from output regressions

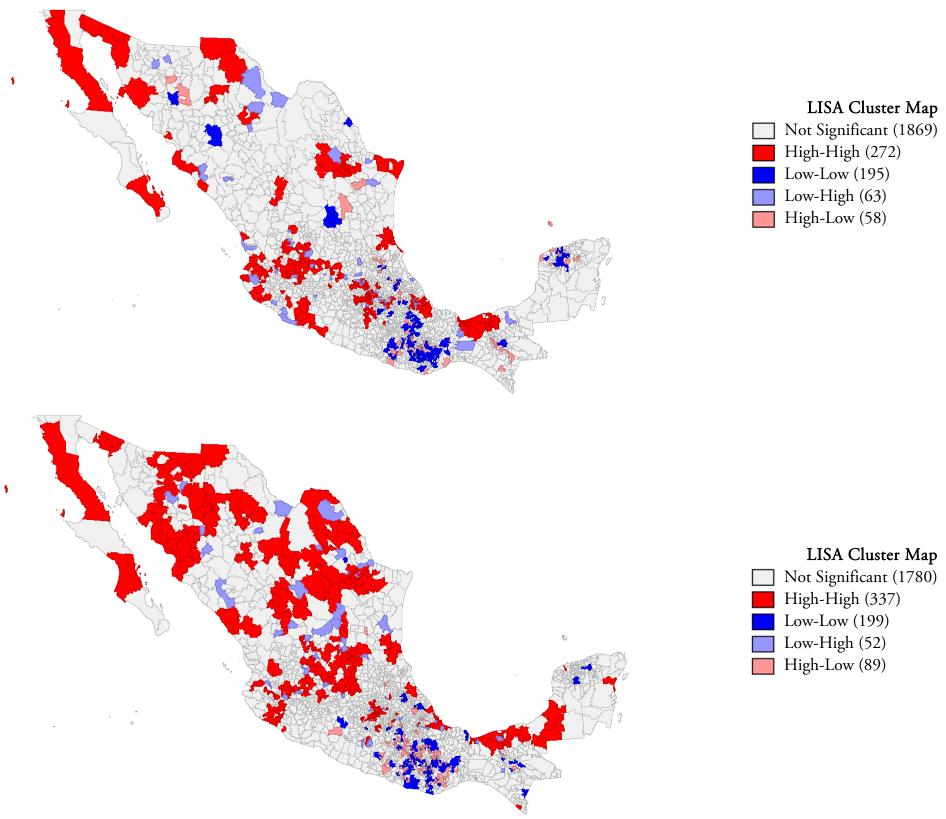
Variable	20km ln y	60km ln y	100km ln y	140km ln y	180km ln y	220km ln y	260km ln y	300km ln y
ln k	0.109***	0.109***	0.110***	0.110***	0.109***	0.110***	0.110***	0.110***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Wln y	0.122***	0.246***	0.339***	0.392***	0.477***	0.495***	0.528***	0.530***
	(0.011)	(0.020)	(0.028)	(0.034)	(0.039)	(0.044)	(0.048)	(0.053)
Wln k	-0.003	-0.006	-0.037**	-0.030	-0.022	-0.036	-0.040	-0.052
	(0.007)	(0.012)	(0.017)	(0.021)	(0.025)	(0.028)	(0.029)	(0.031)
1993	-0.080***	-0.060***	-0.064***	-0.049**	-0.028	-0.034	-0.032	-0.039
	(0.017)	(0.018)	(0.020)	(0.021)	(0.023)	(0.024)	(0.025)	(0.026)
1998	-0.005	0.008	-0.008	0.003	0.020	0.009	0.009	0.000
	(0.017)	(0.019)	(0.022)	(0.024)	(0.027)	(0.028)	(0.030)	(0.031)
2003	0.050***	0.052***	0.032	0.039	0.048	0.036	0.033	0.024
	(0.017)	(0.019)	(0.022)	(0.024)	(0.026)	(0.027)	(0.029)	(0.030)
2008	-0.100***	-0.069***	-0.082***	-0.062**	-0.030	-0.042	-0.038	-0.049
	(0.018)	(0.021)	(0.026)	(0.029)	(0.032)	(0.035)	(0.037)	(0.039)
2013	0.054***	0.060***	0.034	0.044	0.058	0.043	0.041	0.029
	(0.018)	(0.021)	(0.025)	(0.029)	(0.032)	(0.035)	(0.036)	(0.038)
Standard errors in parentheses p<0.01 ***, p<0.05 ***, p<0.1 *								
N	14,742	14,742	14,742	14,742	14,742	14,742	14,742	14,742
AIC	25,051	25,004	25,024	25,039	25,030	25,055	25,065	25,084
Sp Hausman	3989.8	620.97	3164.1	1053.5	1377.1	1487.5	1529.6	1494.3
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CLM test (λ)	11.287	15.485	16.987	17.477	19.621	19.397	19.227	18.494
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CLM test (μ)	53.560	57.743	60.761	59.278	60.502	62.772	64.378	65.590
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

TABLE 2.
Direct and indirect impacts from output regressions

		20 km	60 km	100 km	140 km	180 km	220 km	260 km	300 km
Direct	ln k	0.110	0.110	0.111	0.110	0.110	0.110	0.110	0.110
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Indirect	ln k	0.015	0.035	0.056	0.070	0.099	0.107	0.122	0.124
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	ln k	0.125	0.145	0.167	0.181	0.209	0.217	0.232	0.234
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

In the next maps are shown the spatial association of capital per worker in 1988 and 2013. Capital per worker in 1988 is scatter over the country, just a few clusters are detected around the main metropolitan areas like Guadalajara, Mexico City, Monterrey, and some others in the north, nevertheless, in 2013, there are no clusters yet in the south of the country, chiefly in municipalities that belong to the states of Chiapas, Guerrero, Michoacán, Oaxaca, whereas there are several cluster identified in the north and in the middle of the country.

FIGURE 8.
LISA cluster maps of capital per worker, 1988-2013



Note: This analysis is performed with a first order contiguity spatial weight matrix.
Source: Author's own estimation with data from INEGI, 1989-2014.

Also, the map shown in figure 8 helps to explain a high indirect impact at long distances; shorten distances are common in the south of the country, spatial weight matrices for 20 and 60 km show high connection among southern, southern-center municipalities. At these distances the externalities from capital on output are weak and the explanation comes from the fact that many municipalities in the south highlight in the spatial structure. On the other hand, externalities from capital on output are higher at long distances because the northern municipalities play a more relevant role in the sample when longer distances are considered, and a higher indirect impact is obtained. Notice that feedback effect is found at 20, 60 and 180 km, even though this effect is very small, shows that southern and southern-center municipalities are more interconnected than northern ones. The northern municipalities should interact each other less than southern ones, due to that they are farther away each other, also, their economic dynamics obey to the U.S. economy more than the national, because main economic activities in northern municipalities are linked to the international trade.

The results of estimating equation (23) are presented in table 4, the dependent variable is the municipalities' output growth rate. Based on CLM test, only for distance threshold of 20, 100 and 140 km, RRE would constitute the best assumption for estimating these equations, however, following Spatial Hausman test, spatial fixed effects become a better option. In the rest of equations, CLM test shows evidence against RRE, such that, the estimation is following spatial fixed effects assumptions.

The coefficient associated with the dependent variable spatially lagged, Wg_y, measures the spatial dependence of the growth rates on municipalities. It also computes the degree to which the growth rate of the municipality *j* impacts the growth rate of neighbors. This coefficient is monotonically increasing with the distance. Its range of values is from 0.139 for 20 km to 0.656 for 300 km and it is significant at 1% in all cases. This means that economic growth is highly concentrated in a few municipalities as well as the production does, when the output growth rate increases, spatially speaking, the increasing is not randomly distributed. As distance increases, a higher dependence between municipalities' growth rate is expected, the ups and downs in the growth rate in *j* impact the ups and downs in the growth rate of *i*. In comparison with the results of table 2, the spatial dependence on output growth rate is stronger than the spatial dependence on output, this is explained by the lack of externalities from capital. Municipalities may depend each other to grow, a municipality with high share of capital and high productivity levels, drags surround municipalities, maybe with complementary activities or secondary activities, however, the lack of externalities from capital implies that it keeps concentrating in the same territories, instead of spread out to others.

Just as for the results in Table 1, there are computed the direct and indirect impacts for the last set of regressions. The results are shown in table 4. Following the same reasoning, direct impact is the effect of the initial level of production of a municipality on its own output growth rate, it is independent on the distance and on the number of neighbors, also it is statistically significant at 1%. Direct impact is the coefficient that reflects the classical speed of convergence. These effects are quite similar to some of the convergence coefficients obtained in Rodríguez-Benavides, López-Herrera and Mendoza-González (2016) through a different methodology than the presented here.

Indirect impact is the spatial effect of starting level of production of neighbors *j* on *i*'s output growth rate. It shows a negative relationship between those variables. The first implication without considering distance, is that municipalities with low production per worker in a previous year caused higher growth rates on neighbors during that period. Conversely, high output per worker in the first period imply low growth rates on neighbors.

Moreover, indirect impact is different for each distance threshold, whereas for 20 km is -0.163, for 300 km is -2.010, this effect is also increasing along with the distance. The implication of this result is that, the negative relationship between starting level of output and output growth rate holds anywhere, however, closer municipalities are likely to have the same output growth rate with respect to those located farther away, in other words, there are higher differences in growth rates among far away municipalities than closer ones. Not only the gap between output levels matters for explaining the difference in growth rates, but spatial location matters as well.

TABLE 3.
Results from growth regressions

Variable	20 km gy	60 km gy	100 km gy	140 km gy	180 km gy	220 km gy	260 km gy	300 km gy
W gy	0.139***	0.281***	0.419***	0.484***	0.563***	0.589***	0.642***	0.656***
	(0.012)	(0.021)	(0.028)	(0.033)	(0.037)	(0.042)	(0.043)	(0.046)
ln y	-1.064***	-1.062***	-1.060***	-1.058***	-1.057***	-1.057***	-1.057***	-1.057***
	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)	(0.009)
W ln y	0.115***	0.230***	0.345***	0.391***	0.481***	0.520***	0.591***	0.594***
	(0.021)	(0.034)	(0.046)	(0.055)	(0.062)	(0.067)	(0.069)	(0.075)
				Standard errors in parentheses				
				p<0.01 ***, p<0.05 ***, p<0.1 *				
N	12,285	12,285	12,285	12,285	12,285	12,285	12,285	12,285
AIC	20,032	19,962	19,919	19,916	19,900	19,920	19,912	19,925
Sp Hausmn	18,076		1,402,385	303,242				
p-value	0.000		0.000	0.000				
CLM test (λ)	23.151	36.306	47.561	57.129	69.027	75.776	81.437	86.487
p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
CLM test (μ)	2.353	1.552	3.147	2.223	1.731	1.526	1.117	0.567
p-value	0.019	0.121	0.002	0.026	0.084	0.127	0.264	0.571

TABLE 4.
Direct and Indirect impacts of lny0

		20 km	60 km	100 km	140 km	180 km	220 km	260 km	300 km
Direct	ln y0	-1.074	-1.074	-1.073	-1.069	-1.067	-1.065	-1.066	-1.064
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Indirect	ln y0	-0.163	-0.402	-0.752	-0.981	-1.350	-1.506	-1.887	-2.010
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Total	ln y0	-1.237	-1.476	-1.824	-2.050	-2.417	-2.572	-2.953	-3.075
	p-value	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

This is evidence in favor of the convergence hypothesis that considers more than just differences in stationary states. In this case, this additional factor considered is the geographical distance between municipalities. Clearly, the indirect impacts show a spatial speed of convergence, at the same time, there is evidence in favor of the existence of increasing returns to scale. This also corroborates the fact that economic activity tends to concentrate instead of spreading out over space.

6. Concluding remarks and further directions

This work corroborates the existence of spatial externalities from physical capital on output in the Mexican municipalities, however, these externalities are weak for municipalities that are close each other. The weak and the lack of externalities is also evidence of a high concentration of capital and output in a few territories.

The lack of externalities from capital at short distances chiefly occurs among southern municipalities, this reflects the possible existence of physical and institutional barriers that avoid those territories to grow. It reflects even the lack of good policies that allow those territories to catch up the most advanced ones, because these municipalities have the disadvantage of be located far from the northbound. There are no changes along 25 years of the analysis, southern municipalities stay in the same relative position when a cluster analysis is performed, these municipalities remain with output levels below the average, surrounded by municipalities with output levels below the average. In this sense, local and regional development policies could help those territories let behind their lack of externalities. These policies could focus on redirect the capital flows through infrastructure development in municipalities with low capital per worker but with high potential for production and distribution of goods and services. These policies also must be focused on local characteristics of the municipalities, it should be able to remove physical and institutional barriers that block the development process, for instance, more spend on railways, roads, airports and seaports are obvious recommendations, however, spend on education and health have positive effects on economic growth (Fonseca, Gómez-Saldívar, & Ventosa-Santaularia, 2019). These policies also should seek the regional integration alongside the trade agreements as attempt to reduce the disparities among municipalities (Baylis, Garduño-Rivera, & Piras, 2012); (Asuad & Quintana, 2010); (Carrion-i-Silvestre & German-Soto, 2009).

In order to remove institutional barriers, more autonomy to the mayoralties would improve the capabilities to take decisions to solve local problems based on local characteristics. From the fiscal policy approach, an effort could be made through preferential taxes in municipalities potentially growing, it generates incentives to the capital to flow to those places instead of traditional ones. Policies in this direction may be aggressive for those municipalities that traditionally receive capital flows, however, it must be considered that externalities arise from other sources rather than physical capital, like human capital, which generates strong spatial externalities, as mentioned by Ertur and Koch (2006); Dall'erba and Llamosas-Rosas (2015).

Redirect flows is a feasible option to allow the capital arrival to the less favored places in the process of increasing openness. At the same time, this issue points to a possible extension of the present work, where human capital could be considered, however, the lack of information may restrict this type of study because this information is not available at disaggregated level such as municipality, hence, a state level approach would be feasible. Evenmore, the physical capital may be split into private and public to determine which one generates more externalities over space, such as Dall'erba and Llamosas-Rosas (2015); Fonseca, Gómez-Zaldívar and Ventosa-Santaularia (2019) point out.

Another growth dimension assessment in this works is the so-called convergence hypothesis which is linked with that described in the last paragraphs, the underlying idea of convergence hypothesis is that differences between *per cápita* output of economies tend to vanish in the long-term. Externalities are by themselves a catalyst for convergence, while territories generate benefits to their neighbors, those trailing in last place could catch up the more advanced ones. Most of the research about convergence just considers steady state distances, ensuring that poor economies grow faster than rich ones, furthermore, the conditional convergence indicates that each economy has an own steady state, and they converge on this steady state. However, in this work the test carried out also considers the physical distance between territories, this may be considered a spatial speed of convergence, because closer territories have similar growth rates to each other, relative to those located farther away, whose rates of growth are different.

The assumptions of decreasing returns on production factors and constant returns to scale, implicitly ensure that the capital factor flows from rich territories toward poor ones, an argument against the last affirmation is that, in the world, agglomerations are observed, in consequence, the statement is not consistent with reality, however, in the present work it is shown under the neoclassical assumptions framework, that the convergence hypothesis holds, along with movement of capital through externalities, from rich toward poor territories. The key issue is to understand the size of the externalities and the spark that generates them, this issue may lead further works in this field.

Municipalities depend each other to improve their growth rate, although the municipalities are not benefiting from the capital flows from neighbors, they are impacted by the economic growth generated in the neighborhood. The benefit comes from the mobility of labor factor and by the complementary markets that surround the most prosperous territories.

Some extensions of this work might consider the irregularity of territory and carry out an analysis for municipalities from the north and another one for municipalities from the southern-central region of the country, also a different collection of spatial weight matrices might be considered.

References

Anselin, L. (1988). *Spatial Econometrics: Methods and Models.* Springer Science+Business Media, B.V.

Anselin, L. (1995). Local Indicators of Spatial Association - LISA. *Geographical Analysis, 2*(2), 94-115.

Arbia, G. (2014). *A Primer for Spatial Econometrics With Applications in R.* Hampshire, UK: Palgrave Macmillan. doi:10.1057/9781137317940

Aroca, P., Bosch, M., & Maloney, W. F. (2005). Spatial Dimensions of Trade Liberalization and Economic Convergence: Mexico 1985-2002. *The world bank economic review*, 345-378. doi:10.1093/wber/lhi018

Arrow, K. (1962). The Economic Implications of Learning by Doing. *The Review of Economic Studies, 29*(3), 155-173.

Asuad, N., & Quintana, L. (2010). Crecimiento económico, convergencia y concentración económica espacial en las entidades federativas de México 1970-2008. *Investigaciones Regionales*(18), 83-106.

Baltagi, B. H., Song, S. H., & Koh, W. (2003). Testing panel data regression models with spatial error correlation. *Journal of Econometrics*(117), 123-150. doi:10.1016/S0304-4076(03)00120-9

Baylis, K., Garduño-Rivera, R., & Piras, G. (2012). The distributional effects of NAFTA in Mexico: Evidence from a panel of municipalities. *Regional Science and Urban Economics*(42), 286-302. doi:10.1016/j.regsciurbeco.2011.09.006

Bernat, G. A. (1996). Does manufacturing matter? A spatial econometric view of Kaldor's law. *Journal of Regional Science, 36*(3), 463-477.

Carmeño, R. (2001). Decrecimiento y convergencia de los estados mexicanos: Un análisis de panel. *El Trimestre Económico, 61*(272(4)), 603-629.

Carmeño, R., Mayer-Foulkes, D., & Martinez-Gonzalez, A. (2009). Convergencia, divergencia y estratificación. *El Trimestre Económico, LXXVI*(302), 349-378.

Carrillo, M. M. (2001). La teoría neoclásica de la convergencia y la realidad del desarrollo regional en México. *Problemas del desarrollo, 32*(127), 107-127.

Carrion-i-Silvestre, J. L., & German-Soto, V. (2009). Panel data stochastic convergence analysis of the Mexican regions. *Empir Econ*(37), 303-327. doi:10.1007/s00181-008-0234-x

Chiquiar, D. (2005). Why Mexico's regional income convergence broke down. *Journal of Development Economics*(77), 257-275. doi:10.1016/jdeveco.2004.03.009

Dall'erba, S., & Llamosas-Rosas, I. (2015). The impact of private, public and human capital on the US states economies: theory, extensions and evidence. In C. Karlsson, M. Andersson, & T. Norman (Eds.), *Handbook of Research Methods and Applications in Economic Geography* (pp. 436-467). Chaltenham, UK: Edward Elgar.

Díaz, A., Fernández, E., Garduño, R., & Rubiera, F. (2017). ¿El comercio lleva a la convergencia? Un análisis del efecto del TLCAN sobre la convergencia local en México. *El Trimestre Económico, LXXXIV*(333), 103-120.

Díaz-Bautista, A. (2008). Economic Integration, Regional Convergence and Growth in North America. *Análisis Económico, XXIII*(54), 32-51.

Ertur, C., & Koch, W. (2006). *Convergence, Human Capital and International Spillovers.* Dijon Cedex.

Ertur, C., & Koch, W. (2007). Growth, technological interdependence and spatial externalities: Theory and evidence. *Journal of Applied Econometrics*(22), 1033-1062. doi:10.1002/jae.963

Esquivel, G. (1999). Convergencia regional en México, 1940-1995. *El Trimestre Económico, 66*(264(4)), 725-761.

Fonseca, F., Gómez-Saldívar, M., & Ventosa-Santaularia, D. (2019). Public investment and economic activity in Mexico, 1925-1981. *Economics Discussion Papers*(2019-21), 2-18. Retrieved from http://www.economics-ejournal.org/economics/discussionpapers/2019-21

Isard, W. (1960). *Methods of Regional Analysis: An introduction to regional science.* Cambridge, Massachusetts, USA: The M.I.T. Press.

Jung, J., & López-Bazo, E. (2017). Factor accumulation, externalities, and absorptive capacity in regional growth: evidence from Europe. *Journal of Regional Science, 57*(2), 266-289. doi:10.1111/jors.12304

Krugman, P. (1991). History and Industrial Location: The Case of the Manufacturing Belt. *The American Economic Review, 81*(2), 80-83.

LeSage, J., & Pace, R. K. (2009). *Introduction to Spatial Econometrics.* Baton Rouge, Lousiana, U.S.A.: CRC Press.

López-Bazo, E., Vayá, E., & Moreno, R. (1998). Grow, neighbor, grow, grow... Neighbour be good! *38th Congress of the European Regional Science Association*, (pp. 1-33). Vienna. Retrieved from http://hdl.handle.net/10419/113480

Lucas, R. (1988). On the mechanics of economic development. *Journal of Monetary Economics, 22*, 3-42.

Marshall, A. (1920). *Principles of Economics.* London, UK: Palgrave Macmillan.

Muñiz, I. (1998). Externalidades, localización y crecimiento: una revisión bibliográfica. *Estudios Regionales*(52), 155-175.

Mutl, J., & Pfaffermayr, M. (2011). The Hausman test in a Cliff and Ord panel model. *Econometrics Journal, 14*, 48-76. doi:10.1111/j.1368-423X.2010.00325.x

Ocegueda, J. M. (2007). Apertura comercial y crecimiento económico en las regiones de México. *Investigación Económica, 66*(262), 89-137.

Rey, S. J., & Montouri, B. D. (1999). US Regional Income Convergence: A Spatial Econometric Perspective. *Regional Studies, 33*(2), 143-156. doi:10.1080/00343409950122945

Richardson, H. (1973). *Regional Growth Theory.* London, UK: Palgrave Macmilan.

Rodríguez-Benavides, D., López-Herrera, F., & Mendoza-González, M. Á. (2016). Clubs de convergencia regional en México: un análisis a través de un modelo no lineal de un solo factor. *Investigaciones Regionales*(34), 7-22.

Rodríguez-Benavides, D., Mendoza-González, M. Á., & Venegas-Martínez, F. (2016). ¿Realmente existe convergencia regional en México? Un modelo de datos panel TAR no lineal. *Economía Sociedad y Territorio, XVI*(50), 197-227.

Rodríguez-Gámez, L. I., & Cabrera-Pereyra, J. A. (2019). Convergencia municipal en México con modelos de econometría espacial (1999 - 2014). *EconoQuantum, 16*(1), 7-32.

Rodríguez-Pose, A., & Villarreal, E. M. (2015). Innovation and Regional Growth in Mexico; 2000-2010. *Growth and Change, 46*(2), 172-195. doi:10.1111/grow.12102

Romer, P. (1986). Increasing Returns and Long-Run Growth. *Journal of Political Economy, 94*(5), 1002-1037.

Ruiz, C. (2000). Desigualdades regionales en México, 1900-1993. *Estudios Demográficos y Urbanos*(45), 533-582.

Sala-i-Martin, X. (2000). *Apuntes de crecimiento económico.* Barcelona, España: Antoni Bosch.

Valdivia, M. (2007). Heterogeneidad espacial, Convergencia y Crecimiento Regional en México. *XVII Coloquio de Economía Matemática y Econometría*, (pp. 1-18). Cancún.

Vayá, E., López-Bazo, E., Moreno, R., & Suriñach, J. (2004). Growth and Externalities Across Economies: An Empirical Analysis Using Spatial Econometrics. In L. Anselin, R. J. Florax, & S. J. Rey (Eds.), *Advances in Spatial Econometrics.* Berlin, Germany: Springer-Verlag.

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