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Unfolding Smart Specialisation for Regional Economic Resilience: the role of Industrial Structure

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Abstract:

The European Regional Development Funds for the programmatic cycle 2014-2020 aims to support regions that implement an innovation strategy based on Smart Specialisation. Within this framework, the European Commission emphasises the role of smart specialisation in favouring regional transformation, enhancing competitiveness and fostering resilience. However, the concepts of smart specialisation and resilience have been poorly combined. The article aims at investigating their relationship to understand if a smart specialisation strategy may promote the economic resilience of regions in response to major economic shocks. Drawing upon the concepts of adaptation/adaptability, the analysis investigates the relatedness of new industrial specialisations to the existing industrial structure before and after a shock occurrence. Evaluating the resilience of Italian provinces in relation to the economic crisis of 2008, the analysis aims to understand if provinces that resisted and recovered better followed a smart specialisation framework where new industrial specialisations are related to the existing industrial structure.

Keywords: Industrial structure; resilience; relatedness; smart specialization.

JEL Classification: O25; L16; R11.

Despliegue de la Smart Specialisation para la resiliencia económica regional: el papel de la estructura industrial

Resumen:

El Fondos Europeos de Desarrollo Regional para el ciclo programático 2014-2020 tienen como objetivo apoyar a las regiones que aplican una estrategia de innovación basada en la Smart Specialisation. En este marco, la Comisión Europea destaca el papel de la Smart Specialisation para favorecer la transformación regional, mejorar la competitividad y fomentar la resiliencia. Sin embargo, los conceptos de Smart Specialisation y resiliencia han sido poco combinados. El artículo pretende investigar su relación para entender si una estrategia de Smart Specialisation puede promover la resiliencia económica de las regiones en respuesta a las grandes crisis económicas. Basándose en los conceptos de adaptación/adaptabilidad, el análisis investiga la relación de las nuevas especializaciones industriales con la estructura industrial existente antes y después de una crisis. Evaluando la resiliencia de las provincias italianas en relación con la crisis económica de 2008, el análisis pretende comprender si las provincias que resistieron y se recuperaron mejor siguieron un marco de Smart Specialisation en el que las nuevas especializaciones industriales están relacionadas con la estructura industrial existente.

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Palabras clave: Estructura industrial; resiliencia; relatedness; smart specialization.

Clasificación JEL: O25; L16; R11.

1. Introduction

One of the main points of the debate regarding the transformation of the industrial structure is how regions develop – or fail to develop – new sectorial specialisations. Evolutionary economic geography scholars have tackled the question through different theories and empirical applications, modelling the evolution of regional paths (Martin, 2010; Isaksen, 2015; Simmie, 2017) and arguing that new specialisations may emerge as related to close existing specialisations (Boschma, 2017; Balland et al., 2018; Xiao et al., 2018).

From a policy perspective, the problem of the evolution of the industrial structure and the creation of new industrial paths has been the central focus of several regional innovation policies led by concepts such as the Technology Plans or the Regional Innovation System (Cooke et al., 1997; Cooke, 2001) that have evolved recently into the idea of 'smart specialisation' (Foray et al., 2009; McCann and Ortega-Argilés, 2015).

This debate has assumed a central role after the occurrence of the economic and financial crisis of 2008 when both academics and politicians have tried to understand how and why some regions and cities better resist and react to crisis (Oliva and Lazzeretti, 2018) and how innovation policies may influence the responsiveness of regions in developing new industrial trajectories after crisis (Fingleton et al., 2012; Bristow and Healy, 2018). These questions have led to rethinking the economic recovery as a path of industrial transformation through the lens of regional economic resilience. The latter acts as a dynamic and evolutive process that generates positive hysteretic outcomes of opportunities for the development of new sectors and new economic growth. "*Regional economic resilience in this framework could be viewed as having to do with the capacity of a regional economy to reconfigure, that is adapt, its structure (firms, industries, technologies and institutions) so as to maintain an acceptable growth path in output, employment and wealth over time.*" (Martin, 2012, p.10).

Concerning the policy perspective, failures in innovation systems have emerged due to the economic crisis. An example is the relative inability of regions' policies to promote solutions considering regional differences. This scenario has led to going beyond an innovation policy that supports neutrally technology, science and innovation, opening up to the renaissance of the industrial policy (Foray et al., 2011; Ortega-Argilés, 2012).

In this scenario, the theory of 'resilience' (Simmie and Martin, 2010; Martin, 2012; Boschma, 2015; Lazzeretti and Cooke, 2015) and the concept of 'smart specialisation' have become guiding principles for many policies. Despite the criticisms (Cooke, 2017; Marques and Morgan 2018; Foray, 2019; Hassink and Gong, 2019), they have started to influence a large part of the research on regional economies. Both approaches recognise the significant role of the industrial structure in promoting new specialisations and developing new industrial paths. Regional economic resilience defines structural change as the output of a resilient regional economy (Martin, 2012). Based on concepts of adaptation and adaptability, response to exogenous shocks can lead towards the recombination of existing resources to create new knowledge or the development of new and unrelated trajectories (Grabher, 1993; Hu and Hassink, 2017). Following the smart specialisation framework, a new specialisation may be linked to the existing economic structure in which the region has a competitive advantage compared to other regions (Foray et al., 2011).

Despite the emerging works in evolutionary economic geography (Balland et al., 2018; Xiao et al., 2017), few studies have explored the relationship between smart specialisation and regional economic resilience. The present work contributes to this debate by merging the two approaches and questioning if a strategy based on 'smart specialisation' may promote regional economic resilience in the face of shocks.

This conceptual approach is applied to the case of 103 Italian provinces (NUTS-3) to understand if provinces following a strategy of diversification into related industries before the crisis resisted and recovered better to the Great Recession of 2008. In line with other research concerning economic resilience in Italy (Cellini and Torrisi, 2014; Lagravinese, 2015; Faggian et. al., 2018; Cainelli et al., 2019), Italian provinces represent an interesting unit of analysis due to regional differences related to sectors specificities and productive structure. Moreover, the Italian economy is strongly characterized by economic inequalities expressed by the divide between the Northern and Southern regions. Such differences may contribute to the ability of Italian regions to respond and recover from a crisis (Di Caro, 2015). Additionally, the crisis context may constitute an interesting field to reflect on the successful (or not) of smart specialisation strategy in an uncertain scenario.

From an evolutionary perspective, the analysis can provide valuable insights to explain how regions transform and evolve in response to shocks. Furthermore, such analysis can help understand whether the smart specialisation strategy can be an instrument to foster resilience leading towards more comprehensive and sustainable growth.

The article is organized as follows. Section 2 discusses the similarities between the concepts of resilience and smart specialisation, building the conceptual framework of our empirical analysis. Section 3 clarifies the data sources and the methodology applied. Section 4 introduces the results of the empirical research, while Section 5 underlines the conclusions and the implications for the policy and theoretical discussion of smart specialisation.

2. Smart specialisation, resilience and the industrial structure

The origin of the idea of 'smart specialisation' dates to the debate of the divergence in productivity between the USA and Europe since 1995 (see van Ark et al., 2008). From a European perspective, the Cohesion Policy 2014-2020 puts the development of an innovative strategy based on a 'smart specialisation' as a necessary condition to access European funds. In a post-crisis context, the idea of policymakers is to promote a plan for favouring the emergence of new economic activities with a specific policy based on innovation, investments in R&D and information and communication technology (ICT) within the framework of the Research and Innovation Strategies for Smart Specialisation (RIS3). Such a strategy stresses the industrial strength of regions, enhances competitiveness and fosters resilience (European Commission, 2010; 2012; 2017).

The idea of a 'smart specialisation' would like to represent a response to the risks and uncertainties of the global economy. The concept comes from the observation of the competitive scenario of European regions and recognises the high fragmentation of the European research systems and their almost everywhere national organisation. This aspect may limit the possibility of creating knowledge hubs that are spatially localised. Moreover, investments in innovation generally occur on similar activities, leading towards a 'homogenization' of industrial trajectories among European regions. In some cases, such characteristics may make regions unattractive for firms' global location (Foray, 2015).

Moreover, as EU regions have different economic and institutional structures, a unique top-down policy is impossible to apply (Balland et al., 2018). So smart specialisation should enhance entrepreneurial coordination within a framework structured by the government (Foray et al., 2018). Discovering the domain on which prioritising investments to generate a long-term economic transformation assumes a bottom-up perspective through the interactions between the government and the private sector (Montresor and Quatraro, 2017). The smart specialisation framework identifies this as the entrepreneurial discovery process (EDP). This process is the main difference between smart specialisation and other innovation strategies (Pinto et al., 2019). Smart specialisation formally recognises the entrepreneurial discovery process's role in fostering the region's structural change based on the current industrial commons. European Commission identifies the smart specialisation strategy as a roadmap to help regions to adapt to the changes derived from globalisation, energy and digital transactions. It may be considered a way to increase regional resilience in facing global challenges (European Commission, 2017).

Resilient growth is a theoretical framework widely explored in studies of regional economies (Bailey and Turok, 2016; Cooke, 2017; Fröhlich and Hassink, 2018; Webber et al., 2018; Evenhuis, 2017). It discusses the capacity of a region to recover, reorganise and reorient its structure and functions in order to respond to external pressure (Martin, 2012).

The concept of smart specialisation has been poorly studied in regional economic resilience studies, although the two approaches present interesting similarities. A first similarity concerns that both smart specialisation and resilience stress structural change and transformation as the output of their processes. Smart specialisation embraces a more productive use of resources to achieve regional sustainable growth. The concept goes beyond the investments in R&D and high technologies, involving a broader meaning of inputs of innovation – such as creativity and design - and outputs of the innovative process and promoting productive use of resources to achieve smart regional growth. Thus, this is based on existing local capabilities that ultimately develop new high value-added activities fostering existing strengths. Smart specialisation, therefore, assumes that a new specialisation is related to the existing economic structure in which the region has a competitive advantage compared to other regions. The result is not just technological innovation, but a structural change based on different paths (Foray et al., 2011). According to Foray (2015), each path of structural change shows a degree of relatedness between the existing resources and the new domain. The transition, modernisation and diversification patterns link with the original industrial commons. A regional transition occurs when a new domain is generated from the existing range of capabilities. At the same time, modernisation involves increasing the quality and efficiency of an existing sector through developing applications of a general-purpose technology. Finally, diversification can be achieved by identifying synergies between the new and existing activities. On the contrary, *radical foundation* is actuated when the new domain has not any connections with the existing industrial structure.

Within the theory of regional resilience, the region's possible structural change is the evolutionary approach's guiding principle (Boschma, 2015). Exogenous shocks can lead to the recombination of existing resources in order to create new knowledge or the development of new and unrelated trajectories (Grabher, 1993). According to this view, resilience refers to the adaptive ability of regions to change structure and functions to deal with external pressures (Martin, 2012). However, regional economic resilience cannot be directly observed but it is inferred analysing adapting processes and how they evolve in time and space (Evenhuis, 2017). This adaptive process may be discussed in terms of 'adaptation' and 'adaptability' (Grabher and Stark, 1997). Adaptation represents a path-dependent process that involves a non-radical transformation of the regional path based on the existing structure. Adaptability deals with a long-term change within the regional economy that may occur through a shift in the industrial path. Such processes coexist and interact as old and new industries coexist and interact within the region (Hu and Hassink, 2017; Simmie, 2017). When resilience is conceived as a long-term transformation, a synergic action of adaptation and adaptability should be considered. Reciprocity between adaptation and adaptability may involve the need for a degree of relatedness between existing industries and new emerging trajectories (Boschma, 2017).

A second similarity between the framework of smart specialisation and regional resilience is the importance that both approaches reserve to the existing industrial structure in boosting regional transformation processes. Regional and local economies are an aggregation of technological capabilities, routines and institutions. The emergence of new trajectories depends on several variables that deal with the internal dynamics of the regions and their capacity to absorb external knowledge. The existing base of knowledge plays an important role. New technologies and new sectors do not develop from random events but encompass the capabilities of regional agents that shape the regions' distinctive technological and industrial characteristics (Balland et al., 2018). As Boschma and Gianelle (2014) proclaim, the objective of smart specialisation is "*to favour a specialised diversification into related technologies which generates new economic activities that are rooted in the region and that can draw on local related resources*". Foray et al. (2018) stress the idea of 'differentiation with specialisation' – and vice versa. On the one side, differentiation is based on the existing peculiarities of the region, such as institutions, socio-economic characteristics, geographic and demographic conditions. So, each region should prioritise some domains based on its capabilities. On the other side, a degree of specialisation is required to agglomerate actors and resources and develop related projects in order to produce innovation in the selected domain.

In respect of resilience, recent literature considers factors and dynamics that can contribute to making a region more resilient. Such contributions focus on determinants of resilience, considering it a process rather than a simple system property (Simmie and Martin, 2010; Sedita et al., 2017) and aim to identify the most suitable form of sectoral structure in influencing the responsiveness of regions to external pressures. As argued by Martin et al. (2016), several explanations stress the role of specialisation (Storper et al., 2015), complexity (Hausmann et al., 2013) or related-variety (Frenken et al., 2007) of the existing industries. A regional economy specialised in activities that involve intensive knowledge and information capital can easily adapt to changing circumstances and be more resilient (Martin et al., 2016). By contrast, high diversity hardly impacts the sustainability of the growth rate (Eraydin, 2016).

Moreover, sector-specific shocks may likely hit more diversified regions than regions with specialised economies. However, the damage will be less dangerous for the whole local economy because variety spreads risks among different sectors (Boschma, 2015). Frenken et al. (2007) reconduct the issue to the degree of 'related' and 'unrelated' variety of regions. In this regard, the concept of relatedness is particularly useful because it captures both dimensions and identifies the proximity of sectors that are usually not considered as close as they are.

Based on an analysis of the industrial structure, the article wants to understand if smart specialisation may foster regional economic resilience in the face of shocks. The analysis focuses on the core of the smart specialisation, namely, the structural change as the process of regional transformation (Foray, 2015). For this reason, we analyse how the regional diversification paths before and after the advent of the great recession affect the regional capacity to resist and react to the crisis. As highlighted above, the smart specialisation is a policy adopted within the Europe 2020 initiative and financed with the European Regional Development Funds for the programmatic cycle 2014-2020, thus, subsequent to the considered period. However, an analysis that explores if diversification's patterns, coherent with the smart specialisation framework, are associated with higher or lower resilience, may promote further insights concerning this kind of policy in an uncertain scenario. The article's main arguments are that the regions that follow a more related diversification path before the crisis are better suited to resist the shock than those that follow a more unrelated diversification in new industries and ultimately perform higher growth rates in the medium-long run.

3. Data and methodology

The article explores the relationship between smart specialisation and regional economic resilience. Even if the European Commission (2017) recognises that smart specialisation policy may increase the resilience of regions, the two approaches have not been frequently combined. However, as explicated in the previous section, they have some interesting similarities and deserve more extensive investigation.

The study concerns the totality of Italian provinces (103) corresponding to the NUTS-3 classification of the European Union, existing before the changes occurred from the 2007.

The paper builds on data drawn from the firm-level AMADEUS database of Bureau Van Dijk, which referred to the number of employees subdivided by the NACE code up to the four-digit level of detail (560 industrial categories) for the period 2006-2015.

Using these data, we firstly measured the occurrence of new specialisation, taking the cue from Xiao et al. (2017), following the procedure presented in section 3.1. Section 3.2 shows how we measure the relatedness between the occurred new specialisations and the existing ones. For this purpose, we have followed the methodology developed by Hidalgo et al. (2007) computing, firstly, a relatedness index for every pair of industrial categories and, secondly, a synthetic index measuring how the existing specialisations are related to the new specialisations occurred in every province for each year (Innocenti and Lazzeretti, 2019b). Finally, section 3.3 shows how the resistance and recovery indexes are calculated. This procedure allows understanding if a relationship exists between a province's related diversification and the capacity to resist and react to the economic crisis. It is also useful to understand how the 'diversification/specialisation' strategy of the provinces has changed after the 2008 economic crisis and if this has affected their recovery process.

3.1. New industrial specialisations

To understand which new industrial specialisations occurred during the period 2007-2014 we partly followed the method proposed by Xiao et al. (2017). Firstly, we compute a Location Quotient (LQ) for every industrial category of each province for the whole period.

$$LQ_{pi} = \left(\frac{E_{pi}/E_P}{E_I/E} \right) \tag{1}$$

To avoid considering new specialisations that are not structural for the area but tend to appear and disappear frequently, a new specialisation is defined as follows:

- The LQ is higher than 1, meaning that the specific industry has a concentration in that province that is higher than the national average.
- The LQ has been lower than 1 since 2006, this is aimed at avoiding the consideration of those industrial specialisations that appear and disappear frequently, concentrating the analysis only on those that are more stable.
- At least 0.5% of the province's workers are employed in that sector. This point is aimed to exclude those micro-sectors where a change in a few employees may determine the appearance of the specialisation.
- There has been an increase in employment in that sector compared to the previous year. This last point is aimed at excluding those specialisations that appear in connection to a decrease in the area's employment rather than an increase in the specific industry (Xiao et al., 2017).

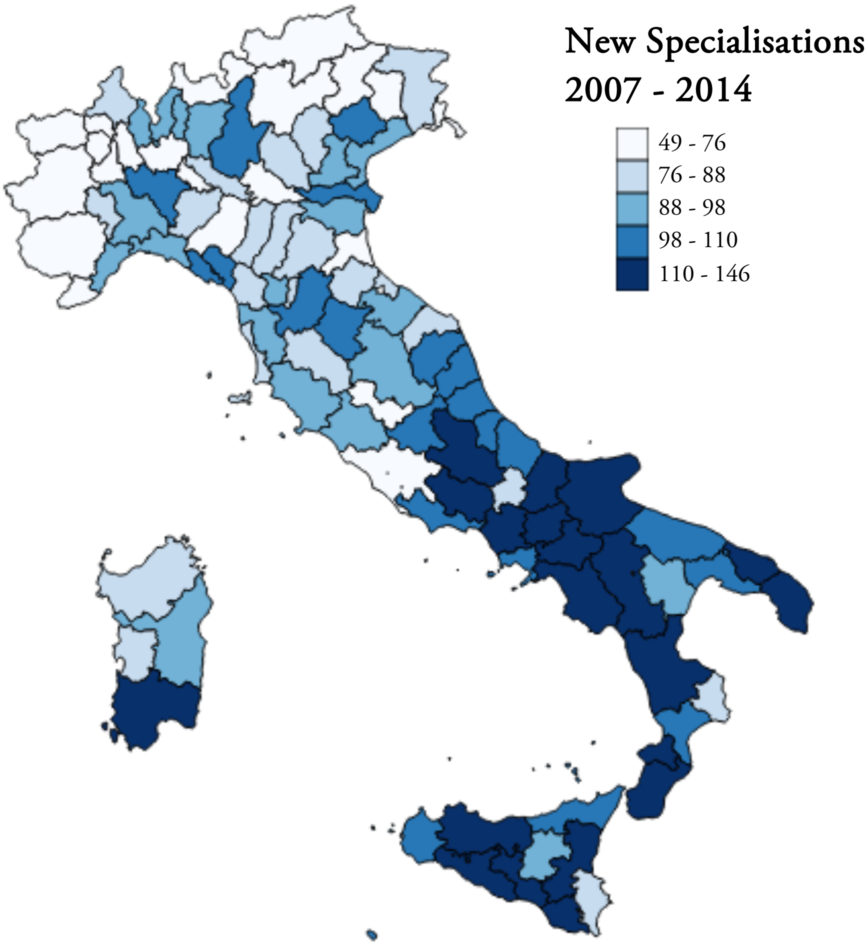
Following this analysis, 9684 new specialisations were identified during the nine years period considered. Figure 1 shows the number of new specialisations occurred in each Italian province during the period 2007-2014. This result shows clearly how the occurrence of new specialisations is largely concentrated in the south of Italy. It may seem an unexpected result at first sight. However, the changes that occurred in the south of the Italian peninsula were much larger than those appearing on the north since the beginning of 2000 (Barca, 2006). This result is then confirmed by the fact that the productivity growth and the diversification of industrial structure of the south were largely higher than the national average since the mid of the '90 (Boschma and Iammarino, 2009). Of course, this did not allow us to cover the gap between north and south, and it is probably connected to the diversification strategy followed that will be considered here.

3.2. Relatedness of new specialisations

The following step aims at understanding if the new specialisations that occurred in each province are related or unrelated to the specialisations existing already. For every new specialisation, we have computed an index based on the relatedness measure between each pair of industrial categories.

Firstly, it is necessary to compute the relatedness measure between each pair of industrial categories. It is done following the methodology of Hidalgo et al. (2007) for creating the *product space*. We want to create an *industry space* (Neffke et al., 2011) among the industrial categories in order to determine their proximity. However, in this case, the *industry space* is built differently because the data about the labour flow between industries, or the co-occurrence in the same plant are unavailable. The number of workers in every industrial category will be used to determine if there is a higher or lower proximity among them (Innocenti and Lazzeretti, 2019b). It also differs from the *product space* construction, where export data are used to compute the proximity among products. This is done because the work aims to understand the industrial relatedness to infer the industrial diversification and the specialisation of each Italian province.

FIGURE 1.
New specialisations in Italian provinces 2007-2014



Source: Authors' elaboration using QGis software.

This way of measuring relatedness allows to infer that two sectors draw on similar knowledge and to overcome the problem of the classification-based measures (ex-ante determination of relatedness like related variety) with an ad-hoc determination of relatedness and so we do not rely on the number of digits shared between two industries to determine their level of relatedness.

In this specific case, measuring industry relatedness, from a theoretical point of view, allow us to be near to the definition firstly made by Frenken et al. (2007) and the following works that rely on industries' employment to determine relatedness (Cortinovis et al. 2015; Hartog et al., 2012; Fritsch and Kublina, 2018; etc.). Summing up, higher relatedness implies that the two industries share similar knowledge that allows cross-fertilisation and spillovers between the two industries.

Now, we explain briefly how we have created the *industrial space*. The *product space* represents in the network the exported products, where the nodes represent every different product and the lines, the relatedness degree between them, based on the idea that two products are related if they are co-exported by many nations.

In our case, we use the same concept but we refer to the industrial categories and we will consider related those categories that are present together in many Italian provinces with an employment level higher than the national average.

We create an $n*n$ matrix where n represents the number of industrial categories considered, that in our case are 560, classified following the NACE classification, and we will calculate the degree of relatedness as follows:

$$\varphi_{ijt} = \min\left\{P\left(RCAx_{it}|RCA_{x_{jt}}\right), P\left(RCAx_{jt}|RCA_{x_{it}}\right)\right\} \tag{2}$$

The relatedness of every pair of industrial categories is calculated as the minimum of the conditional probability for every Italian province to find an industrial category *I* given the category *j* is already available in the province.

Then, using this measure of relatedness among industrial categories, the following step is to compute a measure of relatedness of each new industrial specialisation. This leads to a measure of how the new specialisation is related to the already existing specialisations of the area.

$$C_{ip,t} = \frac{\sum_{k=1}^{n} \varphi_{ikt-1}}{n} \tag{3}$$

Where i is the industrial category of the new specialisation, p represents the province, k represents the industries that province p was specialised at time t-1, and φ is the proximity among the new specialisation i and industry k.

This measure is specific to each new industrial specialisation in each province (as each province has its specialisation tree) and each year (as the specialisation tree changes every year). This measure is then aggregated at the provincial level. The results give us a measure of how the new specialisations of each province are connected to the already existing specialisations.

$$RC_{pt} = \frac{\sum_{i=1}^{n} C_{ipt}}{n} \tag{4}$$

Figure 2 shows the measure of relatedness of new specialisations of each Italian province, respectively in the year 2007, 2011 and 2013. They show that the relatedness of new specialisations does not follow the occurrence of new specialisations. However, in this case, it is also possible to see how higher levels are reached in the center and south of Italy than in the North.

Meaning that in the north of Italy there is a larger search for new paths based on new specialisations unrelated to the already existing specialisations. This is an interesting pattern that could be due to the high competition favouring the search of new sectors less related to those with already high competition in the considered area.

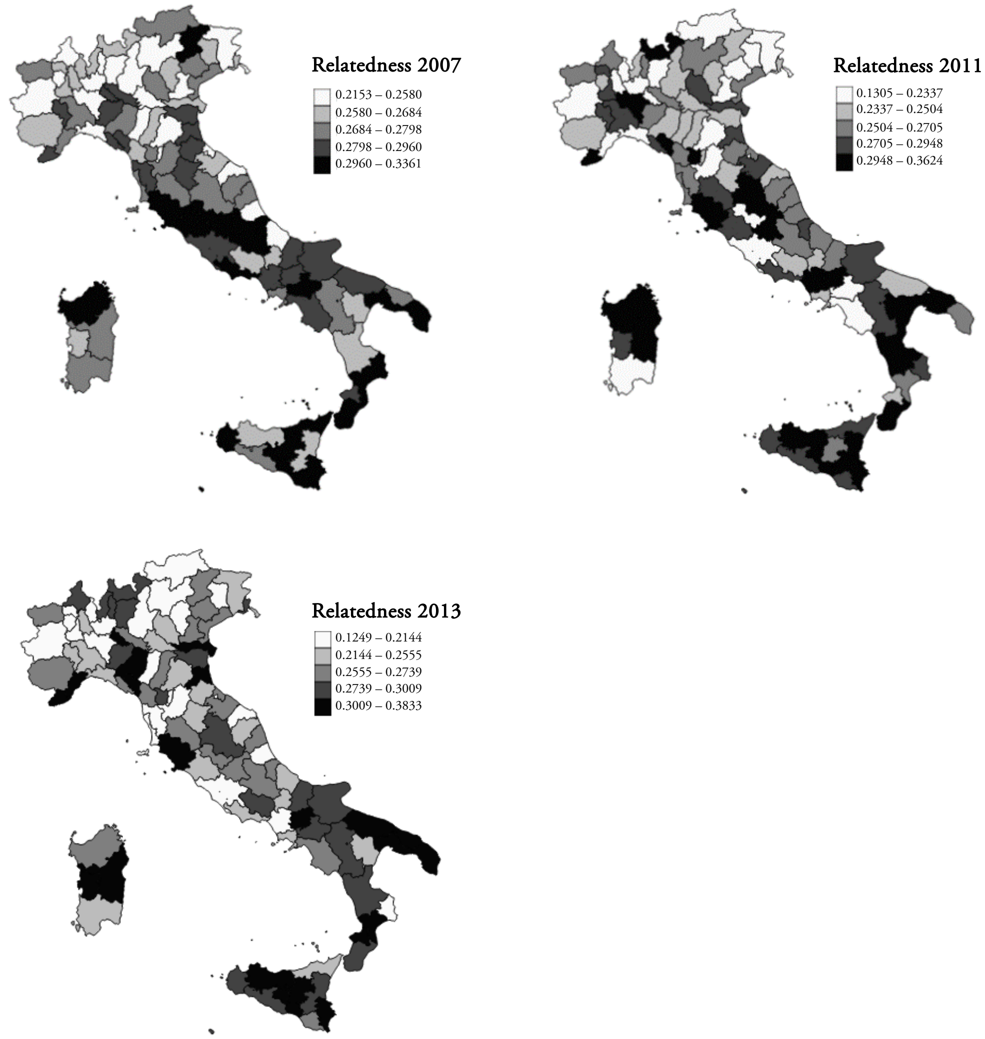
Following the framework developed in the theoretical background, we infer that:

- A high value of relatedness indicates a propension for a '**related diversification**'.
- A low value of relatedness indicates that new specialisations are '**un-related**' to the existing specialisations.

3.3. Measuring Resilience

We measure resilience through resistance and recovery indices using the index firstly developed by Martin (2012). Particularly, resistance is measured using the method adapted by Faggian et al. (2018) and recovery through the measure proposed by Lagravinese (2015).

FIGURE 2.
Relatedness of new specialisations (years 2007, 2011, 2013)



Source: Authors' elaboration using QGis software.

The measure of resistance is used to understand how each province resisted the occurred shock.

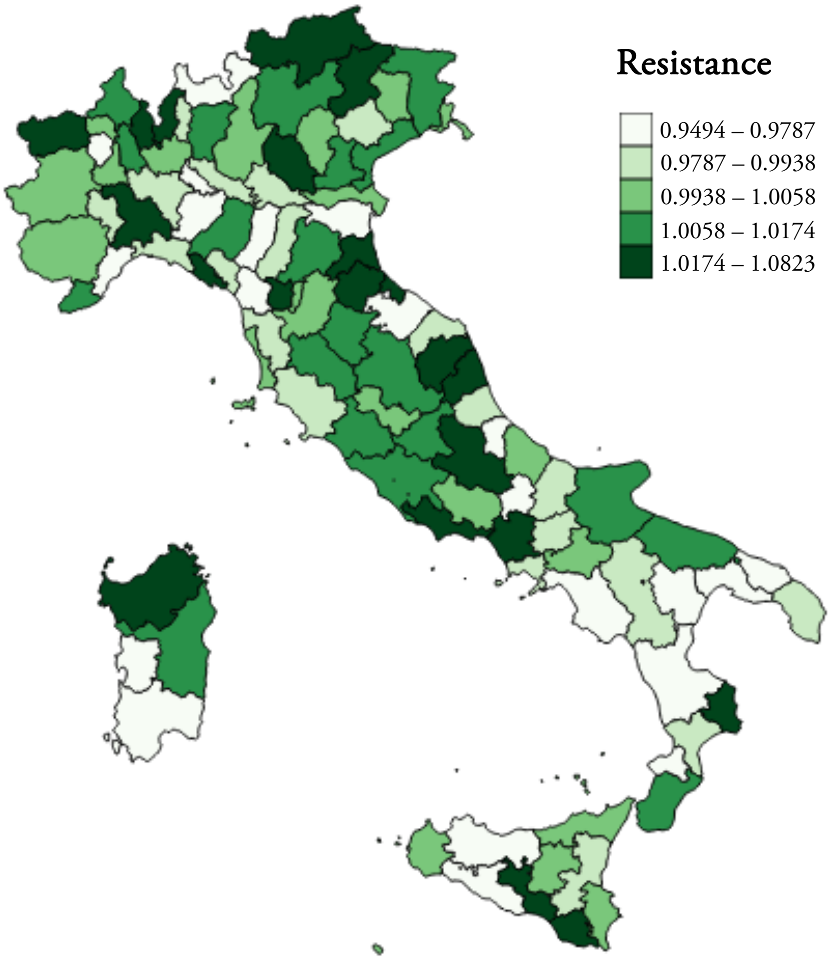
$$RES = \frac{E_{p,t}}{E_{p,t-1}} \Big/ \frac{E_{n,t}}{E_{n,t-1}} \tag{5}$$

Where E_p is the total employment in the province of interest and E_n is the total employment in the nation. The period (t) represents the recessionary period and the period (t_{-1}) represents the pre-recessionary period. In this case, following the literature, the recession period is considered as the variation between 2009 and 2010.

A value of the index higher than 1 indicates that the province resisted better than the others to the shock, while a level lower than 1 indicates a performance lower than the average compared to other provinces.

Figure 3 shows the resistance of Italian provinces to the great recession of 2008. It is possible to see that there is not a precise pattern of resistance through the north-south divide. However, a slightly higher resistance appears in the center-north of Italy even if there are some highly resistant provinces in the north of Sardinia in the extreme south of Sicily and that the crisis hit so bad also in some provinces in the north.

FIGURE 3.
Resistance of Italian provinces



Source: Authors' elaboration using QGis software.

The following index of recovery shows how a province has reacted after the occurrence of the shock.

$$REC = \left(\frac{\Delta E_p}{E_p}\right) / \left(\frac{\Delta E_N}{E_N}\right) \tag{6}$$

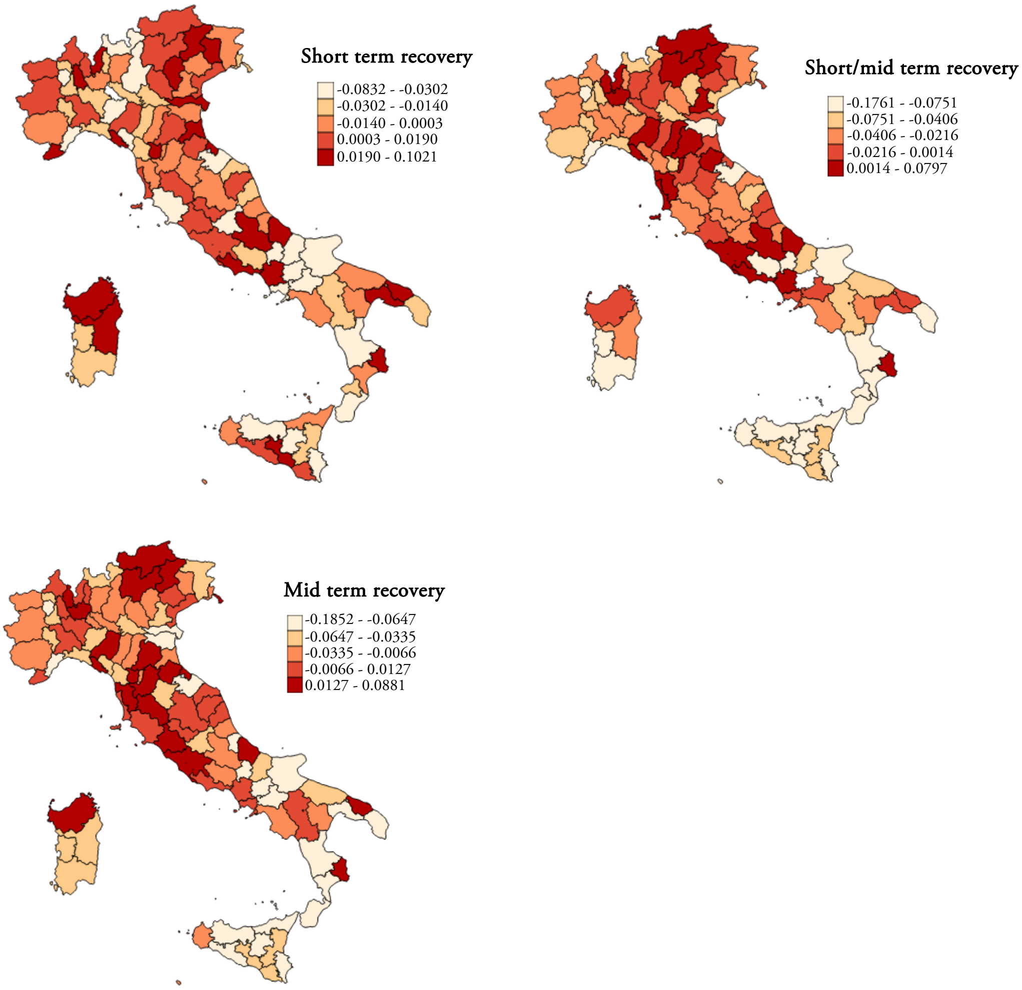
It is represented by the change in the percentage of the province's employment after the shock and is usually computed between one and five years after the crisis[1]. In this case, figure 4 shows the recovery of Italian provinces after one year (2011), to capture the recovery in the very short-term, after three years (2013) representing a short/mid-term recovery and five years (2015), that represents a mid-term recovery after the crisis occurrence.

It is possible to see how in this very short term the levels of recovery are quite similar to those of resistance, meaning that the provinces that resisted the crisis also continued to grow in the following

[1] Here the indexes of recovery have been computed after one, three and five years after the occurrence of the crisis, to understand if different diversification strategies where effective in short or medium term.

period. At the same time, after three and five years the north started to recover and grow much more than the south of Italy.

FIGURE 4.
Recovery of Italian provinces after 1, 3 and 5 years



Source: Authors' elaboration using QGis software.

4. RESULTS

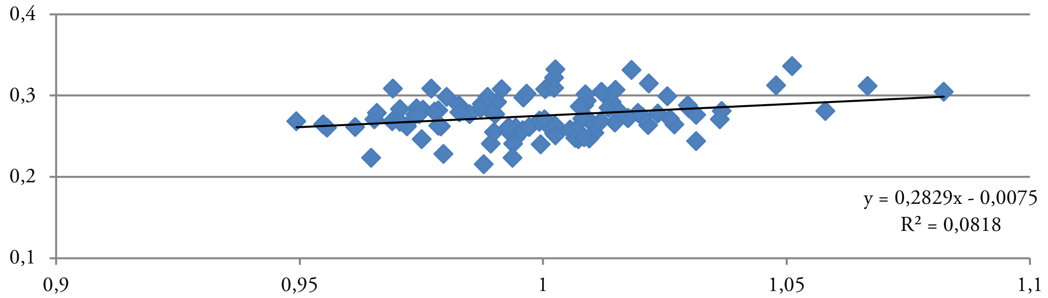
4.1. NEW SPECIALISATIONS AND RESILIENCE

This section investigates the relation among the relatedness of new specialisations of the Italian provinces compared to resistance and recovery. This allows us to understand if following a strategy of diversification in industries related to those already existing in the province, during the years before the crisis, is associated with a higher resistance to the shock occurred in 2008.

Figures 5 and 6 present the scatterplot between the relatedness of new specialisations occurred in the Italian provinces in the period 2006-2007 and 2007-2008 and the resistance in term of employment after the occurrence of the great recession 2008-2010.

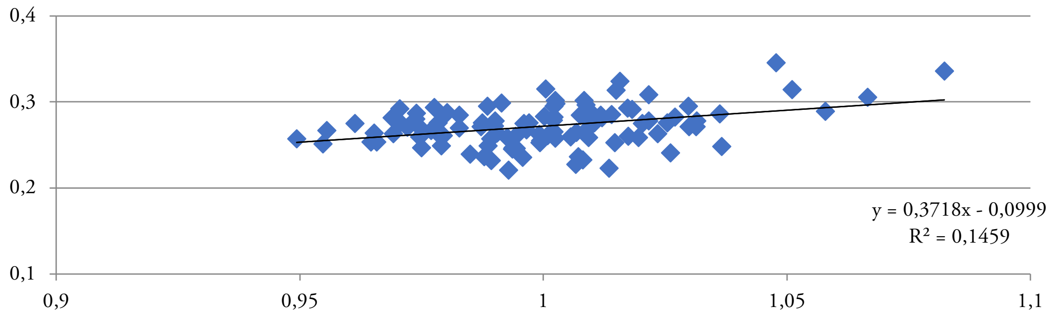
The results show how provinces that were following a strategy of diversification into related industries before the crisis resisted better to the great recession. This result is confirmed in the case of the relatedness of both years before the advent of the crisis.

FIGURE 5.
Relatedness before the crisis (2007) and resistance of Italian provinces



Source: Authors' elaboration.

FIGURE 6.
Relatedness before the crisis (2008) and resistance of Italian provinces



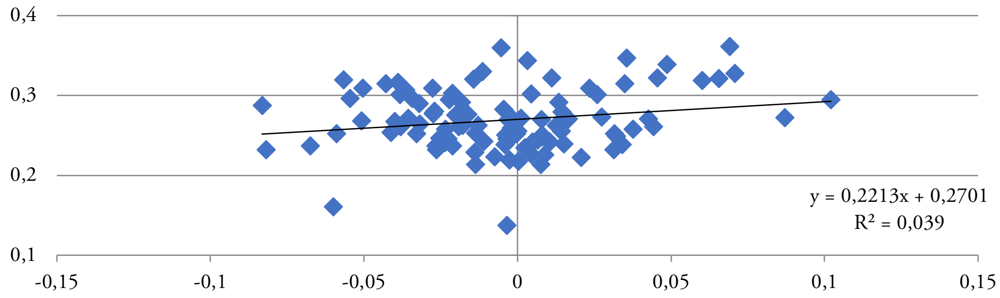
Source: Authors' elaboration.

The following figures use the same methods to establish a relationship between the relatedness after the occurrence of the great recession and the recovery of the Italian provinces. In the very short-term recovery – two years - (Figure 7), the relation with the strategy of diversification followed immediately after the crisis is positive but very weak, which means that new specialisations relatedness to the already established specialisations of the area does not seem to have a clear association with the recovery of the regions in the very short-term.

However, when we look at the Figure 8 showing the short/mid-term recovery (2013), the relationship becomes negative. Finally, this result is even more evident in the mid-term recovery (2015) represented in Figure 9, meaning that concerning the capacity to grow after the occurrence of the crisis, the strategy that seems to play a positive role is to diversify into less related activities.

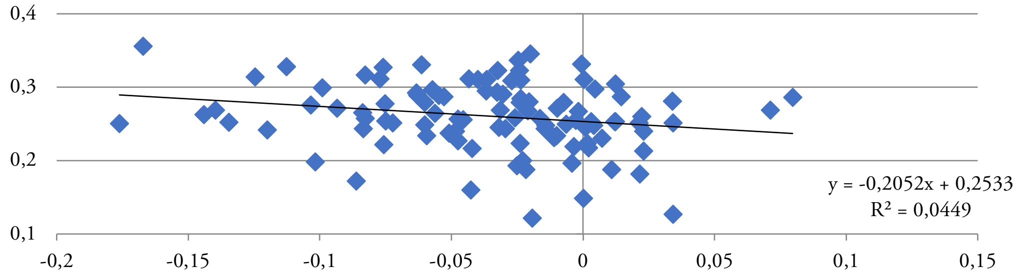
The results are in the opposite direction compared to the resistance to the shock. This implies that to resist the shock occurrence, a more conservative strategy that diversifies into related activities enables the region to better absorb the shock. Thus, those regions that followed riskier diversification, specialising into less related activities had a lower capacity to resist the shock. An explanation could be that new specialisations, born immediately before the crisis and unrelated to those already present in the area, are probably less consolidated in the region and thus less suited to resist a shock occurred few years after their birth. While after the crisis, it seems that a riskier diversification path is needed to enable the region's recovery and thus start to grow again. This result could be associated with new opportunities and new niches that arise after the shock.

FIGURE 7.
Relatedness 2009 and short term recovery (2011) of Italian provinces



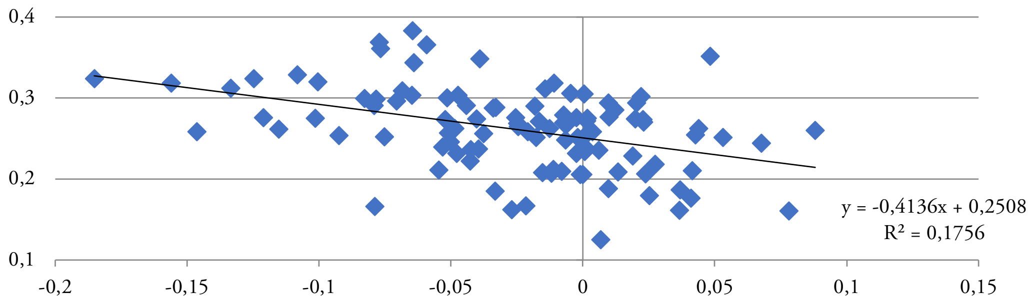
Source: Authors' elaboration.

FIGURE 8.
Relatedness (2011) and short/mid term recovery (2013) of Italian provinces



Source: Authors' elaboration.

FIGURE 9.
Relatedness (2013) and mid term recovery (2015) of Italian provinces



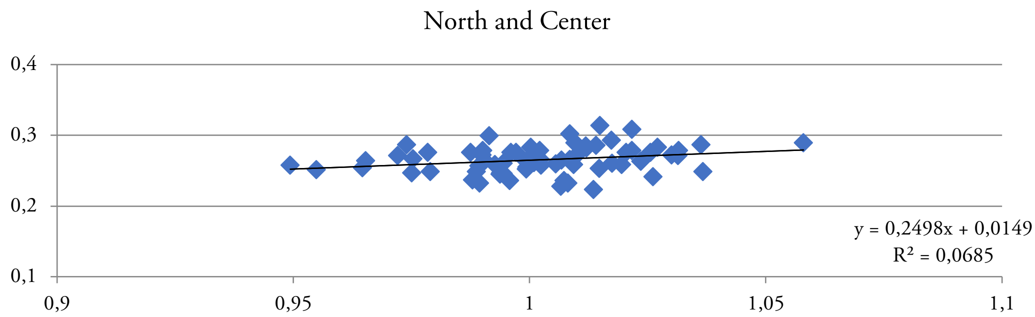
Source: Authors' elaboration.

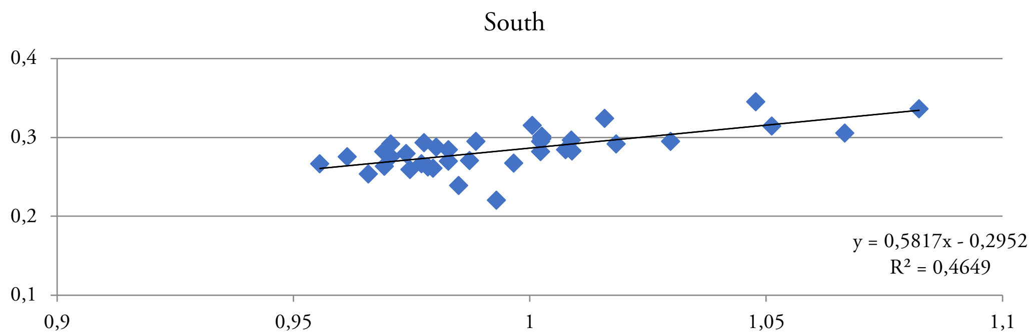
4.2. Differentials of development

The different effects on resistance and recovery of new specialisations relatedness to the industrial structure of the region may be due to differentials in the industrialisation between regions. For this purpose, the Italian case is particularly relevant. In fact, it is well known that the differentials in the industrial development between the north and the south of the Italian peninsula (Cellini and Torrisi, 2014; Di Caro, 2015) could have influenced the capacity to react to the shock occurrence. To better investigate this phenomenon, Figures 10 and 11 show the results of the relation between the level of relatedness and resistance divided respectively for the provinces located in the north-center and the south of the Italian peninsula.

The results show that the positive association between the relatedness of new specialisations occurred in the period before the crisis and the resistance is strongly driven by the provinces located in the south of Italy. In fact, the results for the provinces located in the north-center are still positive but largely less robust than those of the provinces located in the south.

FIGURES 10, 11.
Relatedness before the crisis (2008) and resistance of Italian provinces divided by north and south of Italy





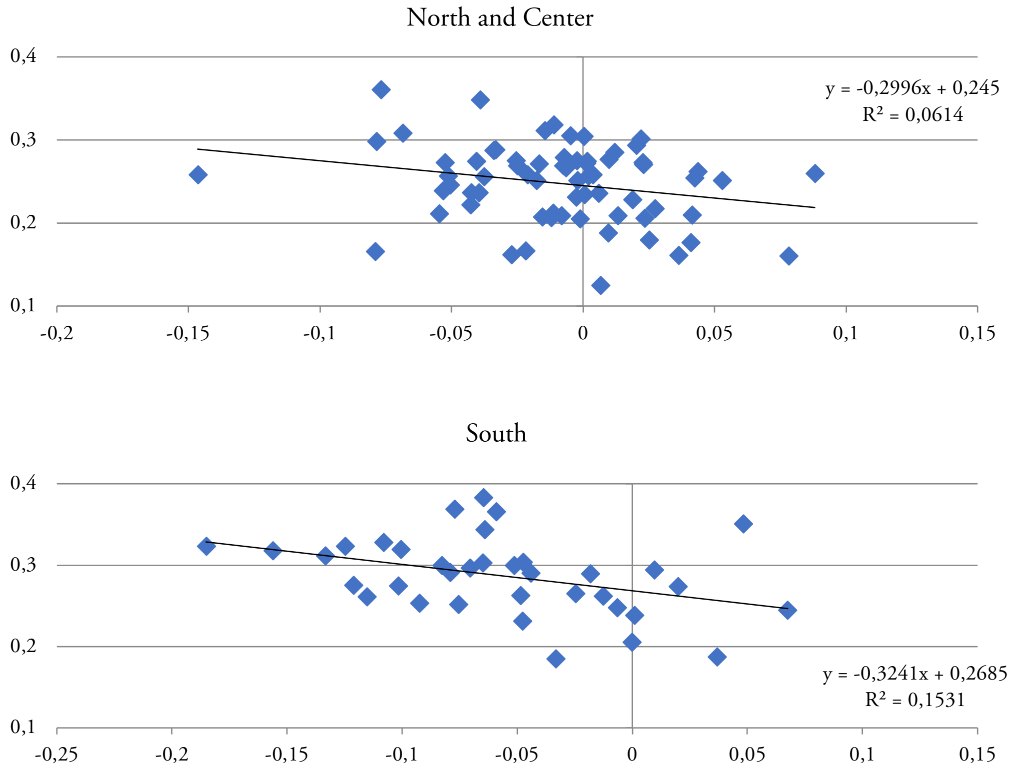
Source: Authors' elaboration.

The same results can be seen in Figures 12 and 13. In fact, when we decompose the results related to the connection between the relatedness of new industrial specialisations occurred after the crisis and the recovery of the last period considered in our analysis (2015), we can observe that the negative relation is stronger for those located in the south of the Italian peninsula.

What it seems to emerge from an in depth analysis of the new specialisations occurred before the crisis and that drive the south into a higher resistance of those provinces specialising into related activities, is that they diversified their specialisations into activities more connected with the heavy industry and this lead to a higher capacity to absorb the shock in respect to the provinces located in the north of the country.

However, what seems to have a negative impact is the diversification into related activities after the shock. And what emerges is that, after the shock, the diversification into related activities leads to lower growth in terms of employment and thus to a slower recovery of the provinces. In fact, with the great recession, many firms were driven to failure. Even if the market shrunk, new opportunities arose that were occupied by less competitive firms before the advent of the crisis. This result led the provinces that diversified in those less related activities, to achieve higher performance and a faster recovery.

FIGURES 12, 13.
Relatedness after the crisis (2013) and recovery of Italian provinces divided by north and south of Italy



Source: Authors' elaboration.

5. Discussion and conclusions

As shown in the previous sections, Italian provinces reacted differently to the crisis and the diversification effect was strongly affected by the area's industrial development. Results show that provinces following related diversification are resistant in the very short-term. However, considering recovery in short to mid-term, the adoption of a related diversification is unexpectedly not associated with higher performance in the following years. Such results may be explicated assuming that when regions face a crisis, a radical change is required because the relatedness effect may reduce in the long-term (Saviotti and Frenken, 2008).

In general, the principle of relatedness (Hidalgo et al., 2018) affirms that the probability of the entry of a region in a new economic activity depends on the number of related activities, hence the related diversification is a key driver of economic growth (Boschma, 2017). However, some empirical evidence suggests that cases of unrelated diversification may lead to a higher growth rate under certain conditions (Pinheiro et al., 2018). This result could also be shown in the case of an economic crisis.

The canonical model of path dependence suggests that a paradigmatic change occurs as a response to an external shock (Arthur, 1994; David, 2001). It implies that certain lock-in mechanisms supporting path-dependent industrial trajectories may be de-locked by the advent of an economic shock, leading actors to explore unusual and less-related paths. A crisis context makes diversification/specialisation strategies different from the usual context of economic growth. It may open possibilities to fill underused potentialities of regions to favour growth.

Both resilience and smart specialisation approaches look at structural change as a positive output of regions and a successful application of the policies. In line with the existing literature (Martin, 2012; Evenhuis, 2017), our results suggest that structural change is the output of the resilient process and that resilience can be influenced by the industrial structure. Contrary to the expectations, it emerges as an unrelated diversification. These implications are highly interesting for further development of smart specialisation and resilience approaches.

Concerning resilience, before the advent of a crisis, a related diversification strategy can lead to a higher resistance to shocks because it may favor the consolidation of acquired regional advantages and easy integration of new specialisations with existing ones. On the contrary, a path of diversification in unrelated sectors may expose the region to a higher sensitivity to an external shock, in the short-term because synergies and connections with other sectors are not yet stabilized. However, during the recovery period, further dynamics come into play and these are linked to new opportunities where the crisis forced the exit of firms outside the market. Furthermore, sector-specific crises may entail the need to invest in less related activities, less affected by the crisis and, therefore, still profitable. This reflection is in line with the literature on resilience that affirms that the diversity of economic structure, especially with little dependence on procyclical industries, may reduce the effect of shocks (Evenhuis, 2017). This aspect may be even more significant for those countries strongly specialized in certain industrial fields and where a big difference in the levels of development of northern and southern regions exists, such as Italy. The effect of unrelated variety on the growth of specific sectors, such as manufacturing (Bishop and Gripaios, 2010; Mameli, et al., 2012), or in all sectors (Fritsch and Kublina, 2018) is confirmed by empirical evidence. Moreover, concerning the specific case analysed, previous studies on resilience in Italy (Di Caro, 2015; Lagravinese, 2015) underline the inability of the Italian southern regions to recover from a series of economic crises over time. This feature has exacerbated their 'un-resilience' and has probably favoured the conditions to develop related specialisations due to a low innovative capability and the consequent inability to create new and un-related sectors. On the contrary, longer and higher resilience of northern regions may explicate their higher innovation capacity in generating new less path-dependent trajectories.

Concerning policy implications for smart specialisation, results suggest that a higher risky context, such those of a crisis, may lead towards unexplored opportunities and the structural change advocated by smart specialisation may coincide with patterns of *radical foundation* where the new domain has few connections with the existing industrial structure (Foray, 2015). A variety of smart specialisation strategies exist and they do not only concern 'related diversification'. Among the others, they may be connected to a combination of unrelated knowledge to move into new related and unrelated industries or a strategy based on related activities to move into unrelated industries (Asheim et al., 2017). What is important is to consider also some contextual elements, such as those that can characterise an uncertain economic environment, to achieve the most desirable model of structural change. These should coincide with the search for the entrepreneurial knowledge that corresponds to this vision (Foray and Rainoldi, 2013).

Moreover, some characteristics, such as the quality of institutions and the propensity for innovation by policymakers, can inhibit the application of smart specialisation policies and lead to the failure of the entrepreneurial discovery process (Marques and Morgan, 2018). Indeed, if a successful strategy should be based on the economic structure of regions and should support the discovery process undertaken by companies and organisations operating within that economic structure (Foray et al., 2011), this would require a high level of institutional capabilities. These are, therefore, 'place-based' and may lack in those economically weaker regions that most need innovation policies (McCann and Ortega-Argilés, 2016). It may be the case in the southern Italian regions where the poor quality of institutions and a weaker socio-economic structure can interfere with applying innovative policies based on existing local capacities. It follows that the planning of a successful strategy of smart specialisation should take into account not only the strengths of the regions, such as their competitive advantages, but also their weaknesses, often linked to a socio-economic context not inclined to innovation due to absence of entrepreneurial capacity, low quality of the government, unemployment, few propensity for R&D investments, etc. This evidence aligns with the European Regional Development Funds' idea for innovation-led territorial development based on smart specilisation that has activated specific strategies for lagging regions. These strategies should involve not only the identification of potential local strengths and market opportunities for competitive advantage but also require policymaking and governance support to innovation strategy to avoid institutional failures and limit their transformative potential.

Despite this evidence, there is still little knowledge about the relationship between 'smart specialisation' and resilience. This article represents a preliminary contribution to combining such approaches. The analysis explores the transformation of industrial structure concerning economic shocks, both in a short and mid-term perspective, through evaluating dimensions of resistance and recovery. It aims to understand if new industrial specialisations may emerge in a context of crisis and are related to the existing ones. Moreover, applying the methodology of relatedness, the research has made an effort to develop a framework that operationalizes the concept of smart specialisation and connects resilience with a policy dimension.

Of course, the paper is not free of limitations. Firstly, the rather short period under consideration does not allow us to make considerations regarding long term structural changes. In the same direction, the few years considered before the advent of the great recession limit the strength of the association between structural change and resilience. For this purpose, studying resilience and smart specialisation is particularly interesting and opens the discussion for further research. Future analysis should go deep into understanding which characteristics of the pre-shock industrial structure may influence the recovery trajectories, taking into account other place-specific features, such as innovation capacity, endowment of territories, quality of institutions or interregional linkages. These arguments are tackled by both the resilience and the smart specialisation literature. Finally, future research should investigate the implications of the discovery process of domains that should be prioritized when contexts of change and uncertainty are considered. This aspect could indeed be useful for the orientation of the policy of smart specialisation and to cope with the challenge of the global scenario.

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Articles

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Articles

Convergencia regional sigma débil en México: 1970-2019

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Resumen:

El objetivo de este trabajo es brindar evidencia sobre la hipótesis de convergencia en México a través de una prueba relativamente novedosa, la prueba de σ-convergencia débil aplicada no sólo a todo el periodo analizado sino también a distintos periodos, los cuales dependen de donde se ubique el año de ruptura que representa la apertura comercial ya sea 1986 o 1995 así como a distintos grupos clasificados de acuerdo a los terciles como de ingreso alto, medio y bajo. Los resultados muestran que únicamente en el primer periodo encontramos evidencia de este tipo de convergencia para la totalidad de las entidades federativas, independientemente de donde se ubique el año de quiebre, mientras que tanto para el segundo periodo como para todo el periodo en su conjunto no encontramos evidencia de σ-convergencia débil. De igual forma, encontramos evidencia de sigma-convergencia débil en ambos periodos para los grupos de ingresos alto y medio pero no para los de bajo ingreso, lo cual sugiere que los resultados encontrados para la totalidad de las entidades federativas puede atribuirse al comportamiento que las entidades de bajo ingreso muestran en este último periodo. Adicionalmente, estos resultados son consistentes con el análisis de sigma-convergencia tradicional.

Palabras clave: Crecimiento económico; σ-convergencia débil; desigualdad regional; México.

Clasificación JEL: O40; O47; C32; C33.

Regional covergence in Mexico: a test of weak σ-convergence

Abstract:

The objective of this paper is to provide evidence on the convergence hypothesis in Mexico through a relatively novel test, the weak σ-convergence test applied not only to the whole period analyzed but also to different periods, which depend on the location of the break year representing trade liberalization, either 1986 or 1995, as well as to different groups classified according to terciles such as high, middle and low income. The results show that only in the first period we find evidence of this type of convergence for all the states, regardless of where the break year is located, while for the second period and for the whole period as a whole we find no evidence of weak σ-convergence, however, we find evidence of weak sigma-convergence in both periods for the high and middle income groups but not for the low income groups, which suggests that the results found for all the states can be attributed to the behavior that the low income states show in this last period. Additionally, these results are consistent with the traditional sigma-convergence analysis.

Keywords: Economic growth; weak σ-convergence; regional inequality; Mexico.

JEL Classification: O40; O47; C32; C33.

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1. Introducción

Una de las principales preocupaciones de los economistas, los responsables del diseño e implementación de las políticas gubernamentales y los funcionarios de las organizaciones internacionales en términos económicos es la cuestión de si la enorme discrepancia que representa el PIB per cápita entre los países más ricos y los más pobres se está acentuando o reduciendo, Sakikawa (2012). De hecho, la historia del desarrollo y el progreso ha sido testigo de divergencias y convergencias entre las regiones, tanto entre los países como al interior de los mismos, Narayan (2017). Las disparidades regionales con frecuencia son motivo de problemas económicos y políticos importantes por lo que numerosos estudios han abordado las tendencias y patrones de convergencia y divergencia regionales.

Pocos temas de la investigación económica aplicada han recibido tanta atención como la hipótesis de la convergencia en las últimas tres décadas. En su forma más simple tal hipótesis establece que las condiciones iniciales no tienen implicaciones para el nivel de ingreso per cápita de un país (región) a largo plazo, Johnson y Papageorgiou (2020), por lo que las regiones menos desarrolladas tenderían a crecer más rápido que las desarrolladas, lo cual conduciría a una eventual igualdad, Barro y Sala-i-Martin (1995) y Sala-i-Martin (1996). En la práctica, a menudo se considera que la hipótesis significa que los ingresos per cápita en diferentes países (regiones) se están acercando en cierto sentido, lo que implica que los países (regiones) más pobres están alcanzando a los países (regiones) más ricos. El interés teórico y empírico de esta hipótesis se acentuó con el surgimiento de la teoría moderna del crecimiento a mediados de los años ochenta, ya que el abordar esta hipótesis se consideró como una parte importante del proyecto de desbloquear la mecánica del crecimiento económico.

México representa un interesante caso de estudio para la economía regional en el sentido de que tiene una etapa de sustitución de importaciones (1960-1985) versus una era de liberalización comercial (de 1985 al presente) además de que el país desplazó la industria fuera del área central del país (Estado de México y Ciudad de México) a la región fronteriza del norte (Baja California, Sonora, Chihuahua, Coahuila, Nuevo León y Tamaulipas), Brock y German-Soto (2013), Becerril *et al.* (2010), Jordaan y Rodríguez-Oreggia (2012), Rodríguez-Oreggia (2005). Además, la literatura económica sobre convergencia ha identificado diversos mecanismos a través de los cuales las reformas comerciales han tenido efectos diferenciados en las regiones de México, Chiquiar (2005). Es por ello que la investigación sobre la experiencia de México en materia de disparidad regional puede proporcionar a las economías en desarrollo algunas lecciones relevantes, Sakikawa (2012). Razón por la cual este trabajo se centra en determinar si los resultados de la convergencia varían entre los períodos anteriores y posteriores a la liberalización económica.

Con la finalidad de determinar de manera empírica la existencia o no de convergencia empleamos una prueba relativamente novedosa, la prueba de σ-convergencia débil propuesta por Kong, Philllips y Sul (2019), la cual permite probar distintas formas de variabilidad decreciente en los datos a través de un modelo de regresión. El enfoque se basa en un estadístico de prueba t que permite identificar convergencia a pesar de que la regresión diseñada para tal fin se especifique de manera incorrecta bajo una variabilidad decreciente.

2. Revisión de la literatura empírica

Con el fin de probar distintas hipótesis de convergencia regional en México se ha hecho un esfuerzo notable por construir bases de datos históricas que cubran mayores periodos de tiempo, ejemplo de ello son los trabajos de Esquivel (1999), German-Soto (2005), Mendoza (2014) y Aguilar-Retureta (2010) y (2016) entre otros, ya que las bases de datos oficiales con las que se cuenta cubren intervalos de tiempo relativamente cortos o bien se dispone sólo para algunos periodos. En este trabajo empleamos las series del PIB por habitante de 1970 a 2019 de Mendoza (2014).

Entre los trabajos que han analizado convergencia en México con los enfoques de (β-convergencia y σ-convergencia se encuentran los de Mallick y Carayannis (1994), Juan Ramón y Rivera Bátiz (1996), Esquivel (1999), Messmacher (2000), Rodríguez Oreggia (2001), García Verdú (2002) y Rodríguez-Pose y Sánchez-Reaza (2002a) quienes estudian la convergencia absoluta entre los estados mexicanos. Todos tienden a concluir la presencia de convergencia a nivel de entidades federativas en México hasta mediados de los ochenta, pero que este patrón se rompió posteriormente. Sin embargo, el horizonte temporal de la mayoría de estos estudios comprende hasta 1996, por lo que la experiencia de crecimiento posterior al TLCAN es limitada y no se analiza explícitamente.

Messmacher (2000) y Rodríguez-Pose y Sánchez-Reaza (2002a), analizan la convergencia durante el período posterior al TLCAN en relación a los patrones observados anteriormente. Los resultados de Rodríguez-Pose y Sánchez-Reaza (2002a) son consistentes con otros autores y sugieren que el TLCAN no restableció la convergencia. Los resultados de Messmacher (2000), sin embargo, contradicen los hallazgos de estos autores en virtud de que no obtiene estimaciones estadísticamente significativas para el parámetro de convergencia β en ningún periodo muestral. Esquivel y Messmacher (2002) muestran que el comportamiento de la productividad laboral fue una fuente importante de convergencia en el producto per cápita entre 1960 y 1990. Por el contrario, la productividad laboral fue el principal factor detrás del patrón de divergencia regional en el producto per cápita observada en la década de los noventa.

Chiquiar (2005) encuentra que el patrón divergente observado después de 1985 no se revirtió con el TLCAN y que los estados que se beneficiaron con las reformas fueron aquellos estados que contaban con una mejor dotación inicial y que fueron más capaces de atraer mayores niveles de capital físico y humano, así como una mejor infraestructura.

Plata, Calderón y Salazar (2013) encuentran evidencia de convergencia a nivel de entidades federativas en México, pero a una velocidad inferior, de 1.1% en promedio, a la reportada en otros estudios a nivel internacional que es de aproximadamente del 2%. Kido-Cruz y Kido-Cruz (2015) rechazan las hipótesis de convergencia absoluta y condicional en cuatro estados de la República Mexicana: Chiapas, Guerrero, Michoacán y Oaxaca en el periodo de 1990 a 2010. German-Soto, Rodríguez y Gallegos (2020) investigan el proceso de convergencia regional en México a nivel de estados a través del enfoque de β-convergencia en el periodo 1940-2015, sus resultados muestran evidencia de β-convergencia regional y que la velocidad en la que se registra es mayor para los estados más expuestos a la globalización y menor para los menos expuestos a dicho proceso.

Brock (2019) examina empíricamente la convergencia a nivel de municipios dentro de la región sur de Oaxaca de México. Encuentra que los municipios están convergiendo más rápidamente que la "ley del hierro" del 2% con hasta una velocidad de β convergencia de 8%.

Otra serie de trabajos se han enfocado en mostrar evidencia de convergencia estocástica en México, la cual se prueba básicamente a través de pruebas de raíces unitarias ya sea de manera univariada o en panel. Por ejemplo, Carrion-i-Silvestre y Germán-Soto (2007 y 2009) a través de pruebas de raíces unitarias analizan el proceso de convergencia estocástica en México, sus resultados muestran que dicho proceso no se puede entender si no se considera el cambio estructural registrado en la década de los ochentas.

Gómez y Ventosa (2009) analizan la convergencia entre regiones de la República Mexicana en relación a la capital del país, encuentran evidencia de que los diferenciales en ingreso per cápita de cada estado tiende a disminuir a través del tiempo. Sus resultados muestran también que las reformas comerciales de mediados de los años ochenta incidieron negativamente en el proceso de convergencia para algunas regiones, principalmente las más pobres, tampoco encuentran evidencia que les permita concluir que la apertura comercial promovió la convergencia entre las regiones fronterizas de México y Estados Unidos.

Díaz, Sánchez y Mendoza (2009) a través de pruebas de raíces unitarias y de cointegración en panel proveen evidencia empírica respecto a la convergencia del ingreso per cápita de los estados de la República Mexicana con respecto a la economía líder. Sus resultados muestran que las pruebas de raíces unitarias no respaldan la hipótesis de convergencia absoluta hacia la economía líder mientras que las pruebas de cointegración favorecen la hipótesis de convergencia condicional.

Gómez y Ventosa (2010) describen dos posible resultados de acercamiento (*loose catching-up/loose lagging-behind*) que se han tendido a pasar por alto en la literatura, los cuales se sitúan entre la convergencia y la divergencia. Sus resultados ilustran que la excesiva evidencia a favor de la divergencia puede atribuirse a la falta de atención de estos dos resultados.

Gómez y Ventosa (2012) examinan la conducta de las disparidades a nivel de regiones en México en relación a la región más rica, la Ciudad de México, durante el periodo 1940-2009, sus resultados muestran que mientras algunas regiones han mostrado un proceso de acercamiento sistematico (*catching-up*) la región fronteriza de México se ha rezagado con respecto a su contraparte estadounidense.

Rodríguez, Mendoza y Venegas (2016a) evalúan la hipótesis de convergencia regional en México a través de un modelo de crecimiento no lineal, específicamente a través de un modelo panel-TAR. Sus resultados muestran evidencia de convergencia parcial y absoluta para el grupo de las 11 entidades consideradas como las "más ricas" en determinados periodos.

Rodríguez, Trejo y Mendoza (2016c) analizan la convergencia en el PIB per cápita de las entidades de la República Mexicana en el periodo 1940-2010 a través del enfoque de pares propuesto por Pesaran (2007). Sus resultados muestran evidencia que va en contra de la hipótesis de convergencia principalmente para todo el periodo, que va de 1940 a 2010, y también para el primer periodo en que dividen la muestra que va de 1940 a 1985. No obstante, encuentran evidencia mixta de dicha hipótesis en el segundo periodo en el que ellos dividen la muestra, el cual corresponde de 1986 a 2010.

Mendoza, Ventosa y German-Soto (2019) a través de una batería de pruebas de raíces unitarias brindan evidencia sobre el proceso de convergencia de la desigualdad interregional en México, sus resultados muestran que la mayoría de las regiones divergen o se están poniendo al día (*catching-up*).

Mendoza, German-Soto, Monford y Ordoñez (2020) argumentan que uno de los inconvenientes de las pruebas de raíces unitarias para probar la hipótesis de convergencia es que proporcionan resultados engañosos si los datos contienen dinámicas de transición (o combinan tanto estados estacionarios como dinámicas de transición). Apergis, Christou y Miller (2012), destacan que este tipo de pruebas fracasan en la detección de convergencia si se encuentra presente más de un equilibrio.

Rodríguez, López y Mendoza (2016b) investigan la hipótesis de convergencia relativa en el PIB per cápita de las entidades federativas de la República Mexicana en el periodo 1970-2012 a través de la metodología empleada por Phillips y Sul (2007) y encuentran evidencia de convergencia relativa en seis grupos o clubes de convergencia. Mendoza, German-Soto, Monford y Ordoñez (2020) emplean la misma metodología con datos de ingreso per cápita de las entidades federativas en el periodo 1940-2015, sus resultados tienden a corroborar la existencia de clubes de convergencia en ambos indicadores.

Recientemente, se han empleado metodologías novedosas que incorporan efectos espaciales en el proceso de convergencia. En este contexto, Díaz, Fernández, Garduño y Rubiera (2019) a través de un modelo de β convergencia condicional espacial prueban la hipótesis de convergencia regional con datos a nivel de entidad federativa y de municipio en el periodo de 1980 a 2008. Sus resultados muestran que para el periodo previo al TLCAN hay un proceso de convergencia alentado por las entidades de la región fronteriza mientras que para el segundo periodo no encontraron evidencia de convergencia.

Valdez (2019) estima el impacto de las externalidades espaciales del capital en la producción. Sus resultados muestran que la difusión espacial del crecimiento económico está relacionada directamente con la distancia y encuentran evidencia a favor de la hipótesis de convergencia. Adicionalmente muestran que la distancia entre los estados estacionarios es insuficiente para explicar las diferencias entre las tasas de crecimiento, sino que también es importante considerar la distancia geográfica.

Rodríguez y Cabrera (2019) investigan si la contigüidad geográfica es importante en el proceso de convergencia (absoluta y condicional) a nivel de municipios en México en el periodo 1999-2014. Sus resultados muestran que los municipios pobres crecieron más que los ricos, principalmente en el último periodo de la muestra y que la dimensión espacial es un elemento cuya importancia se reduce a través del tiempo. De igual forma, sus resultados les permiten prever un crecimiento más autónomo de las economías en años recientes.

Rodríguez, Mendoza y Climent (2022) efectúan un análisis de σ-convergencia débil con los datos del PIB per cápita por entidades federativas de German-Soto (2014) en el periodo 1940-2019 con el fin de determinar si el proceso de liberalización comercial y la entrada en vigor del Tratado de Libre Comercio de América del Norte (TLCAN) promovieron la convergencia regional. Sus resultados muestran que para el primer periodo, ya sea de 1970 a 1984 o de 1970 a 1994, hay evidencia de σ–convergencia débil, mientras que para el segundo periodo encuentran evidencia de divergencia y para el periodo completo la evidencia es mixta. Mientras que los resultados de la prueba aplicados a grupos formados a partir de niveles de ingreso contribuye a identificar que algunos de ellos pueden ser los causantes de la ausencia de convergencia para todas las entidades federativas.

3. Metodología econométrica

3.1. La prueba de σ-convergencia débil

El concepto de σ-convergencia mide las brechas entre las series de tiempo al examinar si la variación de la sección transversal disminuye con el tiempo, como se anticiparía si dos series convergen, Kong, Phillips y Sul (2019). Curiosamente, la convergencia condicional requiere divergencia entre las tasas de crecimiento para garantizar el acercamiento (*catch up*) y la convergencia en los niveles. Por lo tanto, para que los países pobres se pongan al día con los países ricos (*catch up*), los países pobres deben crecer más rápido que los países ricos. De acuerdo con Kong, Phillips y Sul (2019) las pruebas econométricas de convergencia tienen que lidiar con esta sutileza. Phillips y Sul (2007) propusieron el concepto de "convergencia relativa" para superar este inconveniente y desarrollaron un modelo de regresión econométrico simple para probar convergencia. Bajo este concepto, dos series convergen relativamente a lo largo del tiempo cuando las series de tiempo comparten los mismos elementos de tendencia estocástica o determinista a largo plazo, de modo que la razón de las dos series tiende a converger a la unidad.

No obstante, los conceptos de convergencia condicional ni relativa son adecuados para caracterizar la convergencia entre series de tiempo que no tienen elementos de tendencia deterministas o estocásticos divergentes (comunes), como tendencias de tiempo polinomiales o series de tiempo integradas. En cambio, muchas series de tiempo económicas, especialmente después de la diferenciación (como las tasas de crecimiento), no muestran evidencia de crecimiento determinista o el comportamiento errante aleatorio que es la característica principal de los datos integrados. Además, gran parte de los datos experimentales de laboratorio no están integrados en virtud de su construcción en términos de respuestas limitadas, y muchos datos macroeconómicos muestran menos evidencia de comportamiento de tendencia persistente durante la llamada Gran Moderación a mediados de la década de 1980. Los investigadores interesados en las propiedades empíricas de convergencia de tales series de tiempo necesitan un enfoque alternativo que se adapte a paneles de series asintóticamente estacionarias o débilmente dependientes, donde el concepto de convergencia implica una función explícita de disminución del tiempo que puede ser común en todas las series del panel.

La medición de la dispersión transversal decreciente o divergente ha desempeñado un importante papel en la evaluación de la convergencia o divergencia a lo largo del tiempo en indicadores económicos clave. Recientemente se han desarrollado métodos econométricos, conocido como prueba de σ-convergencia débil, Kong, Phillips y Sul (2019) para evaluar la tendencia en la dispersión en datos de panel utilizando una regresión de tendencia lineal simple. Para alcanzar la generalidad en las aplicaciones, estas pruebas se basan en estimaciones de varianza heterocedástica y de autocorrelación consistente (HAC), Kong, Phillips y Sul (2020).

La prueba de convergencia sigma débil permite probar convergencia en paneles con series asintóticamente estacionarias o débilmente dependientes, Jangam y Akram (2019). De acuerdo con Kong *et al.* (2019) la prueba consiste en determinar si la dispersión transversal decae a través del tiempo, para lo cual se estima la siguiente regresión de tendencia lineal:

$$K_{nt}^{y} = \hat{\alpha}_{nt} + \widehat{\emptyset}_{nt}t + \hat{u}_t \tag{1}$$

donde K_{nt}^{y} es la variación muestral de sección cruzada o transversal, con $n=1,\ldots,N$ y $t=1,\ldots,T$, es decir:

$$K_{nt}^{y} = \frac{1}{n}\sum_{i=1}^{n}\left(y_{it} - \frac{1}{n}\sum_{i=1}^{n} y_{it}\right)^{2} \tag{2}$$

la cual se regresa en función de una constante, $\hat{\alpha}_{nt}$, y de una tendencia, t, y $\hat{u}_t$ es el error estimado. Hay evidencia de convergencia si el coeficiente estimado de la pendiente, $\widehat{\emptyset}_{nt}$, es significativo. La significancia de la pendiente de la tendencia se lleva a cabo a través del estadístico t estándar robusto que viene dado por:

$$\hat{t}_{\emptyset_{nt}} = \frac{\widehat{\emptyset}_{nt}}{\sqrt{\widehat{\Omega}_u^2 / \sum_{t=1}^{t} \tilde{t}^2}} \tag{3}$$

donde $\tilde{t} = t - T^{-1}\sum_{t=1}^{T} t$, Sul (2019). La presencia de convergencia débil se confirma en la medida en que $\hat{t}_{\emptyset_{nt}}$ tiende a -∞. La varianza de largo plazo, $\widehat{\Omega}_u^2$, se estima con los residuos del modelo (1), de tal forma que el estimador Bartlett-Newey-West (BNW) tipo (HAC) de la varianza viene dado por:

$$\widehat{\Omega}_u^2 = \frac{1}{t}\sum_{t=1}^{T}\hat{u}_t^2 + 2\frac{1}{t}\sum_{l=1}^{L} v_{lL}\sum_{t=1}^{T-l}\hat{u}_t\hat{u}_t + l \tag{4}$$

donde v_{lL} es el peso del kernel de rezagos de Bartlett con parámetros de rezago $L = [T^k]$ para $k > 0$. De esta forma, para proveer evidencia de convergencia en el panel en cuestión se consideran los valores críticos unilaterales de una distribución normal estándar. Debido a que la prueba es de un sólo lado, el valor crítico al nivel de significancia del 5% es -1.65. Entonces, hay evidencia de sigma-convergencia débil si la pendiente es negativa y el valor de la prueba $\hat{t}_{\emptyset_{nt}}$ es menor a -1.65, se dice que hay variación fluctuante si no es significativa, y hay evidencia de divergencia si es positivo y estadísticamente significativo, es decir mayor a 1.65, Kong *et al.* (2019).

4. Datos

Las series del PIB per cápita a precios de 2013 por entidad federativa de 1970 a 2019 se construyeron a partir de la metodología propuesta por Mendoza (2014), la cual emplea métodos de interpolación estructural-espacial con las series del PIB, a precios de 2003, compatible con la estructura de los censos económicos, las cuentas nacionales y de las series del Indicador Trimestral de la Actividad Económica Estatal (ITAEE), y datos de la población de los censos del INEGI y estimaciones por CONAPO.

Con el fin de proveer evidencia adicional optamos por realizar un análisis pormenorizado dividiendo en terciles de pib por habitante a las entidades de la republica mexicana.[1] Los resultados de esta clasificación en base al último año de la muestra, 2019, se presentan en el cuadro 1.

Cuadro 1.
PIB por habitante por entidades federativas
Pesos de 2013

Entidades federativas	PIB por habitante		Grupos de ingreso	Tasa de crecimiento promedio anual			
	1970	2019	2019	1970-1985	1970-1994	1986-2019	1995-2019
Aguascalientes	50.6	162.9	alto	2.4	2.6	2.6	2.6
Baja California	132.1	166.4	alto	1.0	0.4	0.4	1.0
Baja California Sur	132.6	212.3	alto	0.0	0.6	1.5	1.5
Campeche							

[1] Agradecemos a uno de los dictaminadores anónimos el habernos sugerido esta veta de análisis para enriquecer la aportación empírica del trabajo.

CUADRO 1. CONT.
PIB por habitante por entidades federativas
Pesos de 2013

Entidades federativas	PIB por habitante		Grupos de ingreso	Tasa de crecimiento promedio anual			
Coahuila	102.6	201.6	alto	1.4	1.3	1.6	1.6
Colima	76.5	149.0	medio	3.3	1.9	0.7	1.2
Chiapas	44.3	48.8	bajo	3.9	1.1	-1.1	-0.6
Chihuahua	51.4	157.2	alto	2.2	2.6	2.5	2.5
Ciudad de México	144.8	349.5	alto	1.9	1.9	2.0	2.2
Durango	53.0	109.7	medio	3.2	2.0	1.0	1.2
Guanajuato	55.0	119.3	medio	1.7	1.2	1.7	2.3
Guerrero	46.3	66.1	bajo	1.6	1.1	0.4	0.7
Hidalgo	48.7	90.3	bajo	3.0	1.9	0.6	1.3
Jalisco	89.7	149.9	medio	1.6	1.0	1.0	1.6
México	70.1	91.2	bajo	1.1	0.3	0.5	1.3
Michoacán	45.4	90.9	bajo	2.0	1.5	1.2	1.6
Morelos	67.0	98.7	medio	1.2	1.4	0.8	0.8
Nayarit	81.2	96.2	bajo	0.8	0.1	0.3	1.1
Nuevo León	132.7	244.3	alto	1.4	1.1	1.4	1.9
Oaxaca	34.3	62.3	bajo	3.9	2.2	0.2	0.5
Puebla	46.9	92.3	bajo	2.0	1.4	1.3	1.9
Querétaro	65.6	187.9	alto	3.5	2.6	1.9	2.1
Quintana Roo	76.3	175.3	alto	1.9	3.0	1.7	0.9
San Luis Potosí	51.0	131.3	medio	2.6	2.2	1.8	2.3
Sinaloa	86.0	127.4	medio	0.7	0.6	1.0	1.2
Sonora	119.7	192.4	alto	0.9	0.8	1.2	1.4
Tabasco							
Tamaulipas	91.0	142.6	medio	1.3	1.0	0.9	1.2
Tlaxcala	47.1	78.1	bajo	4.8	1.9	-0.3	0.5
Veracruz	75.4	96.3	medio	1.1	0.4	0.4	0.8
Yucatán	60.1	118.6	medio	1.4	1.4	1.6	1.9
Zacatecas	37.4	91.9	bajo	3.1	1.9	1.3	1.9

Nota: Los grupos de ingreso se construyeron con los terciles del PIB por habitante de 2019; y, no se consideraron las entidades petroleras de Campeche y Tabasco.

También en el cuadro 1, se muestra el PIB por habitante de cada estado al principio y al final de la muestra bajo estudio, el grupo de ingreso al que pertenece de acuerdo al tercil en el que se ubica, ordenado de acuerdo con el año de 2019, y las tasas medias de crecimiento del PIB por habitante por periodos de interés.

La figura 1 presenta las entidades federativas de acuerdo a los grupos de ingreso alto, medio o bajo con la finalidad de mostrar la distribución espacial de las entidades que conforman estos grupos. De dicha distribución espacial destaca el hecho de ciertos agrupamientos ya que como se puede ver, las entidades identificadas como de ingreso alto se ubican en el norte del país, con excepción de Aguascalientes, Querétaro, la Ciudad de México y Quintana Roo, las de ingreso medio tienden a ubicarse en la región central del país, con excepción de Yucatán, mientras que las de ingreso bajo se ubican en el sureste del país, excepto Nayarit y Zacatecas. De ahí la importancia de considerar en el análisis empírico el factor espacio.

FIGURA 1.
PIB por habitante por grupos de entidades federativas, 2019
Pesos de 2013

Nota: Los grupos de ingreso se construyeron con los terciles del PIB por habitante de 2019; y, no se consideraron las entidades petroleras de Campeche y Tabasco.

El cuadro 2 muestra un análisis descriptivo de la evolución del ingreso por habitante agrupando las 30 entidades federativas por terciles.

CUADRO 2.
PIB por habitante por grupos de entidades
Pesos de 2013

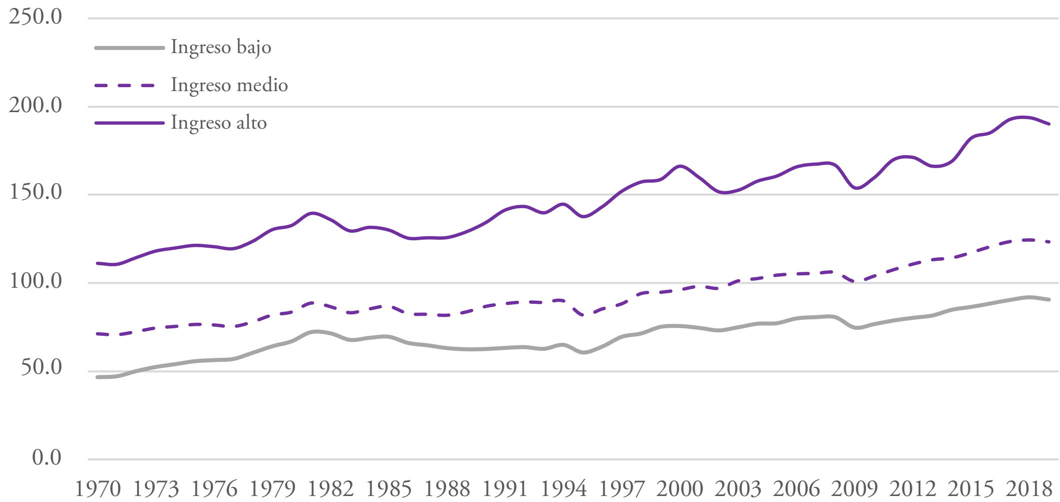
Grupos de entidades	PIB por habitante promedio				Tasa de crecimiento promedio anual			
	1970	1986	1995	2019	1970-1985	1970-1994	1986-2019	1995-2019
Ingreso bajo	46.6	66	60.6	90.6	2.7	1.4	1.0	1.7
Ingreso medio	71.2	82.6	81.8	123.3	1.3	1	1.2	1.7
Ingreso alto	111.1	125.4	137.6	190.2	1.1	1.1	1.3	1.4
Todos	66.3	82.6	81.8	123.3	1.8	1.3	1.2	1.7

Nota: Los grupos de ingreso se construyeron con los terciles del PIB por habitante de 2019; para los promedios se utilizó la mediana; y, no se consideraron las entidades petroleras de Campeche y Tabasco.

En el cuadro 2 se puede apreciar que las tasas medias de crecimiento del primer tercil obtenidas para el primer periodo en el que se divide la muestra, correspondiente a las entidades de ingreso bajo, son mayores que las de los otros dos deciles e incluso mayores a la de la totalidad de los estados, independientemente en donde se ubique la fecha de quiebre ya sea en 1985, año en el que culmina el periodo de sustitución de importaciones en México, o en 1994, año en el que entra en vigor el tratado de libre comercio de America del Norte, lo cual es consistente con la hipótesis de convergencia en el sentido de que muestra evidencia de un mayor crecimiento de las entidades con menores ingresos en relación a las de mayores ingresos, como es reportado en la mayoría de los trabajos empíricos efectuados para este periodo. Por el contrario, las tasas medias de crecimiento del primer tercil para el segundo periodo, ubicado de 1986 a 2019 o de 1995 a 2019, son menores o iguales a las registradas por los terciles mayores, lo cual es más notorio para el periodo de 1986 a 2019, esta desaceleración en el crecimiento de las entidades del primer tercil refuerza la evidencia de divergencia en el segundo periodo reportada por muchos estudios y con la obtenida en este trabajo como se muestra mas adelante.

La figura 2 muestra la evolución de la mediana del PIB por habitante calculada para cada uno de los terciles de ingresos. Como se puede apreciar en dicha gráfica, el PIB por habitante del tercil de las entidades de ingreso alto es el que mas ha crecido en el periodo de estudio, lo cual es más evidente a partir de finales de la década de los ochentas. Mientras que la evolución del PIB por habitante de los terciles de ingreso medio y bajo tienen un comportamiento similar, no obstante la brecha entre ambos se amplia ligeramente en los años posteriores a 1986 y a 2008, lo cual revela que el PIB por habitante de las entidades de ingreso bajo se ha rezagado en los periodos posteriores a las crisis que se registraron en estos años. También se observa que el PIB por habitante de las entidades del tercil de ingreso alto creció más en relación al de los terciles de ingreso medio y bajo. Estos hechos estilizados mostrados por evolución del PIB por habitante de las entidades federativas clasificadas por terciles fortalecen la idea de la ausencia de convergencia en el segundo periodo que corresponde a la liberalización comercial en México.

FIGURA 2.
Tendencias del PIB por habitante por grupos de entidades
Pesos de 2013



Nota: Los grupos de ingreso se construyeron con los terciles del PIB por habitante de 2019; para los promedios se utilizó la mediana; y, no se consideraron las entidades petroleras de Campeche y Tabasco.

5. RESULTADOS

En los cuadros 3 y 4 se presentan los resultados de la prueba de σ-convergencia débil para determinar si existe convergencia en los datos del PIB per cápita en México. Adicionalmente a los resultados presentados para la totalidad del periodo 1970-2019, también se presentan los resultados para dos subperiodos: de 1970 a 1994 y de 1995 a 2019, esto con la finalidad de verificar si hay evidencia de convergencia en el periodo previo al año en que México ingreso al Acuerdo General sobre Aranceles Aduaneros y Comercio (GATT, por sus siglas en inglés), o bien en el periodo posterior al año en que entró en vigor el Tratado de Libre Comercio de América del Norte (TLCAN). Es preciso aclarar que esta periodización corresponde a los procesos de apertura y liberalización comercial en México, cuyos efectos en términos de convergencia económica son de interés tanto para los tomadores de desiciones públicas como para los académicos y pueden o no coincidir con la fecha de algunas rupturas estructurales que en algunos estudios estiman con pruebas de manera endógena, esto es importante en el estudio de la convergencia estocástica porque la omisión de dichos quiebres puede sesgar los resultados de las pruebas bajo este enfoque. El cuadro del anexo A1, presenta las pruebas de raíces unitarias de Lee y Strazicich (2003) de acuerdo a lo que ellos denominan el modelo A que considera únicamente cambios de nivel, como se puede ver en dicho cuadro en el caso de la prueba con dos rupturas, la mayoría de las rupturas de la primera fecha son de los años ochentas, 24 de 32, lo cual sugiere que es apropiado identificar el primer periodo hasta mediados de los ochentas. En lo que respecta a las fechas de ruptura identificadas tanto por la prueba con un quiebre como la segunda fecha de la prueba de dos quiebres, hay una mayor heterogeneidad en las fechas ubicadas y resulta más difícil establecer periodos de estudio a través de estos resultados.

CUADRO 3.
Resultados de la prueba tomando a 1995 como año de quiebre

De 1970 a 1994			**1995-2019**			**Todo el periodo**		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{t}_{\emptyset_{nt}}$ (4)
-0.1842	-3.5235	-3.2348	0.1805	5.9980	5.8499	0.0671	2.1606	1.9929

Notas: Con 30 estados excluyendo Campeche y Tabasco. Los números son los rezagos incorporados en el cálculo de la varianza de Newey-West.

CUADRO 4.
Resultados de la prueba tomando a 1985 como año de quiebre

Todos los estados					
De 1970 a 1984			De 1985 a 2019		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)
-0.3662	-20.9467	-22.2276	0.2014	10.4507	9.8725

Notas: Con 30 estados excluyendo Campeche y Tabasco. Los números son los rezagos incorporados en el cálculo de la varianza de Newey-West.

Los resultados de las pruebas de σ-convergencia débil muestran evidencia de convergencia para el primer periodo, independientemente en donde se ubique la fecha de quiebre o año de ruptura, y de divergencia en el periodo posterior a la firma y entrada en vigor del Tratado de Libre Comercio de América del Norte así como para la totalidad del periodo analizado, es decir de 1970 a 2019. El número de rezagos en cada caso se determinó de acuerdo a la recomendación de Sul (2019) de que el número apropiado es de $T^{\frac{1}{3}}$, como en todos los casos tal número no resultó en un número entero, la prueba se realizó con los dos números enteros entre los cuales se encuentra dicha cantidad.

Estos resultados tienden a corroborar lo encontrado por otros estudios de que tanto los procesos de apertura y de liberalización comercial como de relocalización registrados a partir de mediados de la década de los ochentas provocaron una disrupción en el proceso de convergencia en la economía mexicana, en virtud de que encontramos evidencia de σ-convergencia débil únicamente para el primer periodo en el que dividimos la muestra, es decir, para el periodo que va de 1970 a 1984 o hasta 1994, y no encontramos evidencia de σ-convergencia débil para el segundo periodo, que va de 1985 o 1995 a 2019, ni tampoco evidencia de este tipo de convergencia para todo el periodo analizado. De esta manera encontramos evidencia de que las entidades de la República Mexicana muestran un notable patrón de σ-divergencia en el segundo periodo, independientemente en donde se ubique el año de quiebre, en el que se dividió la muestra en contraposición con el periodo previo y de que este resultado tiende a dominar sobre la totalidad del periodo analizado

El cuadro 5 muestra los resultados de las pruebas de sigma convergencia débil aplicadas a los grupos de estados clasificados de acuerdo a los terciles como de ingreso alto, medio y bajo, tanto para todo el periodo como por periodos tomando como año de quiebre a 1995. Como se puede ver en dicho cuadro, hay evidencia de sigma convergencia débil en todos los grupos de ingreso en el primer periodo y en todo el periodo bajo estudio. No obstante, para el segundo periodo los resultados no son homogéneos ya que para los estados que se ubican como de ingreso alto hay evidencia de que sigma es fluctuante, de sigma convergencia débil para los de ingreso medio y de divergencia para los de ingreso bajo. Con fines comparativos mostramos los resultados de aplicar las pruebas a estos grupos de entidades tomando como fecha de quiebre el año de 1986, que representa el año en que México ingresó al GATT, cuyos resultados se presentan en el cuadro 6. Los resultados son prácticamente los mismos en términos cualitativos, con excepción de que en el segundo periodo, de 1986 a 2019, hay evidencia de sigma convergencia-débil para las entidades que conforman el grupo de ingreso alto, lo cual sugiere que la evidencia de divergencia encontrada para este periodo para la totalidad de las entidades consideradas se puede atribuir a la evolución de las entidades de bajo ingreso.

CUADRO 5.
Resultados de la prueba tomando a 1995 como año de quiebre para los distintos grupos de ingreso

Ingreso alto								
De 1970 a 1994			1995-2019			Todo el periodo		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{t}_{\emptyset_{nt}}$ (4)
-0.3519	-20.684	-19.480	-0.0005	-0.322	-0.304	-0.2051	-8.522	-7.762
Ingreso medio								
De 1970 a 1994			1995-2019			Todo el periodo		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{t}_{\emptyset_{nt}}$ (4)
-0.0797	-18.402	-18.083	-0.0271	-2.962	-2.832	-0.0630	-14.932	-14.124
Ingreso bajo								
De 1970 a 1994			1995-2019			Todo el periodo		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{t}_{\emptyset_{nt}}$ (4)
-0.1913	-20.479	-19.247	0.1202	9.132	8.651	-0.0406	-1.983	-1.814

Notas: Con 30 estados excluyendo Campeche y Tabasco. Los números son los rezagos incorporados en el cálculo de la varianza de Newey-West.

Las pruebas efectuadas a las entidades clasificadas por grupos de ingresos y en distintos periodos permiten identificar que grupos y en que lapsos de tiempo se encuentra ausente la convergencia. De esta manera, en el periodo posterior a la entrada en vigor del TLCAN las entidades de ingreso alto han fluctuado mientras que las de ingreso bajo han tendido a diverger, lo cual puede atribuirse a que este último grupo de entidades no se han logrado anclar a la dinámica de crecimiento que ha representado la integración comercial de México con sus principales socios comerciales como si lo han hecho otras entidades identificadas como de ingreso alto. Otra posible interpretación que pueden tener estos resultados es la posible presencia de diferentes estados estacionarios por grupos de ingreso.

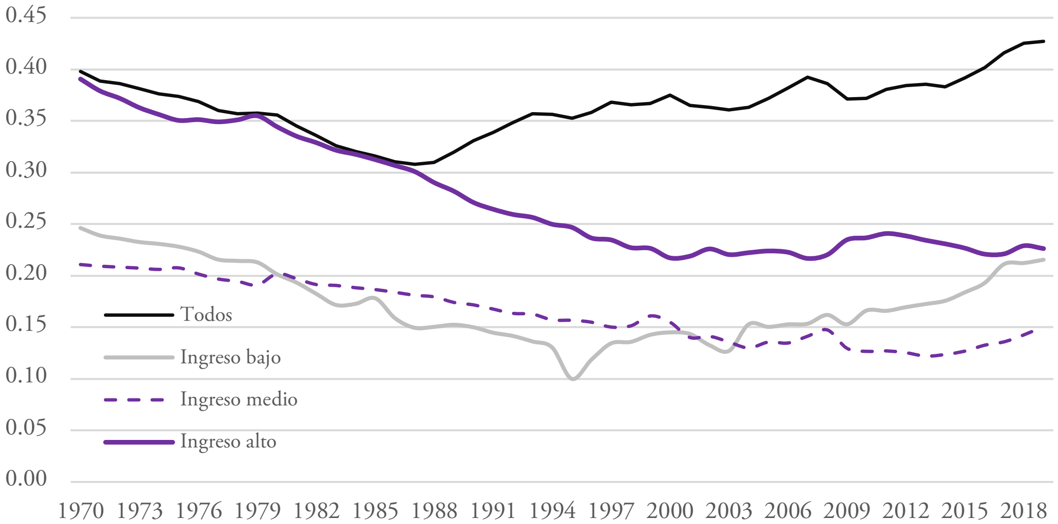
Por otro lado, con el fin de comparar que tan consistentes son los resultados obtenidos a través de la prueba empleada sigma-convergencia débil con los que se obtienen a través de la metodología sigma convencional la figura 3 muestra la evolución de este último indicador, tanto para las 30 entidades federativas analizadas como para los terciles de ingreso en que fueron agrupadas.

Cuadro 6.
Resultados de la prueba tomando a 1986 como año de quiebre para los distintos grupos de ingreso

Ingreso alto					
De 1970 a 1985			De 1986 a 2019		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)
-0.3073	-9.810	-9.746	-0.0929	-3.934	-3.529
Ingreso medio					
De 1970 a 1985			De 1986 a 2019		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)
-0.0644	-9.936	-11.440	-0.0469	-7.118	-6.688
Ingreso bajo					
De 1970 a 1985			De 1986 a 2019		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)
-0.2127	-15.304	-14.947	0.0621	4.215	3.8563

Notas: Con 30 estados excluyendo Campeche y Tabasco. Los números son los rezagos incorporados en el cálculo de la varianza de Newey-West.

Figura 3.
Convergencia sigma tradicional del PIB por habitante por grupos de entidades



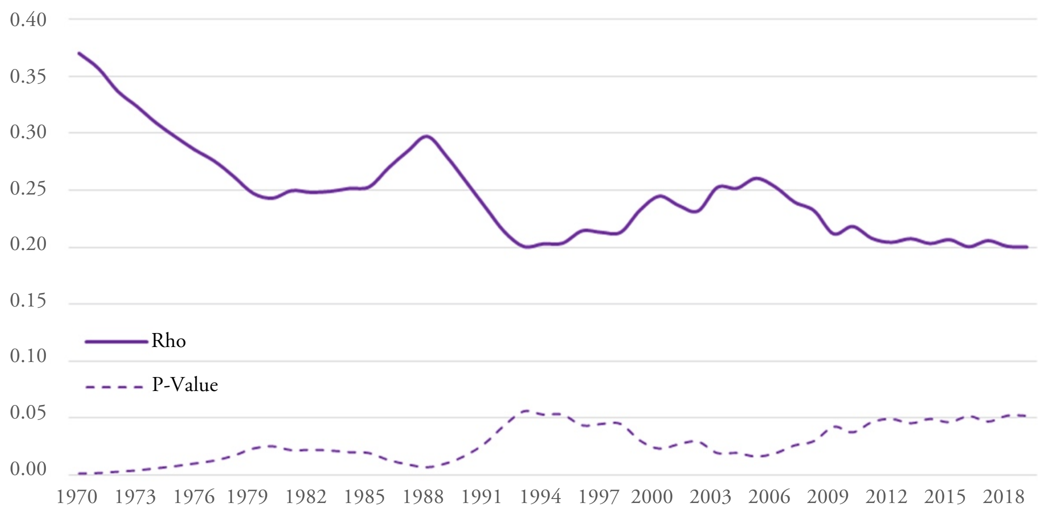
Nota: La convergencia sigma se mide como la desviación estándar del logaritmo natural del PIB por habitante; la convergencia sigma para los grupos de ingreso considera los terciles del PIB por habitante de 2019; y, no se consideraron las entidades petroleras de Campeche y Tabasco.

Como se puede ver en la figura 3 la sigma convergencia obtenida para las treinta entidades federativas muestra la conocida forma de "U", cuyo punto de quiebre se ubica en 1986, la cual es consistente con los resultados obtenidos tanto en este trabajo como en una extensa literatura que reporta convergencia para el primer periodo, hasta 1985, y divergencia para el segundo periodo. De igual forma, los resultados obtenidos con sigma-convergencia para las entidades pertenecientes a los grupos de ingreso alto, medio y bajo son consistentes con los reportados de las pruebas de sigma-convergencia débil en virtud de que los resultados de está ultima prueba muestran convergencia para los grupos de ingreso alto y medio y el análisis de sigma-convergencia tradicional muestra que la desviación estándar para estos grupos de ingreso decrece o por lo menos se mantiene estable en los últimos años de la muestra, mientras que los resultados de sigma convergencia de las entidades que conforman el grupo de bajo ingreso revelan divergencia para el segundo periodo de análisis lo cual coincide con el resultado de una sigma-convergencia tradicional creciente a partir de 1995, de hecho hasta antes de este año todas las sigma-convergencia de los tres grupos de ingreso son decrecientes. Este resultado es relevante en el sentido de que ubica la fecha de quiebre en 1995 y no en 1986 como la mayoría de los estudios tienden a ubicarla.

6. Análisis de robustez por autocorrelación espacial[2]

Con el objetivo de revisar la posibilidad de sesgo en los resultados por la presencia de autocorrelación espacial (Anselin, 1988; Lesage y Pace 2009) se propone el siguiente ejercicio de robustez. Para detectar la existencia de autocorrelación espacial se aplica el test I de Moran a el PIB por habitante entre entidades para cada año de 1970 a 2019 y como se observa en la figura 4 la correlación espacial tiende de un valor máximo de 0.37 al mínimo de 0.20. Es importante mencionar la tendencia creciente de la correlación espacial con la firma del TLCAN en 1994 (Aroca *et al*, 2005; Mendoza-González, 2021) y la permanencia en 0.20 después de la crisis económica de 2008-2009.

Figura 4.
Test I de Moran para correlación espacial del PIB por habitante entre entidades, 1970-2019



Nota: Rho es el coeficiente de correlación espacial y p-value es valor para las pruebas de significancia del test de Moran. La matriz de pesos espacial se construye con la regla queen y no se consideraron las entidades petroleras de Campeche y Tabasco.

Con el fin de eliminar el posible sesgo de autocorrelación espacial empleamos la siguiente transformación del PIB por habitante $(pibh): dpibh = pibh - \rho Wpibh$, donde ρ es el coeficiente de correlación espacial estimado con el procedimiento del test I Moran y (W) es una matriz de pesos espaciales tipo queen (W).

Los resultados de las pruebas de σ convergencia débil aplicadas a las series sin el sesgo de autocorrelación espacial (datos filtrados) confirman los resultados obtenidos por periodos a las series sin

[2] El análisis de robustez por autocorrelación espacial para la prueba de σ-convergencia débil se incorporó gracias a la recomendación de un dictaminador anónimo. Sin embargo, dado que nuestro análisis se enfoca en un solo indicador (PIB por habitante) se decidió no utilizar una metodología alternativa sobre filtros espaciales como el de Getis y Griffith (2002) debido a que fue diseñada para el análisis de regresión tipo OLS, donde se supone la existencia de dependencia espacial múltiple tanto de la variable endógena (y) como del conjunto de variables explicativas (x) y una prueba estadística espacial local basado en la descomposición asociada con vectores y raíces características del índice de Moran.

eliminar dicho sesgo (datos sin filtrar) cuando se toma como fecha de ruptura el año de 1995, en virtud de que se identifica convergencia para el primer periodo 1970-1994 y de su ausencia en el segundo periodo que va de 1995-2019. No obstante, los resultados no confirman lo reportado por las pruebas para los datos sin filtrar en el caso de las pruebas aplicadas a todo el periodo ya que hay evidencia de divergencia mientras que para los datos filtrados la evidencia es que hay variación fluctuante en virtud de que el estadístico de la prueba, con tres y cuatro rezagos, resultó no significativo como se puede apreciar en el cuadro 7.

En cuanto a los resultados de las pruebas con los datos filtrados tomando a 1985 como año de quiebre, los cuales se muestran en el cuadro 8, estos también tienden a confirmar lo encontrado por las pruebas en el sentido de que hay evidencia de σ-convergencia débil en el primer periodo y de que no hay evidencia de este tipo de convergencia en el segundo periodo.

CUADRO 7.
Resultados de la prueba con los datos filtrados tomando a 1995 como año de quiebre

De 1970 a 1994			1995-2019			Todo el periodo		
$\hat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{t}_{\emptyset_{nt}}$ (4)
-0.7550	-6.1049	-5.5696	0.1633	3.6675	3.5958	-0.1145	-1.5368	-1.4167

Notas: Con 30 estados excluyendo Campeche y Tabasco. Los números son los rezagos incorporados en el cálculo de la varianza de Newey-West.

CUADRO 8.
Resultados de la prueba con los datos filtrados tomando a 1985 como año de quiebre

Todos los estados					
De 1970 a 1984			De 1985 a 2019		
$\hat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)
-1.3863	-13.0530	-12.4365	0.1872	7.7816	7.5033

Notas: Con 30 estados excluyendo Campeche y Tabasco. Los números son los rezagos incorporados en el cálculo de la varianza de Newey-West.

En lo que respecta a los resultados de las pruebas por grupos de ingreso para todo el periodo y para distintos periodos con los datos filtrados, cuyos resultados se presentan en los cuadros 9 y 10, permiten confirmar los hallazgos encontrados con los datos sin filtrar, con excepción de las entidades que conforman el grupo de "ingreso bajo" en el segundo periodo tomando a 1985 como año de quiebre ya que con los datos filtrados se encuentra evidencia de σ-convergencia débil, lo cual no es posible inferir con los datos sin filtrar para las entidades de ingreso bajo en este periodo.

De esta manera, los resultados de las pruebas aplicadas a grupos de ingresos y por periodos, permiten inferir procesos de convergencia por este tipo de grupos, lo cual implica procesos de divergencia cada vez mayor para todas las entidades, generando segregación económica que también debe ser motivo de análisis.

CUADRO 9.
Resultados de la prueba con los datos filtrados tomando a 1995 como año de quiebre para los distintos grupos de ingreso

Ingreso alto								
De 1970 a 1994			1995-2019			Todo el periodo		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{t}_{\emptyset_{nt}}$ (4)
-0.8697	-14.647	-13.960	-0.0211	-1.117	-1.070	-0.4379	-7.673	-7.050
Ingreso medio								
De 1970 a 1994			1995-2019			Todo el periodo		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{t}_{\emptyset_{nt}}$ (4)
-0.3055	-11.784	-10.828	-0.0402	-2.662	-2.557	-0.1640	-8.9564	-8.3082
Ingreso bajo								
De 1970 a 1994			1995-2019			Todo el periodo		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (3)	$\hat{t}_{\emptyset_{nt}}$ (4)
-0.8329	-11.133	-10.226	0.0004	1.716	1.623	-0.3125	-5.109	-4.696

Notas: Con 30 estados excluyendo Campeche y Tabasco. Los números son los rezagos incorporados en el cálculo de la varianza de Newey-West.

CUADRO 10.
Resultados de la prueba con los datos filtrados tomando a 1985 como año de quiebre para los distintos grupos de ingreso

Ingreso alto					
De 1970 a 1984			De 1985 a 2019		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)
-1.081	-8.515	-8.270	-0.2000	-4.188	-3.753
Ingreso medio					
De 1970 a 1984			De 1985 a 2019		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)
-0.4243	-11.019	-10.739	-0.0908	-5.681	-6.159
Ingreso bajo					
De 1970 a 1984			De 1985 a 2019		
$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)	$\widehat{\emptyset}_{nt}$ x 100	$\hat{t}_{\emptyset_{nt}}$ (2)	$\hat{t}_{\emptyset_{nt}}$ (3)
-0.0123	-13.384	-12.797	-0.0047	-1.921	-1.780

Notas: Con 30 estados excluyendo Campeche y Tabasco. Los números son los rezagos incorporados en el cálculo de la varianza de Newey-West.

7. Conclusiones

La cuestión de cuáles han sido los efectos de la liberalización comercial y de manera particular el impacto que ha tenido sobre la desigualdad económica entre los estados mexicanos se sigue debatiendo hasta nuestros días, German-Soto y Escobedo (2011).

En este contexto, una de las hipótesis sobre las que se ha centrado la mayoría de los trabajos empíricos sobre convergencia en México es la de probar si a mediados de la década de los ochentas se registró un quiebre en el patrón de crecimiento de las regiones en México, ya que la mayoría de los estudios que se han efectuado estableciendo esa periodización han encontrado evidencia de convergencia en periodos previos a esa fecha a nivel de estados mientras que por el contrario, la evidencia empírica no favorece dicha hipótesis en periodos posteriores a la década de los ochentas, lo cual se atribuye a un quiebre o una ruptura asociada a diversos factores como son el proceso de apertura comercial, la relocalización de grandes industrias y la implementación de diversas reformas. Algunos investigadores como Chiquiar (2005) sostienen que la evidencia en contra de la hipótesis de convergencia reportada para el segundo periodo no necesariamente implica un rechazo del modelo de crecimiento neoclásico.

En este trabajo brindamos evidencia empírica a través de la prueba σ-convergencia débil sobre si la liberalización comercial, independientemente de donde se ubique ya sea en 1986 o en 1995, promovió la convergencia económica a nivel de entidades federativas en México. Para tal fin, dividimos la muestra en dos periodos. El primero de ellos corresponde al periodo previo a la entrada de México en el GATT que va de 1970 a 1985, o bien de 1970 a 1994, dado que en este último año entró en vigor el tratado de libre comercio en México, en tanto que el segundo se puede ubicar de 1986 a 2019, o bien de 1995 a 2019, dependiendo de donde se ubique el año de quiebre, caracterizado principalmente por un periodo de liberalización comercial, así como de diversas reformas estructurales.

Esta metodología es útil para examinar convergencia en series asintóticamente estacionarias o débilmente dependientes y determinar si existe una débil convergencia general entre las unidades investigadas, la cual fue propuesta recientemente por Kong *et al.* (2019).

Los resultados muestran evidencia de σ-convergencia débil para el primer periodo para la totalidad de las entidades federativas consideradas, lo cual tiende a corroborar lo encontrado por la mayoría de los estudios sobre convergencia regional en México y no encontramos evidencia de σ-convergencia débil en el segundo periodo, lo cual parece dominar el resultado para todo el periodo en su conjunto.

Sin embargo, para los grupos formados como de ingreso alto, medio y bajo de acuerdo a los terciles encontramos evidencia de σ-convergencia débil en ambos periodos para los dos primeros, independientemente de donde se ubique la fecha de quiebre, mientras que para el grupo de ingreso bajo únicamente encontramos evidencia de σ-convergencia débil en el primer periodo y de divergencia para el segundo periodo, resultado que sugiere que la ausencia de convergencia reportada para la totalidad de las entidades federativas consideradas para este periodo puede atrubuirse al comportamiento de entidades que conforman el grupo de ingreso bajo. Estos resultados son consistentes con los obtenidos por el análisis de sigma-convergencia tradicional tanto a nivel agregado como para los grupos clasificados de acuerdo a su nivel de ingreso. Los resultados de las pruebas de robustez por autocorrelación espacial obtenidos permiten confirmar los hallazgos obtenidos con los datos sin ajustar por este concepto. De lo que se desprende que la prueba es lo suficientemente robusta aún sin considerar la posible autocorrelación espacial que pueda estar presente en este tipo de datos.

Por otro lado, el análisis de σ-convergencia tradicional efectuado por terciles, permite identificar que la fecha del punto de inflexión para este grupo es muy cercana al año de 1995 a diferencia de la fecha en la que se registra dicho punto para la totalidad de las entidades federativas, lo cual amerita una mayor investigación con datos desagregados que permita establecer las razones de este comportamiento en las entidades que conforman el tercil del ingreso más bajo.

En virtud de que el análisis efectuado sobre la convergencia en México en este trabajo se basa en una sola variable, el PIB per cápita por entidad federativa, es difícil establecer lineamientos de política económica que se orienten a reducir estas discrepancias y que permitan que las entidades con ingresos más bajos tiendan a converger con las de mayor niveles de ingresos. No obstante, debido a que el análisis se lleva a cabo con distintos periodos es posible inferir algunas sugerencias de política económica que se derivan de las condiciones económicas que prevalecieron en el primer periodo, en el cual encontramos evidencia de sigma-convergencia débil, caracterizado por una mayor intervención estatal. En este contexto, entre las recomendaciones de política económica que se infieren de nuestros resultados se encuentran que el gobierno debe atender las regiones con mayores niveles de atraso invirtiendo en el desarrollo de la infraestructura que se requiere, como son carreteras, puertos, vías férreas, telecomunicaciones, etc., para alentar mayores inversiones privadas en estos estados y de esta manera generar mayor crecimiento económico, mayores y mejores empleos que tiendan a abatir las enormes desigualdades que se encuentran presentes con respecto de las entidades con mayores niveles de ingreso per cápita. De igual forma, los gobiernos federal y local deben realizar esfuerzos adicionales por ampliar y elevar los niveles educativos en las entidades con ingreso per cápita más bajo. En este sentido, el gobierno federal ha emprendido en fechas recientes algunos proyectos de inversión de infraestructura en las regiones sur y sureste de México, respectivamente, los cuales se espera contribuyan con un mayor dinamismo no sólo de la región sino de todo el país, sin embargo, sus efectos serán de mediano y de largo plazo. Por el contario, reducir la intervención estatal y dejar que el mercado por si mismo resuelva estas disparidades a través de una asignación efciente de los recursos no es garantía de lograr este objetivo, como lo demuestra la experiencia reciente en las últimas décadas en las cuales se redujo considerablemente la participación del estado en la economía que coincide con el segundo periodo en el cual no se encuentra evidencia de σ-convergencia débil.

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ANEXO

Cuadro 1A.
Prueba LM de Raíz Unitaria con rupturas en el nivel (*Modelo A*)

	Con una ruptura			Con dos rupturas		
	Estad.	*p*	Breaks	Estad.	*p*	Breaks
AGU	-4.309	(7)	1998	-5.381	(7)	1980,1998
BCN	-4.516	(3)	2006	-6.288	(7)	1997,2007
BCS	-5.127	(3)	1980	-5.506	(3)	1980,2007
CAM	-3.600	(7)	1991	-4.479	(8)	1990,1999
COA	-3.064	(7)	2001	-4.632	(0)	1984,1996
COL	-3.796	(3)	1996	-6.229	(4)	1988,2002
CHP	-4.002	(3)	1980	-6.031	(8)	1986,2009
CHH	-3.801	(8)	1996	-5.069	(7)	1987,2000
CMX	-2.901	(2)	1996	-5.155	(7)	1987,2001

CUADRO 1A. CONT.
Prueba LM de Raíz Unitaria con rupturas en el nivel (*Modelo A*)

	Con una ruptura			Con dos rupturas		
	Estad.	*p*	Breaks	Estad.	*p*	Breaks
DUR	-3.740	(1)	1980	-5.757	(3)	1980,2008
GUA	-4.323	(6)	1985	-5.535	(8)	1987,2004
GRO	-3.436	(1)	1999	-4.904	(7)	1982,1996
HID	-4.092	(2)	1991	-5.938	(2)	1991,2012
JAL	-3.600	(1)	2004	-5.055	(8)	1991,2001
MEX	-3.387	(1)	1993	-5.355	(1)	1993,2009
MIC	-4.894	(3)	1986	-5.683	(3)	1983,1988
MOR	-4.768	(4)	1989	-6.544	(4)	1988,2011
NAY	-5.231	(1)	2000	-5.725	(7)	1993,2002
NLE	-3.029	(5)	1995	-5.199	(8)	1985,2004
OAX	-3.251	(1)	1988	-4.908	(2)	1987,2006
PUE	-4.003	(7)	1989	-5.446	(2)	1980,1990
QUE	-3.882	(1)	1993	-5.117	(7)	1984,1995
ROO	-4.861	(3)	2003	-6.044	(3)	1982,1996
SLP	-3.312	(6)	2012	-4.982	(7)	1984,2002
SIN	-3.740	(8)	1994	-4.970	(4)	1980,1996
SON	-3.728	(8)	1981	-4.984	(8)	1980,2005
TAB	-3.971	(4)	1994	-6.418	(6)	1994,2007
TAM	-3.513	(8)	2001	-5.272	(6)	1992,2007
TLA	-3.725	(1)	1987	-4.753	(2)	1988,2003
VER	-4.269	(3)	2007	-4.497	(1)	1995,2008
YUC	-4.714	(7)	1997	-6.566	(7)	1998,2008
ZAC	-4.684	(7)	2006	-5.657	(8)	1989,2006
Panel	-19.103	(7)	2006	-32.575	(8)	1989,2006

Notas: Los números entre paréntesis son los rezagos incorporados en cada prueba.
Fuente: Elaboración propia.

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Articles

The adjustment of primary schools to shrinking populations: a spatial modelling approach

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Abstract:

The adjustment of services of general interest to ageing and shrinking populations is a significant challenge in many European regions. This article analyses the response in the number of primary schools to changes in the student population in the municipalities of mainland Portugal between 2007 and 2016. It focuses on the time lag of this adjustment, the territorial factors that influence it and the role of spatial spill-over effects. The main finding is that the relationship between the number of schools and the number of students is not straightforward and can only be understood considering the broader geographic contexts and spatial dependence structures.

Keywords: Population growth; primary schools; spatial modelling; Portugal; spatial dependence.

JEL Classification: R53; R58.

El ajuste de las escuelas primarias a la disminución de la población: un enfoque de modelado espacial

Resumen:

La adaptación de los servicios de interés general al envejecimiento y la disminución de la población es un reto importante en muchas regiones europeas. Este artículo analiza la respuesta del número de escuelas primarias a los cambios en la población estudiantil en los municipios de Portugal continental para el período de 2007-2016. Se centra en el desfase temporal de este ajuste, los factores territoriales que influyen en él y el papel de efectos de contagio espaciales. El principal hallazgo es que la relación entre el número de escuelas y el número de estudiantes no es directa y solo puede entenderse considerando los contextos geográficos más amplios y las estructuras de dependencia espacial.

Palabras clave: Crecimiento poblacional; escuelas primarias; modelado espacial; Portugal; dependencia espacial.

Clasificación JEL: R53; R58.

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1. Introduction

Sustained low fertility rates have led to shrinking and ageing population in many European countries (EUROSTAT, 2020), which is projected to continue in the next decades, considering the inherited age structures (Davoudi et al., 2010; Lutz et al., 2003) and the limited rebound of fertility rates due to postponement (Luci & Thévenon, 2014; Myrskylä et al., 2013). These processes pose major policy challenges, affecting territories' quality of life in many ways: the presence of vacant housing (Bontje, 2004; Couch & Cocks, 2013; Haase et al., 2013) or brownfields (Jaroszewska, 2019); underused infrastructures (Hollander et al., 2009); the emigration of younger and more qualified age groups (Wolff & Wiechmann, 2018); or image problems (Johnson et al., 2014).

This stresses the importance of local policy responses to decline, namely regarding the different ways local decision-makers react to contracting populations in the provision of services. While it is often assumed that the best policy response to shrinkage is simply "rightsizing" the infrastructure or services (Hollander et al., 2009; Mallach, 2017), which normally implies concentrating them in the more central parts of the territory (Lang, 2012), there are many possible options, which include trivializing it, countering it, accepting it, or utilizing it (Hospers, 2014). There are also very different understandings regarding the minimum acceptable standards that service providers should follow or the right balance between the conflicting goals of maximizing this provision while minimizing costs (Wiechmann & Pallagst, 2012).

In this context, this article analyses the reaction of the number of primary schools to changes in the number of students in the municipalities of mainland Portugal, between 2007 and 2016 (it must be noted that primary education in Portugal refers exclusively to the first cycle of primary education, corresponding to the first four years of level one of the International Standard Classification of Education – EUROSTAT, 2022). Primary schools are an interesting subject for this type of analysis since they are one of the most important services of general interest that are provided at the local scale (Autti & Hyry-Beihammer, 2014; Kearns et al., 2009) and have recently been witnessing a significant number of closures in many European countries (Barakat, 2015; Elshof et al., 2015; Slee & Miller, 2015). In Portugal, in the last decades, there was a very significant decline in the number of public primary schools, obeying a "rationalizing" approach that is assumed by much of the national school planning guidelines (Marques, Tufail, et al., 2021; Wolf et al., 2018) – private primary schools were excluded from this analysis since their opening or closure follows a strict economic rationale and they do not provide any significant degree of territorial coverage, essentially depending on the presence of large, well-off, student populations.

Nonetheless, it has also been noted that, at the local scale, there are many possible responses to declining student populations and that the outcome often results from a negotiation in a multilevel governance framework, where goals and interests are articulated at different scales and in different policy arenas (Cordeiro et al., 2012). In this sense, school planning is the outcome of local micro regulation as much as institutional regulation at the macro scale (Barroso, 2006), where municipalities can implement different strategies (Cordeiro et al., 2014; Wolf et al., 2021). And, while being partly a response to declining student populations, decisions regarding school closures have also been shown to be sensitive to socioeconomic circumstances, cultural and racial factors (Lee & Lubienski, 2017; Lipman, 2009), or student performance (Engberg et al., 2012; Steinberg & MacDonald, 2019). This is also true for the general level of accessibility to primary schools, where socioeconomic factors play a role, in particular leading to higher access for the better-off (Macintyre et al., 2008; Marques, Wolf, et al., 2021). Moreover, the number of schools is influenced by population density, with rural schools being much more susceptible to decreasing student numbers and, thus, closing disproportionally (Amcoff, 2012; Autti & Hyry-Beihammer, 2014; Sørensen et al., 2021). This means that the response of primary school provision to shrinking populations is in no way deterministic and that socioeconomic and territorial factors must be considered jointly with declining (or, occasionally, growing) student numbers.

Accordingly, this article considers the variation in the number of primary schools as a function of the number of students and other explanatory variables, taking into consideration the different factors considered relevant in the literature for explaining the provision of primary schools at the local scale. These variables include population density, as an indicator for the type of settlement, the income of the employed, as indicators of the economic status, and fertility, migrations, and employment, as indicators for locations' attractiveness and general growth perspectives (as was noted by Marques, Tufail, et al., 2021, territories with higher migration and fertility rates tend to have more positive evolutions in the number of schools).

Two types of analyses were made. First, a time series approach is used to identify the time lag with which changes in the number of students lead to school adjustments. Second, a cross-section model that relates changes in the number of schools over the whole period. In both analyses spatial dependence was modelled, taking into consideration that student enrollment does not follow strict administrative boundaries and also that these kinds of phenomena tend to follow geographic patterns. The remaining article is organized into two sections, where the first one presents the data, the methodology and discusses the results, and the second one presents the conclusions.

2. Data and empirical analysis

2.1. Data

The main variables for this study are the number of primary schools (PS) and the number of students (Students), which were retrieved from the DGEED (*Direção-Geral de Estatísticas da Educação e Ciência* datasets available at its website https://www.dgeec.mec.pt/np4/408/). The variables expressing socioeconomic and territorial factors were obtained from the National Statistical Institute and include: residents per km^2 (PopDens); average income of the employed (AIncome) – total income was not available at the local scale; net migration rates (MigRate), expressing the ratio of the difference between immigrants and emigrants and the inhabitants of a given territory (the yearly migration rates are estimated by the National Statistical Institute, taking into consideration the deaths and births, registered migrants and employment data, among other variables); employment in private firms (Empl), meaning the people employed in the private sector (the total employment and employment rate also includes people employed in the public sector, but were not available at the municipal level for the whole period); and total fertility rates (TFertRate), expressing the number of children that a women would have if she were to keep the current age specific fertility rates throughout her reproductive life. All variables were collected for the 278 municipalities of mainland Portugal, from 2007 to 2016 (the decade for which we have complete values for all variables in the dataset).

For modelling purposes, some original variables were transformed into more meaningful variables, using Neper's logarithms to obtain less asymmetric distributions (positive variables which include a caps 'L' in their names (e.g. LAIncome_AVG, DLEmp_AVG) and, in some cases, calculating the differences between the logarithm (if used) of the value in 2016 and the logarithm of the value in 2007. Otherwise, the average values (in logarithms or not) were calculated between 2007 and 2016 (in sections 2.2. and 2.3 the specific transformations made for each variable for each model are stated). Table 1 presents descriptive statistics for the main transformed variables used in this study.

In Figure 1 it is possible to observe that, in the considered period, the main trend is for primary school closures to largely exceed the opening of new schools and, also, that the municipalities which witness a sharper decrease in the number of primary schools tend to be located in the coastal regions in the North and Centre of the country (Figure 1C). On the other hand, there still is a positive trend in the number of Primary Schools in some municipalities in the centre of Portugal.

In the following subsections, two regression approaches for studying the changes that occur in the number of primary schools are analysed and discussed. The first considers a spatial-temporal model estimated as an SDEM (spatial Durbin error model), to find the temporal lag which better helps to explain the dependent variable. The second approach takes into consideration that the explanatory variables do not have an immediate impact on the explained variable. Therefore, it analyses the changes in the number of primary schools and their relationships with other variables for the whole period for which data is available.

TABLE 1.
Descriptive statistics for the variables for mainland Portuguese municipalities in 2016

Variable	Mean	Std	Min	Median	Max
PS	14.270	20.385	1.000	7.000	186.000
TFertRate	1.240	0.256	0.588	1.213	2.242
MigRate	-0.131	0.396	-0.820	-0.210	1.462
AIncome	969.541	190.369	704.128	926.678	2323.088
Emp	11656.640	34057.507	378.000	3682.500	501832.000
PopDens	306.698	854.746	4.176	67.183	7490.908
NStudents	1364.388	2521.186	53.000	481.000	26609.000

Note: The variables are the number of primary schools (PS); the total fertility rate in the period (TFertRate); the net migration rate (MigRate); the average income (AIncome); the employment in private firms (Emp); the populational density (PopDens); and the number of schools' students (NStudents).

FIGURE 1.
Cartograms of key variables

a) N. of Primary Schools (2016) **b) Pop. Density (2016; per km2)**

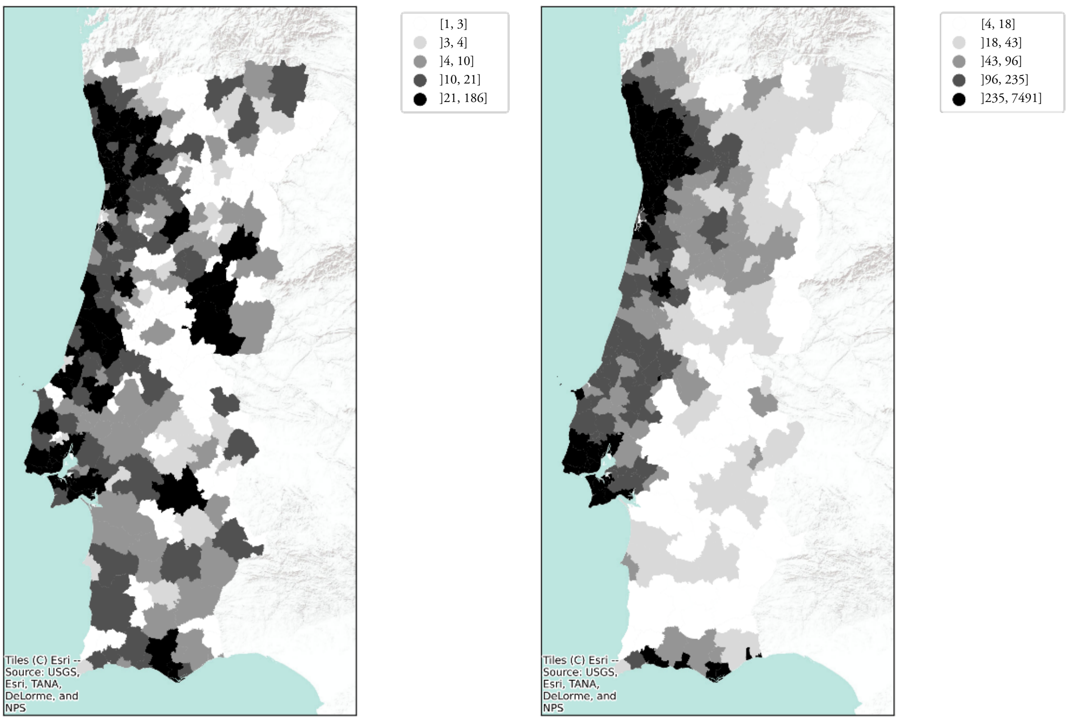
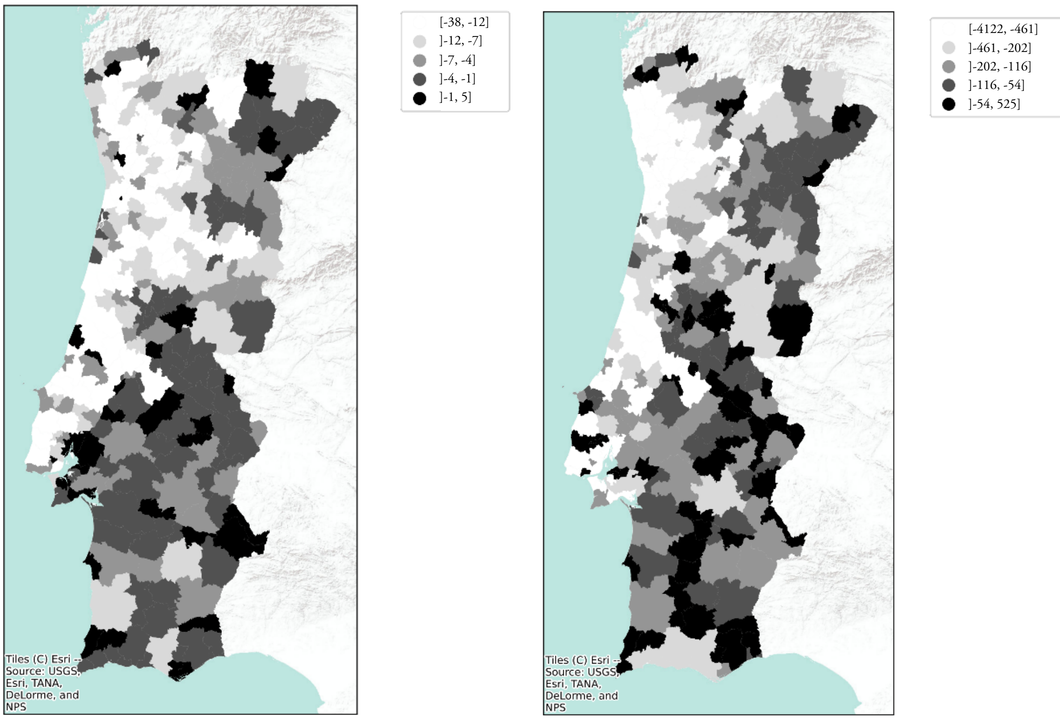


FIGURE 1. CONT.
Cartograms of key variables

c) Difference in the number of Schools (2007-2016)

d) Difference of the P. S. Students (2007-2016)



Note: A. Number of Primary Schools in 2016; B. Population Density (per km^2) in 2016; C. Difference of number of Schools from 2007 to 2016; D. Difference of the Students enrolled in primary school from 2007 to 2016. The range of colours means the variation of values for each variable from the minimum (clearest) to the maximum (darkest) in quintiles.

2.2. Spatio-temporal model

The analysis of the time lag in which changes in the number of students lead to changes in the number of schools was developed with an SDEM (MODEL1), where the explanatory variable was the difference in the number of public primary schools in 2007 and 2016 (DPS). Further explanatory variables were: the average total fertility rate in the period (TFertRate_AVG); the average migration rate in the period (MigRate_AVG); the average of the logarithm of average income in the period (LAIncome_AVG); the average of the differences (in consecutive years) of the logarithm of employment in private firms (DLEmp_AVG); the average of the logarithm of populational density (LPopDens_AVG) and the differences (in consecutive years) of the logarithm of the number of schools' students (DLNStudents). Since there is a certain degree of mobility between pupils of different municipalities, meaning that the decision to open or close a school can be expected to be influenced by the spatial spillover effect, the spatial lag of changes in the number of students was also included, at level, and with 9 temporal lags, using queen contiguity for the spatial weight matrix. The spatial lag was also applied to the residuals (associated with lambda coefficient).

Model 1 - Spatial Durbin Error Model:

$$DPS = \alpha + \sum_{j=1}^{5} \beta_j X_j + \sum_{t=0}^{9} (\theta_t DLNStudents_{-t} + \rho_t W\, DLNStudents_{-t}) + u \qquad (1)$$

where:

$$X = \{TFertRate\_AVG, MigRate\_AVG, LAIncome\_AVG, DLEmp\_AVG, LPopDens\_AVG\};$$

$$u = \lambda\, W\, u + \varepsilon,$$

with $\varepsilon_i \sim iid(0, \sigma^2)$, $i = 1, \ldots, 278$

Interestingly, these results reveal few coefficients that are statistically different from zero for an error type I of 0.05 or 0.1 (Table 2). For all mainland municipalities, only the coefficients associated with the variables DLEmp_AVG, LPopDens_AVG, w_DLNStudents_1, w_DLNStudents_3, and w_DLNStudents_7 can be considered statistically different from zero (with a p-value < 0.1).

TABLE 2.
Spatio-temporal SDEM model to study the changes in the number of schools from 2007 to 2016

Variable	Coefficient	z-statistic	p-value
CONSTANT	0.317	0.115	0.909
TFertRate_AVG	0.272	0.641	0.521
MigRate_AVG	0.151	1.115	0.265
LAIncome_AVG	0.028	0.070	0.945
DLEmp_AVG**	7.271	2.850	0.004
LPopDens_AVG**	-0.170	-4.007	0.000
DLNStudents_0	0.406	0.382	0.703
DLNStudents_1	0.412	0.355	0.723
DLNStudents_2	0.571	0.462	0.644
DLNStudents_3	-0.301	-0.246	0.806
DLNStudents_4	-1.305	-1.124	0.261
DLNStudents_5	1.147	0.925	0.355
DLNStudents_6	-0.847	-0.623	0.533
DLNStudents_7	-0.254	-0.215	0.830
DLNStudents_8	-0.100	-0.105	0.916
DLNStudents_9	-0.374	-0.417	0.677
w_DLNStudents_0	0.410	0.815	0.415
w_DLNStudents_1*	-1.043	-1.933	0.053
w_DLNStudents_2	0.454	0.852	0.394
w_DLNStudents_3**	1.539	3.082	0.002
w_DLNStudents_4	0.081	0.152	0.879
w_DLNStudents_5	-0.634	-1.260	0.208
w_DLNStudents_6	-0.327	-0.538	0.591
w_DLNStudents_7**	1.515	2.641	0.008
w_DLNStudents_8	0.243	0.669	0.503
w_DLNStudents_9	-0.324	-0.912	0.362
lambda	0.005	0.251	0.802

Note: * significant p-value < 0.1; ** significant p-value < 0.05

The positive coefficient of the variable DLEmp_AVG is in line with the literature, considering that more urban municipalities with higher employment growth are likely to witness fewer school closures than more rural and less attractive municipalities (Slee & Miller, 2015). However, the significant coefficients also reveal unexpected results. The negative coefficient for LPopDens_AVG, for example, is contrary to previous findings, which considered that most school closures occur in rural settings (Amcoff, 2012; Autti & Hyry-Beihammer, 2014; Sørensen et al., 2021). Most importantly, the number of primary schools would be expected to respond to changes in the number of students in each municipality, and not only to changes in the number of students of the geographic neighbours.

To further complicate the analysis, the spatially lagged coefficients of time lags 3 and 7 are positive, while time lag 1 is negative. This means that there tends to be a contagion effect associated with the enrolment of pupils in neighbouring municipalities in the short and medium-term, while municipalities in geographic locations where there was growth some years ago are likely to have witnessed a consolidation of the school network since then.

While these findings show the many different policy responses to shrinking student populations mentioned in the literature (Cordeiro et al., 2012; Wolf et al., 2018), they also show signs that these responses do not occur in short periods, but are more a consequence of medium to long term, cumulative, trends. This justifies the approach followed in the next section, where a cross-section model was applied to the whole period.

2.3. Cross-section model

For the cross-section analysis, we used the changes from 2007 to 2016 in the number of schools (DPS), the number of students (DLNStudents), and the employment by private firms (DLEmp). The spatial lag was introduced only for the variable DLNStudents and the remaining variables were considered with their average values from 2007 to 2016. The White robust consistent estimation was used for the variance matrix of coefficients.

This model can be formulated as:

Model 2 - Spatial Lag model:

$$DPS = \alpha + \sum_{j=1}^{3} \beta_j X_j + \rho\ DLNStudents + \theta\ WDLNStudents + u \qquad (2)$$

Where:

$X = \{MigRate\_AVG, DLEmp, LPopDens\_AVG\}$;

$u \sim N(0, \sigma^2 I)$

A specification of this model without the spatial component was also applied (Model 3). The Outputs in Table 3 show the cross-section coefficients' statistics for both models (with and without the spatial lagged independent variable W DLNStudents). The output produced originally with all variables in python showed that residuals cannot be considered normal with the Jarque-Bera statistic (p-value < 0.1). Moreover, the model presented symptoms of multicollinearity (Multicollinearity Condition Number > 10). On the other hand, if the model is reduced to the statistically significant coefficients with a significance of 10%, this solves the problem of multicollinearity (Multicollinearity Condition Number = 8.833).

Relatively to the Ordinary Least Squares model, Model 2 presents a lower AIC (Akaike info criterion – 1790.042 and 1841.926), a lower log-likelihood (-889.021 and -915.963), and a higher R^2 (0.328 and 0.184). The former model reveals a positive impact of the percentual changes of employment in private firms (DLEmp_AVG) to variations in the number of primary schools, in line with the argument made by Slee and Miller (2015) that the major factor in school closures is the inability of some areas to provide work for families within a commuting distance. The spatial lagged variable DLNStudents is positive, meaning that the variation in the number of students in the neighbouring municipalities has a positive influence on the variation in the number of primary schools of a given municipality (Table 3).

TABLE 3.
Estimation results for cross-section model

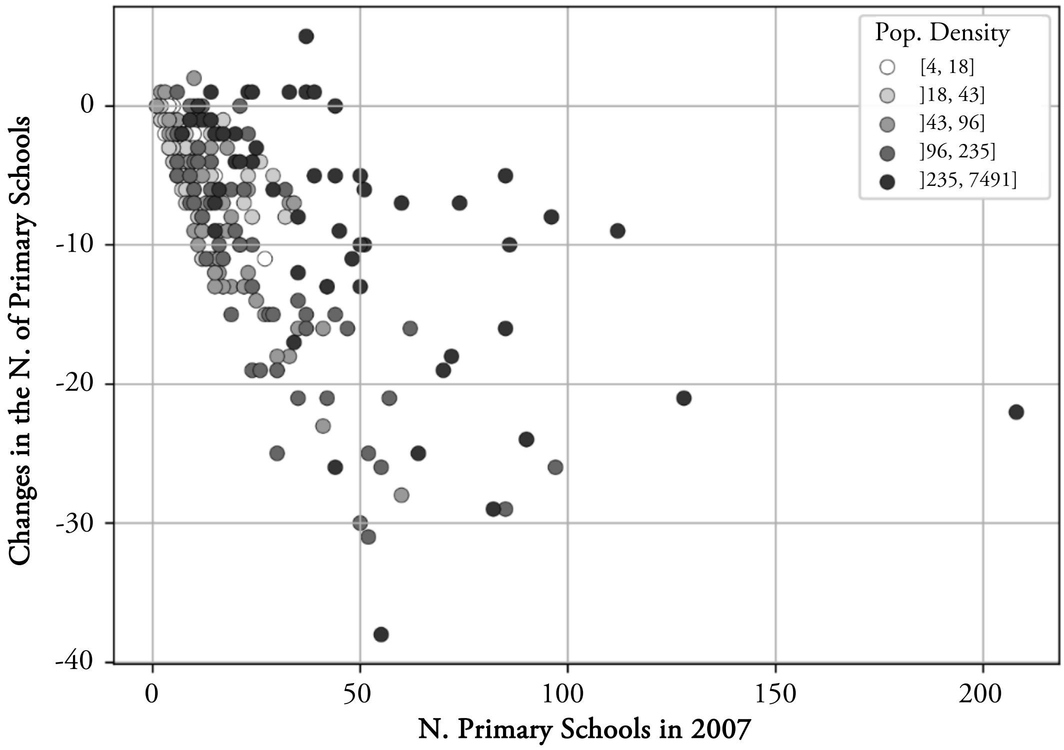
	Ordinary Least Squares Estimation (Model 3)	**Spatial Lag Model (Model 2)**
Variable	**Coefficient**	
Constant	4.318 (2.993)	8.975 (5.871)
MigRate_AVG	1.702 (1.728)*	0.017 (0.017)
DLEmp	2.342 (1.320)	2.930 (1.732)*
LPopDens_AVG	-1.908 (-6.456)**	-2.138 (-7.639)**
DLNStudents	9.370 (3.702)**	1.196 (0.485)
Lagrange Multiplier (lag)	**79.270 (0.000)**	
Robust LM (lag)	74.807 (0.000)	
Lagrange Multiplier (error)	**22.592 (0.000)**	
Robust LM (error)	18.129 (0.000)	
Lagrange Multiplier	**97.399 (0.000)**	
Number of Observations	**278**	
R-squared	0.184	0.328
Log-likelihood	-915.963	-889.021
Akaike info criterion	1841.926	1790.042
Lag coefficient (θ)		3.864 (6.815)**

Note: * significant p-value < 0.1; ** significant p-value < 0.05; estimated with white standard errors.

This stresses the spatial nature of this kind of process, and the need to consider the broader structures of spatial dependence for understanding variations in the number of schools at the local scale (the spatial autocorrelation in school demand has already been observed by Torres and Prior, 2015, while the spatial autocorrelation in demographic variables has been analysed quite extensively by authors such as Carioli et al., 2021, or Castro et al., 2015).

But most importantly, and counterintuitively, the evolution of the number of students and the average population density have no statistically significant relationship with changes in the number of schools (as was noted, low-density, remote, municipalities would be expected to be subject to more school closures). The most plausible explanation for these findings is that in many municipalities the lower threshold of service provision is being approached, considering the many years of school consolidation and the legal obligation to provide this service at a reasonable distance. In other words, some municipalities with very negative values in the number of students cannot close more schools, and most of the more recent consolidation is occurring in municipalities with a higher number of schools. This assumption seems to be confirmed by Figure 2, which shows a negative correlation between the number of primary schools in a municipality, and the evolution of the number of primary schools.

FIGURE 2.
The number of Primary Schools in 2007 and Changes in the Number of Primary Schools from 2007 to 2016 for the mainland Portuguese municipalities



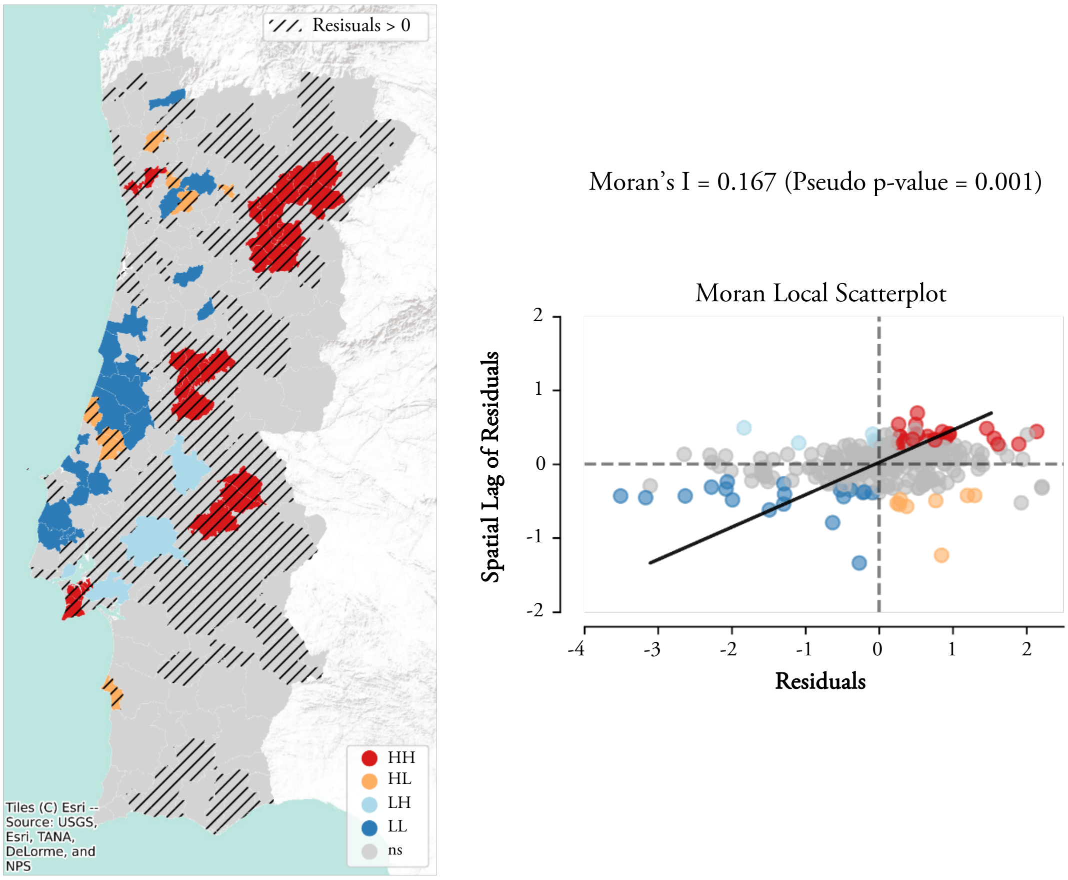
Note: Each coloured ball corresponds to the quintile interval to population density in 2016 from the less dense municipalities (clearer) to the denser municipalities (darker).

2.4. Analysis of the residuals' spatial autocorrelation

Considering that the error term of the model does not follow a normal distribution and that there is a known spatial dimension in the changes in the number of primary schools at the municipal level, it is worth analysing the spatial autocorrelation in the model's residuals. And the Moran's I shows a significant spatial autocorrelation of 0.167 (pseudo-p-value < 0.001) between the residuals of the considered municipalities and their geographic neighbours, using a queen contiguity matrix.

At the local scale, and considering the Local Indicator of Spatial Association (LISA) as defined by Anselin (1995), significant clusters of municipalities with high residuals can mainly be observed in lower-density areas in the northeast and the centre of the country, although a positive cluster is also located in the south of Lisbon, at the Setúbal Peninsula (Figure 1). Significant spatial associations with low residuals mainly occur in the more densely populated coastal areas. This adds evidence to the possibility, discussed in the previous section, that many municipalities have already reached their lower limit in school closures since the more remote and lower-density territories in the interior tend to have a more positive evolution in the number of primary schools than would be expected by their demographic and socioeconomic characteristics.

FIGURE 3.
LISA Cluster of residuals at left. Moran Local Scatterplot at right



Note: [///] means municipalities with dependent variable values greater than estimated values, considering a significance of 0.05. HH means significant clustering of high with high values, HL high with low, LH low with high, and LL low with low; ns means non-significant values.

3. CONCLUSIONS

Drawing on previous work relating to the way the number of schools is adjusted to the number of students at the local scale (Cordeiro et al., 2014; Marques, Tufail, et al., 2021), this article contributes to understanding the time lag of this adjustment, as well as the different factors and territorial contexts that are relevant for this relationship, through a spatio-temporal and a cross-section spatial error model.

The first major finding of this approach is that the decisions to open or close schools cannot be understood as a consequence of short- or medium-term fluctuations in the number of students, but are the outcome of long-term, multidimensional, processes.

The second finding is that, in each municipality, the number of schools has no statistically significant relationship with the changes that occur in the number of students, but there is a significant relationship between changes in the number of schools and changes in the number of students in the geographic neighbours of the municipalities. The spatial structure in these processes is also visible when considering the residuals of the second model, which show that the tendency for closing more or fewer schools than is estimated by the model follows geographic patterns.

The third finding, which is a consequence of the previous one, is that spatial density has a negative relation with the changes that occur in the number of schools. As was discussed, in declining populations, variations in the number of students only lead to school closures until a certain threshold is attained: minimum standards in school provision guarantee that each municipality retains a small number of schools even when the number of pupils continues to decrease. This finding might also be related to the different rhythms of school network consolidation, where the territories which are declining at the fastest rates are the first ones to witness school closures, which afterwards spreads to the more central locations.

Fourth, while primary schools may be able to influence household location decisions and other service investments (Lehtonen, 2021), this analysis also revealed a positive influence of the changes in the employment provided by private firms on the changes in the number of primary schools.

In short, the planning of primary school facilities must be understood in the context of broader spatial processes. These processes, while providing interesting material for scientific inquiry, also pose significant challenges to their analysis. Given the many factors which influence the number of primary schools, and the slow response to changes in these factors, it could be useful to consider: longer time series (several decades), to better understand the significant temporal lags in variables that can contribute to changes in primary schools; smaller (or different) statistically units, to perceive the clustered economic and demographic dynamics of the territory and their relations with the provision of services of general interest; a more diversified set of variables. It could also be useful to explore the lower limit of school provision, namely considering the degree of spatial accessibility or student-to-school ratios, which the models showed to be important. Finally, it could be interesting to explore the different responses of public and private schools to changes in the socioeconomic and territorial contexts, although the relatively small number of private schools and their absence in many contexts would pose methodological challenges.

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Articles

Tertiary industries' value-added as a linkage's engine: An interstate input-output application for Brazilian regions

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Abstract:

Tertiary industries' value-added have been considered an essential input for any production chain, as they have the potential to connect regions and services activities across networks. Moreover, spatially, services move more straightforward than the manufacturing of resource-based industries. This study estimates the interregional and inter-industry linkages regarding a set of services-related economic sectors and accounts for the trade in value-added (TiVA) measures, considering intraregional and interregional trade based on an interstate input-output application for Brazil. The main findings reveal that the poorest Brazilian states tend to lose linkages opportunities in services activities, remaining hostages to supply natural resources to production networks for subnational and foreign demand. On the other hand, the potential for gains from connections in the services' networks reveals greater spatial dispersion across regional hierarchies, increasing the concentration in large urban agglomerations. In this regard, the paper concludes that the connectivity potential of services at the intraregional level can be an essential starting point to promote innovative systems away from large urban areas in the wealthiest regions inside Brazil, potentially reducing value-added imbalances in internal geography trade flows.

Keywords: Tertiary activities; services trade; value-added trade; structural linkages; vertical integration; regional inequalities.

JEL Classification: R12; R59; C67.

El valor agregado de las industrias terciarias como motor de encadenamientos: una aplicación interestatal de insumo-producto para las regiones brasileñas

Resumen:

El valor agregado de las industrias terciarias se ha considerado un insumo esencial para cualquier cadena productiva, ya que tienen el potencial de conectar regiones y actividades de servicios a través de las redes. Además, espacialmente, los servicios se mueven de forma más sencilla que la fabricación de industrias basadas en recursos. Este artículo estima los vínculos interregionales e interindustriales con respecto a un conjunto de sectores económicos relacionados con los servicios y toma en cuenta las medidas del comercio de valor agregado (TiVA), considerando tanto el comercio intrarregional como interregional basado en una aplicación de insumo-producto interestatal para Brasil. Los principales hallazgos revelan que los estados brasileños más pobres tienden a perder oportunidades de vinculación en las actividades de servicios,

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quedando rehenes para suministrar recursos naturales a las redes de producción para la demanda tanto subnacional como extranjera. Por otro lado, el potencial de ganancias de las conexiones en las redes de los servicios revela una mayor dispersión espacial entre las jerarquías regionales, lo que aumenta la concentración en grandes aglomeraciones urbanas. En este sentido, el documento concluye que el potencial de conectividad de los servicios a nivel intrarregional puede ser un punto de partida esencial para promover sistemas innovadores fuera de las grandes áreas urbanas en las regiones más ricas dentro de Brasil, reduciendo potencialmente los desequilibrios de valor agregado en los flujos comerciales de geografía interna.

Palabras clave: Actividades terciarias; comercio de servicios; comercio en valor agregado; encadenamientos estructurales; integración vertical; disparidades regionales.

Clasificación JEL: R12; R59; C67.

1. Introduction

Services have long been perceived as playing a secondary role in regional supply chain studies. The rise of fragmentation of production increased the value-added flows worldwide, with several implications for input-output (IO) linkages' opportunities and vertical integration among different industries (Atienza et al., 2018; Gereffi, 1994; Haddad & Araújo, 2020; Johnson & Noguera, 2012). In this topic, the economic literature has been focused on the national or firm-level analysis, with scarce evidence on the subnational interdependence on chaining different industries among tradable activities, understudying the role of value-added creation and transfers along with IO production networks (Baldwin & Robert-Nicoud, 2014; Koopman et al., 2014; Los et al., 2015). In an interdependent economic context, the structure of regional supply chains influences the ability of economic areas to generate value for local production chains (Arnarson & Gullstrand, 2022; Cuadrado-Roura, 2009; Nordås, 2018). Production networks have boosted the relevance of trade to regional development and the intensity of tradable services in local production networks' trade flows (Cuadrado-Roura, 2016; Ehab & Zaki, 2021; Francois et al., 2015; Miroudot & Ye, 2019; Villoria & Hertel, 2011). In this regard, the tertiary industries play an essential role in the firm's location decisions, given the spatial distribution of IO linkages (Amador & Cabral, 2016; Baldwin & Venables, 2013; Kierzkowski & Studies, 2016).

To provide evidence of the location of tertiary activity and its potential for interregional chaining, this paper estimates both backward and forward IO linkages of tertiary industries for different geographic scales, whit an application to Brazilian regional economy. In this regard, the spatial organization of tertiary-related networks is analysed, assessing the IO linkages and zooms-in on the role of tertiary services industries in local production networks among interregional and international spatial levels. Therefore, the study focuses on estimating the direct and indirect services-related trade flows in terms of value-added computed for different geographical scales – intraregional, interregional, and international. Value-added accounting allows us to understand the potential of regions and industries to contribute to the generation of value at the local level, which depends on the stage of specialized production and is the measure commonly adopted in supply chain studies (Johnson & Noguera, 2017; Koopman et al., 2014; Los et al., 2016; Miroudot & Ye, 2019). Besides the application of the IO framework, we further evaluate the potential of clustering industries across regional hierarchies based on spatial techniques using regional labour market data (Anselin, 2001; Dall'erba, 2009).

The mobility of production factors regarding the service's activities is an essential engine for dealing with location patterns across regional hierarchies as a matter of the strategic position of companies and local assets development opportunities (Cuadrado-Roura, 2013a, 2016; Gervais & Jensen, 2019). However, less attention has been paid to the geography of interdependencies of the tertiary activity to the rest of the industries in both theoretical and empirical ways. Most early studies were concerned with agriculture, manufacturing, or extractive industries, supported by the idea that the existence of services depended on these other significant categories of economic activity (Eaton & Kortum, 2002). However, the empirical evidence has been pointing that the production systems have become more geographically dispersed, with different stages of a given chain located at various places across spatial hierarchies (Beverelli et al., 2019; Imori, 2015; Suder et al., 2015; Zhong et al., 2021). In this regard, trade across domestic (subnational) networks needs to gain empirical notoriety (Beverelli et al., 2019; Gereffi, 2019a, 2019b; Ponte et al., 2019;). Consequently, as the mobility of the activities of the service is different from other industries, the regional economic structure provides an essential analytical element in understanding the spatial patterns of linkages and the capacity of local economies to provide the necessary supply of services (Freytag & Fricke, 2017; Haddad & Araújo, 2020; Haller et al., 2014; Hansen et al., 2021; Kierzkowski & Studies, 2016; Oliveira, 2020; WTO, 2017).

For Brazil, despite the consolidated evidence regarding regional inequalities, there is a gap in identifying the role of tertiary industries' location on boosting the regional value-added creation and transfers along with multiscalar production networks (Barufi et al., 2016; Bohn et al., 2018, 2021; Tian et al., 2019). The need to advance in understanding the relevance of the services industries at the regional level was discussed by Cuadrado-Roura (2016), as the manufacturing or resource-based industries have a greater interest in regional development studies (Hansen et al., 2021; Hoekman & Shepherd, 2017). The relationship between the services sectors and Brazilian regional inequalities was pointed out by Azzoni & Andrade (2005), the productivity growth, regional dependency in selected tertiary sectors and interindustry interdependencies (da Silva & Perobelli, 2018). Recently, the role of services' value-added in exports was analysed by Haddad and Araujo (2020), revealing the potential for concentration for proving to global markets in some Latin American countries. In general, the empirical literature has highlighted the role of the Brazilian national economy in the supply of the services chain without observing the inter and intraregional dimensions of vertical integration.

Moreover, despite the untapped opportunities in a large country like Brazil, regional inequalities tend to be restricted to the dispersion of services-content in value-added, reducing the country's participation in more advanced production networks stages (Amador & Cabral, 2017; Aroca et al., 2018; Azzoni & Haddad, 2018; Haddad & Azzoni, 2017). At the subnational level, the regional inequalities between wealthy regions of the South and Southeast and the poorest regions of the North and West tend to drive the uneven prospects for regional development (Azzoni & Haddad, 2018; Haddad & Azzoni, 2017). Furthermore, concentration and regional economic specialization, especially in resource-based regions, raise doubts about supporting natural resource activities and enclave economies within the regional structure (Atienza et al., 2020). At the same time, Brazil is one of the economies with the lowest foreign value-added in its exports, implying opportunities for subnational networks (De Backer et al., 2018). The productive aptitude of Brazilian regions deals with a geographically demarcated structure of diversification and specialization (Haddad & Azzoni, 2017; Sanguinet et al., 2021; Silveira-neto & Azzoni, 2011), which influences the linkages between tertiary sectors and the rest of the local economic activity. In this sense, it is particularly relevant to understand the spatial patterns of chaining, as tertiary training tends to be intensely value-added, which impacts the extension of production networks and practices of regional development (Francois et al., 2015).

The IO linkages of service activities make it possible to add value to the vertically fragmented production process (Cheng et al., 2022; Pahl & Timmer, 2019). Therefore, in an economy with regional interdependencies, inequalities in the provision of services are a determining factor for factor mobility and spatially heterogeneous access to the tertiary activity (Haddad & Araújo, 2020). First, the trade in benefits depend on the reallocation of production or the movement of factors, as services are partially produced where they are consumed (Egger et al., 2017; Francois et al., 2015). For example, in developed subnational economic areas, specialized services may be provided to other peripheral regions through technology transfer, increasing regional disparities. There is evidence of service offshoring at the international level - relocating a company's business processes to a developing country where economic conditions are more advantageous. In countries with large areas and regional disparities, there is potential for this pattern to be replicated domestically. Second, some tertiary activities are based on the movement of consumers or traded goods, so tertiary activity needs to be developed with other industries, such as industry, agriculture, and the service sector (Kimura & Lee, 2006; Nordås, 2018). Both inter and intra industry vertical integration are a spatially non-blind component, as it is related to regional endowments and the ability of territories to offer and integrate relevant stages of adding value to local production (Arnarson & Gullstrand, 2022; Bohn et al., 2018). Accordingly, this paper contributes by adding empirical evidence on three mains aspects: First, we have advanced the inclusion of the sub-national perspective to understand spatial and industrial dependence patterns for both intraregional and interregional trade scope; second, we detailed the hierarchies of services tertiary sectors in terms of trade in value-added locally identified; and third, we brief on the potential to clustering services' activities associated with the location preferences of companies.

This paper is organized as follows. Section 2 discusses the background theory and empirical literature. Section 3 provides a short characterization of value-added services activities in Brazil. Section 4 presents the empirical strategy. Section 5 shows the main results. The last sections present our conclusions.

2. Background

As changes in the economic structure towards services and the regional inequalities of the production networks of certain types of services began to attract more attention. The theoretical foundations of economic geography were consolidated by Christaller (1966), who developed a geographic theory to explain the size and location of cities based on the assumption that their primary function was to provide services to the surrounding areas. Other classical studies, such as Berry (1967), have supported Christaller's central place theory to explain the relationship between the characteristics of retail services and settlement patterns (Daniels, 1986; Marshall, 1982; Scott, 1985), mainly focused on the causes and consequences of variations in the way different types of services were distributed. These studies have been including different spatial scales of analysis, such as trade within and between cities, between regions within countries and globally. Overall, the spatial location is a problem in the context of market imperfections, as it directly affects the distance between input-output relationships, transport costs (Mason, 1985) and the unequal distribution of natural resources. Recently, greater importance has been given to the role of value-added trade between countries (Koopman et al., 2014; Los et al., 2016; Miroudot & Ye, 2019) and intra-industry (Davis, 1995; Francois et al., 2015; Gervais & Jensen, 2019; Haddad & Araújo, 2020; Tang et al., 2013), as the tertiary activity can increase the value of both the economy's goods and services production (Hummels et al., 2001; R. W. Jones & Kierzkowski, 2001; Luck, 2017; Spencer, 1996).

Tertiary activities are commonly considered intermediate inputs, playing a significant role in the interregional trade of the domestic supply chain (Hansen et al., 2021). Producer services may include transport, communication, insurance, financial and legal services, among others. On the one hand, the rapid growth of trade in goods accelerates the demand for producer services; on the other hand, the linkages between these services coordinate separate production stages (blocks) that can be located in different regions within a country. Some studies emphasize that such service activities have increasing returns to scale so that the growth of trade in goods influences the demand for services (Arndt & Kierzkowski, 2002; R. W. Jones & Kierzkowski, 2001). At the same time, the rising return to scale of service linkages tends to lower trade costs and coordination costs and thus increases trade in goods and fragmentation, which enhances trade in services (; Sun & Pang, 2017). These mechanisms contribute to understanding the regional development potential associated with providing services.

The role of service industries activities has been increasingly boosted by technological advances, implying changes in how companies operate, ongoing structural changes in national economies and societies and greater specialization in the capital, labour and occupations (Atienza et al., 2016; Koopman et al., 2011). In this regard, the tertiary sector has been considered an integral part of the functioning of local economies (Hoekman & Shepherd, 2017; Johns, 2021; Marshall, 1982). In addition, the emergence of a fragmented structure of production networks leads to different stages of processes taking place in different regions, pointing out the role of linkages between sectors, regions, and countries.

The production networks are consolidated across borders but have a subnational dimension forgotten by empirical studies (Coe et al., 2008, 2010; Fold, 2014; Parrilli et al., 2013). Moreover, restructuring through outsourcing and offshoring of tasks highlights the role of services widely used at different stages of the production process (Zhong et al., 2021). Consequently, the separation of production and the underlying embedded services become essential mechanisms for adding value to production and trade through inter-industry and inter-regional linkages: restrictions on trade and the concentration of production at the subnational level restrict the ability of companies to participate in value chains and connect with service activities (Blank et al., 2022; Francois & Hoekman, 2010).

A specific feature of tertiary activity is the ability to move geographically. Therefore, regional economic conditions to attract service activity become a determining factor in understanding the potential for linkages and local interdependencies (Francois et al., 2015; Freytag & Fricke, 2017; Jiang & Lin, 2020). Furthermore, in a regionally uneven productive structure, trade in different sectors is often influenced by relative costs and prices in the economy (Damijan et al., 2015; Haller et al., 2014). The classic Ricardian models point out the difference in production technology or productivity concerning the endowment of factors in different local economies. For tertiary industries, differences in country endowments consider homogeneous levels of labour and capital and differentiated factors (for example, skilled labour or human capital) into account. Other variables that affect the prices of traded products may also explain the origins of comparative advantage; these include technological changes, market imperfections, sector-specific structures, political environment, institutional quality, and demand-side considerations. Due to its intangible and non-storable nature, the trade in services becomes an essential element to be studied from an intra-regional perspective. It affects crucial decisions regarding companies' location and vertical integration (Gervais & Jensen, 2019; Jensen & Kletzer, 2005).

Three main aspects can explain the patterns of regional location of tertiary activity. First, it depends on the location of consumers and the demand for services, which is not spatially neutral. Regionally, the industrial composition plays a governance role in value chains and is responsible for attracting tertiary activity with greater mobility than other industries (Cuadrado-Roura, 2013b; Daniels, 1986; Davis, 1995). Second, the interaction of different scales of geographic integration further induces the geographic patterns of linkages, determining the scope of intersectoral links (Mudambi et al., 2018). Regional economies may be self-sufficient in providing services necessary for generating intraregional wealth or depend on interregional or international supply. In this regard, the spatial patterns of IO linkages are affected both directly and indirectly and can be interregional and global across borders (Acemoglu et al., 2020; D. Lee, 2019). Third, industrial diversification of value chain integration can determine how well a region can meet the demand for services. In addition, economic diversification makes it possible to assess how they can offer services to intra-regional demand or other areas within the country, potentially increasing regional differences (Cuadrado-Roura & Maroto, 2016; Santos et al., 2009). Diversification of local production and exports can ensure self-sufficiency for regional economies against interregional or international competitors, thus offsetting local revenues and assets and promoting development. Notably, the relatively closed Brazilian economy (Perobelli et al., 2018) can be essential for understanding how regions can supply their value chains.

Recent advances show that intra-industry models shallow the role of intermediate goods, becoming an essential driver of linkages-based growth. The role of distortions in the input markets as an element of explanation for productive inequalities (Acemoglu et al., 2007; Ciccone, 2002; C. I. Jones, 2011). Locally, there is potential of win-win linkages among regions within national borders, pointing out the need to measure connections' size and location, geographic scope, and quality. Moreover, the degree of exposure of regions to production networks is an important aspect of understanding the development from the linkages point of view (Hewings & Oosterhaven, 2015). In this sense, this article seeks to generate evidence of the location of tertiary activity and its potential for interregional linkages.

3. Brazilian regional tertiary industry's location

On both theoretical and empirical sides, the models and evidence on industrial locations have been pointed out in a secondary plan in the case of service activities. At the intra-regional level, the spatial analysis of service activity is relevant as it fundamentally depends on the spatial distribution of a country's productive centres (Baldwin & Ito, 2021). First, at the intra-regional level, territorial extension influences the distribution of both population and economic activity. The forces of agglomeration act as essential drivers for the attraction of support services to both the primary and secondary sectors. In Brazil, relevant structural characteristics influence the vertical integration of services to the rest of the regional industries, mainly due to its market size (in terms of the territorial area, population, and trade patterns), favouring the creation of complex internal production networks (Sanguinet et al., 2021). Second, the Brazilian economy is relatively closed internationally and specializes in exporting raw materials (de Backer et al., 2018; Perobelli et al., 2018).

Furthermore, subnational tertiary sector trade is relevant to national and regional economic development (Atienza et al., 2018, 2020; Atienza, Ronda-Pupo, et al., 2019). Third, the structural linkages between the tertiary sectors and the rest of economic activity have a preponderant geographic component. They influence the local capacity to add value to the production of goods and services (Haddad, Perobelli, et al., 2020). In Brazil, persistent regional disparities influence production location and the demand for support from tertiary industries, affecting the decision to verticalize companies (Haddad & Azzoni, 2017). The spatial concentration of diversified economies, mainly in the economic areas of the southeast and south of Brazil, contrasts with the specialization in natural resource industries in the northeast, Midwest, and part of the north of the country, influencing how local economies add value along the local production chains. In this context, it is relevant to analyse how local economies internalize linkages with tertiary industries, as they serve as strategic support for the aggregation of local value, influencing regional development trajectories.

At the subnational level, knowledge-intensive regions and strategic service provision tend to concentrate on economic agglomerations (Lüthi et al., 2013). As the process of innovation becomes spatially limited, the role of providing services in value-added through networks gains relevance (Mudambi et al., 2018). The increasing sophistication of the supply chain highlights the importance of interregional linkages. Linkages could capture impacts across the interdependency on the production system. There is more demand for intermediate services, which also highlights the potential of regions to increase their local capacities for systems with a higher level of technology, with implications for operating costs and competitiveness gains (Foster-McGregor & Stehrer, 2013; OCDE, 2013). Theoretical background on location decision argues in favour of communication costs and their effect on dispersed management activities from production. There exists a dispersion of activities with low value-added, whereas knowledge-intensive industries concentrate, functional hierarchies are key to explain this (McCann & Ortega-Argilés, 2015). Large urban agglomerations offer the best opportunities to promote new ways of service supply. The connectedness of these activities implies greater accessibility to transportation at the local level, increasing the servicification of cities (Villoria & Hertel, 2011). The outsourcing of specific activities has promoted the growth of knowledge transferring and linkages to foreign markets, which are gaining relevance in production networks (Cuadrado-Roura, 2009, 2013b, 2016).

In Brazil, service-related activities became the activity with the largest share of gross output (Table 1). These activities have been gaining relevance in creating value-added value, representing about 76% of the economy. The main activity is intangible, no storage. The production-distribution-consumption co-occurs. One of the main assets assumed by the demand is the quality associated with a high degree of heterogeneity. Interestingly, 76% of all gross production in services activities remains in Brazil, given the type of activity.

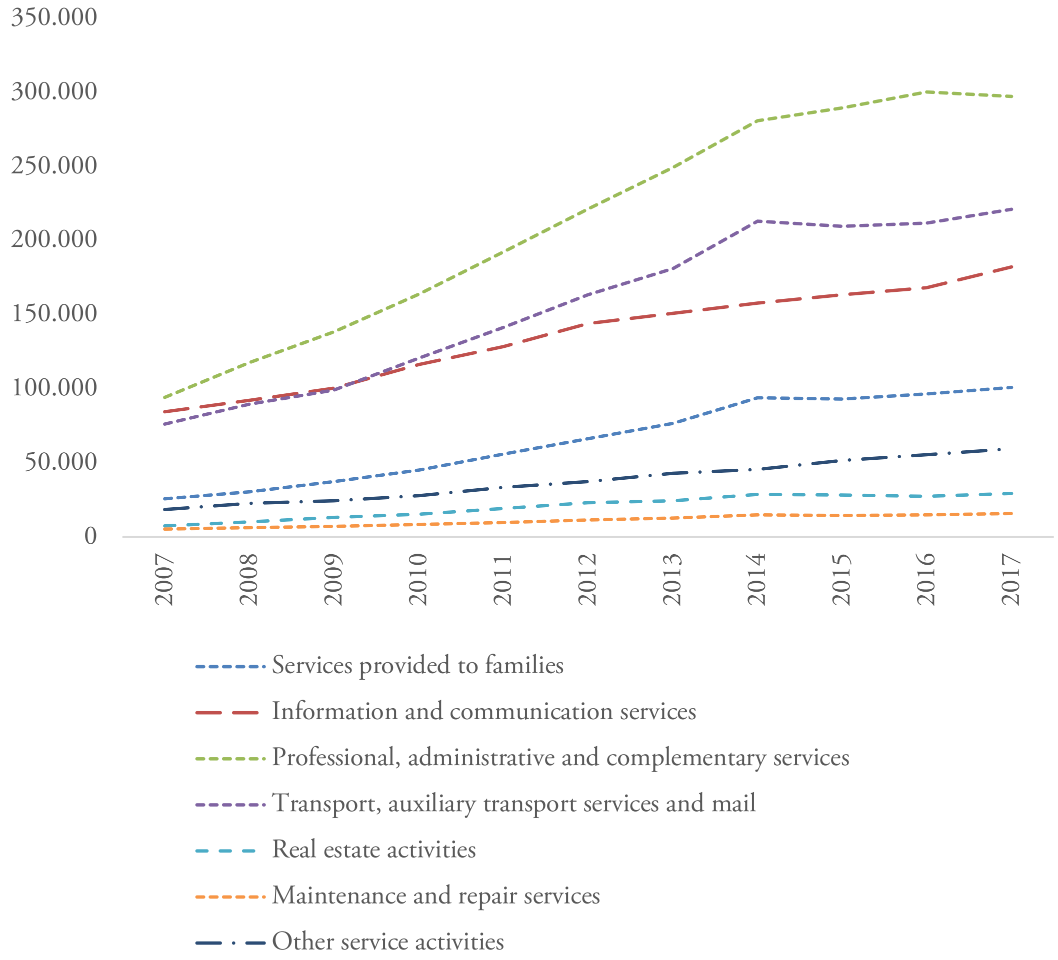
TABLE 1.
Industrial share in Brazilian Economy by large economic activities groups

Large Industry Group	Gross Output	Value-Added	Exports
Primary sector	7.9%	9.5%	30.1%
Secondary sector	29.5%	13.9%	46.1%
Tertiary sector	62.5%	76.6%	23.8%
Total	100.0%	100.0%	100.0%

Source: Interstate input-output table for Brazil (Haddad et al., 2017).

Figure 1 shows the expansion of value-added tertiary sectors. There is heterogeneity in the composition of the economic activity. Production networks studies show the growth of the service sector as related to manufacturing performance, given the complementary relationship of economic activity. The rising share related to technical-professional services (non-real estate rentals and management, non-financial intangible assets, office services, and administrative and business support) shed light on the potential for taking-places in this type of sector. The location of business-support-related activities requires proximity to companies, where agglomeration environments are reinforced. Transportation services also gain importance in the national value-added, indicating that transferring across regions has improved their economic representativeness, and thus follows the sector of Information and Communication Services. Accordingly, this type of activity is characterized by its potential to incorporate knowledge and technology into production and, consequently, into trade flows. A large proportion of its services trade is intra-industry, but Brazil has a concentrated, productive structure, unbalancing the opportunities for growth associated with intensity in value-added. The next section describes the empirical strategy for measuring services linkages at intra and interregional levels and value-added trade measures.

FIGURE 1.
Value-added services in the national economy (BRL millions)



Source: Authors based on Annual Services Survey (Brazilian Institute of Geography and Statistics, 2018).

4. METHOD AND DATA

To analyse the role of tertiary industries linkages at the subnational level, we have adopted a demand-driven IO model (Leontief, 1986). Our empirical strategy is divided into three steps. First, we calculate tertiary industry linkages at different spatial scales to provide insights into the geographic scales of vertical integration. Second, we evaluate the extension of production networks considering value-added trade measures, which allow the dimensioning of the role of tertiary industries in both intra and interregional trade, generating evidence on the geographic organization of networks between the tertiary sectors and the rest the economic activities. Finally, we downscale the spatial unit of analysis to identify spatial patterns of the location of service companies in the country based on Exploratory Spatial Data Analysis (ESDA).

To measure the tertiary activities linkages, let us first consider an interregional input-output model (IRIO) with J industries (labelled as i, j), R subnational regions (r, s), and U final demand components for domestic (U^r, U^s) and foreign (U^{RoW}) consumption, as shown by Figure 2. The final structure given to the data provides a comprehensive and consistent structural picture of the regional income accounting relationships between different sectors. The model is based on the general equilibrium fundamentals within a social accounting matrix (SAM) system, recording the interrelationships of a regional economy, including intermediate uses and final demand (Francois et al., 2015). For our purposes, the IRIO structure offers the advantage of linking consumption and interregional trade patterns to the interindustry structure of intermediate demand at the subnational (internal) level. The modelling allows us to comprehensively analyse the vertical integration of a set of services economic sectors and the value-added content embedded in trade flows.

FIGURE 2.
An interstate IO with *R* regions and *J* sectors

		Industry demand			Final demand				Total
		Region 1	⋯	Region R	Region 1	⋯	Region R	Foreign exports	
		Sector 1	⋯	Sector J					
Region 1	Sector 1	z_{11}^{11}	⋯	z_{1J}^{1R}	F^{11}	⋯	F^{1R}	e^1	x^1
⋮	⋮	⋮	z_{ij}^{rs}	⋮	⋮	F^{rs}	⋮	⋮	x^r
Region R	Sector J	z_{J1}^{R1}	⋯	z_{JJ}^{RR}	F^{R1}	⋯	F^{RR}	e^R	x^R
Foreign imports		z_1^{m1}	⋯	z_J^{mR}	F^{m1}	⋯	F^{mR}	–	M^{for}
Value-added		V_1^1	⋯	Z_J^R	Y^1	⋯	Y^R	0	Y^{nat}
Total		$x_1^{1\prime}$	x_i^S	x_J^R	$C^1\ I^1\ G^1$	⋯	$C^R\ I^R\ G^R$	E^{for}	

Source: Authors' elaboration based on (Hewings & Oosterhaven, 2015).

The fundamental relations in the traditional IO model are given by:

$$\mathrm{x} = \mathrm{A}.\mathrm{x} + \mathrm{y} \tag{1a}$$

$$\mathrm{x} = (\mathrm{I} - \mathrm{A})^{-1}.\mathrm{y} = \mathrm{B}.\mathrm{y} \tag{1b}$$

where **x** is the output, **A** is the intermediate input, **y** is the final demand, and **B** is the Leontief inverse matrix. Our approach is based on an interstate model, and the multiregional extension of these basic relative can be expressed as follows:

$$\mathrm{x} = \begin{bmatrix} \mathrm{x}^1 \\ \vdots \\ \mathrm{x}^R \end{bmatrix}; \mathrm{A} = \begin{bmatrix} \mathrm{A}^{11} & \cdots & \mathrm{A}^{1R} \\ \vdots & \ddots & \vdots \\ \mathrm{A}^{R1} & \cdots & \mathrm{A}^{RR} \end{bmatrix}; \mathrm{y} = \begin{bmatrix} \mathrm{y}^1 \\ \vdots \\ \mathrm{y}^R \end{bmatrix}; \text{and } \mathrm{B} = \begin{bmatrix} \mathrm{B}^{11} & \cdots & \mathrm{B}^{1R} \\ \vdots & \ddots & \vdots \\ \mathrm{B}^{R1} & \cdots & \mathrm{B}^{RR} \end{bmatrix} \tag{2}$$

Initially, we are interested in measuring the sectoral and regional interdependence of subnational value chains based on linkages indicators (backward (BL) and forward (FL)) from the Leontief matrix (Perroux, 1955; Hirschman, 1958). As these indicators are sensitive to the number of activities, we are weighting the measures by the average of the whole B matrix. We detail the effect of interregional and intraregional feedback, as discussed by (Miller & Blair, 2009). The exclusion of the Leontief diagonal blocks allows the measurement of interregional linkages isolating the spillovers between home and foreign regions in the system. Accordingly, we estimated both backward and forward linkages of tertiary activities at the national and regional levels, computing interregional and intraregional spillovers.

The second stage considered the trade in value-added (TiVA) measures to understand the interplay between services activities and linkages patterns among Brazilian states from a multisectoral model. The method extended the spatial scope to measure the local content of tradable services in an interregional system (Chen et al., 2018; Haddad et al., 2020; Los et al., 2016). Furthermore, TiVA measures provide the idea that intermediate inputs can affect the production process other than the trade in final goods, leveraging the promotion of services linkages throughout the intra and interregional production networks. The latter focus on vertical specialization allows for identifying market opportunities to add more value to production and increase regional trade competitiveness (Feenstra & Kee, 2004; Gereffi, 2019b).

When the gross production flows associated with a particular level of final demand are known, value-added production and trade can be derived simply by multiplying these flows with the value-added to gross product ratio in each industry(Los et al., 2016). Compared to the traditional measure based on gross trade flows, TiVA can provide us with a much more detailed picture of the direct and indirect interaction of the regions along with the networks (Meng et al., 2017). By including the local value-added in trade, we can identify the regional hierarchies within networks. To estimate trade flows at the subnational level, we followed the work of Haddad et al. (2020), Meng et al. (2017) and Chein et al. (2018), which have extended the global flow model to the subnational scale. In particular, we are interested in estimating the value-added content of tertiary activities embedded in local production networks at different spatial scales. To do this, we regionalize Equation (1) as follows:

$$\mathrm{x}^{\mathrm{R}} = (\mathrm{I} - \mathrm{A}^{RR})^{-1}\mathrm{y}^{R} \tag{3}$$

where $\mathbf{x^r}$ $([r\ x\ n] \times\ 1)$ is the gross production of region r, $(\mathbf{I} - \mathbf{A^{rr}})^{-\mathbf{1}}$ is Leontief's inverse of this region, and $\mathbf{y^r}$ is their final demand. The value-added needed to produce their final demand is given by

$$\mathrm{va} = \mathrm{diag(v)By}^{R} \tag{4}$$

where $\mathbf{va}$ is a matrix representing the value added by sector n and each region r, $\mathbf{diag(v)}$ is the diagonal matrix of row vector of the ratio between value-added by gross output. According to Meng et al. (2017), the measurement of a region's value-added induced by the other region's final demand' can be written as follows:

$$\begin{aligned}\mathrm{TiVA^{RS}} &= \mathrm{diag}(\mathrm{v}^{R})[\mathrm{B^{RR}y^{RS}} + \mathrm{B^{RS}y^{SS}}] \\ &= \mathrm{diag}(\mathrm{v}^{R})\begin{bmatrix}\mathrm{B^{RR}} & \mathrm{B^{RS}}\\ \mathrm{B^{RS}} & \mathrm{B}^{SS}\end{bmatrix}\begin{bmatrix}\mathrm{y^{RS}}\\ \mathrm{y^{SS}}\end{bmatrix}\end{aligned} \tag{5}$$

where $\mathbf{y^{RS}}$ is the foreign s's region and $\mathbf{y}^{SS}$ is the home region. This provides us with a measure of demand based TiVA. Therefore, at the industry level, we account for the TiVA induced in a specific sector *j* in region *r* by the final demand in region s as follows:

$$\begin{aligned}\mathrm{TiVA_j^{RS}} &= \mathrm{diag}(\mathrm{v_j^R})(\mathrm{B^{RR}y^{RS}} + \mathrm{B^{RS}y^{SS}}) \\ &= \mathrm{diag}\left(\mathrm{v_j^R}\right)\begin{bmatrix}\mathrm{B_{ij}^{RR}} & \mathrm{B_{ij}^{RS}}\\ \mathrm{B_{ij}^{SR}} & \mathrm{B_{ij}^{SS}}\end{bmatrix}\begin{bmatrix}\mathrm{y^{RS}}\\ \mathrm{y}^{SS}\end{bmatrix}\end{aligned} \tag{6}$$

where the vector $\mathbf{v_j^R}$ represents the value-added coefficient for industry j in region *r*. We are interested in the *r*'s outflow of *j*'s sector from *r* to *s*, as $\mathbf{TiVA_j^{RS}} = \sum_{\mathbf{i}} \mathbf{TiVA_{ij}^{RS}}$. So far, it is possible to understand the roles of the regions and the links in subnational (intra and interregional) and transnational (foreign induced) networks in TiVA that extend to different geographical scales (Pike et al., 2011). For analytical discussions, of the total 68 sectors on the interstate system, we consider three large economic activity groups: primary sector (natural resources and unprocessed), secondary sector (manufacturing and transformation), and tertiary sector (services).

The last step incorporates the spatial dependence to look at the hierarchies of services' locations, based on the potential to urban clustering of companies. This study sought to use Exploratory Spatial Data Analysis (ESDA) (Anselin, 2001) to identify the distribution patterns of location, based on a weight matrix on the $k = 5$ nearest neighborhoods. Following Dall'erba (2009), we calculate the Moran's I statistic to measure global spatial autocorrelation of a variable (Anselin, 1995), which null hypothesis is that there exists spatial randomness. Therefore, rejecting this hypothesis indicates the existence of spatial association and global spatial autocorrelation, showing clusters of hotspots.

Using the Moran's I statistic as a base, we compute the Local Indicators of Spatial Association (LISA), which allows us to provide information about the geographic location and statistical significance of these clusters (Anselin, 1995). This local indicator makes it possible to identify areas with high and low spatial values and outliers and elements with no statistical significance (Anselin, 2001). The statistics can be interpreted as follows: positive values of I mean that there are spatial clusters with similar values (high or low); negative values mean that there are spatial clusters with different values between regions and their neighbours. The indicator classifies outliers as low-high and high-low, and clusters are classified as low-low and high-high (Chávez & Rodríguez-Puello, 2022).

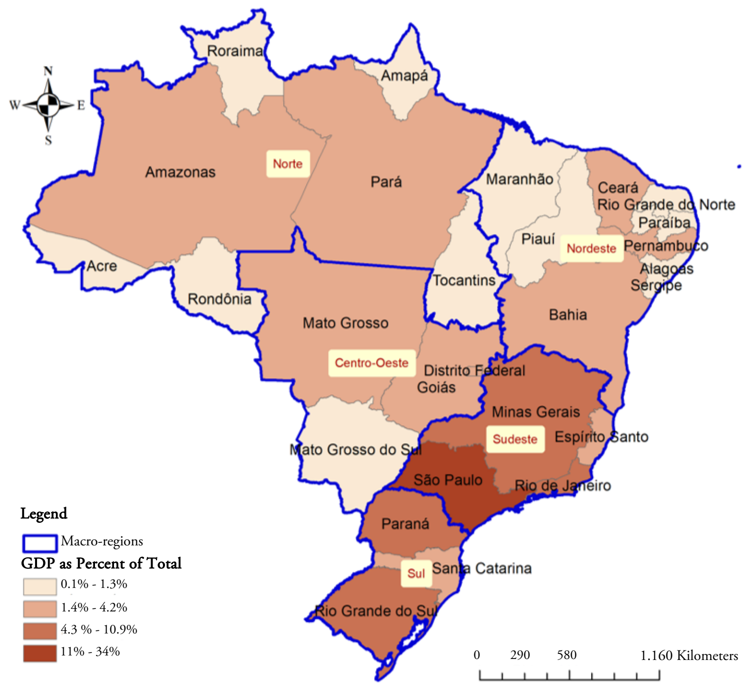
4.1. Data

We use an interstate *input-output* (IRIO) model constructed by the Regional and Urban Economy Lab of the University of São Paulo (NEREUS-USP) for the base year 2011 (Haddad et al., 2017) which contains 68 sectors[1] and 27 regions (Federative Units). Figure 3 shows the IO model's regional setting and indicates the hierarchies of distribution on regional GDP. Evidence in the IO suggests that tables represent interregional and interindustry dependence on the economic structure, which tends to maintain stability over time (Sanguinet et al., 2021). According to the literature, the fragmentation of production has modest changes over time, thereby facilitating the assumption that the economic structure is not considerably different along the time (Timmer et al., 2016). In this regard, the base-year 2011 is adequate to represent the economic structure of interindustry relations and, thus, interregional trade in Brazil. The terms of trade and the spatial distribution of production have not changed drastically in recent years. In this study, we use a public IO table esteemed by a respected research group on regional economics in Brazil available from Haddad et al. (2017).

To improve our knowledge about tertiaries industry's location, we further use the formal labour market data at the municipal level from the Annual Social Information from the Brazilian Ministry of Economy, to identify the potential to service companies' agglomerations. The gap between the wealthiest states of Brazilian Southeastern and Southern compared to the poorest regions of the North and Northeast are persistent over the decades. The concentration and inequality reveal the differentiated opportunities for creating local capacities to supply and production networks (Azzoni & Haddad, 2018; Barufi et al., 2016).

[1] The Annex I present the industrial structure of the model.

FIGURE 3.
Regional distribution of national GDP and regional setting of the model



State	Acronym	Macrorregion
Rondônia	RO	North
Acre	AC	North
Amazonas	AM	North
Roraima	RR	North
Pará	PA	North
Amapá	AP	North
Tocantins	TO	North
Maranhão	MA	Northeast
Piauí	PI	Northeast
Ceará	CE	Northeast
Río Grande do Norte	RN	Northeast
Paraíba	PB	Northeast
Pernambuco	PE	Northeast
Alagoas	AL	Northeast
Sergipe	SE	Northeast
Bahia	BA	Northeast
Minas Gerais	MG	Southeast
Espírito Santo	ES	Southeast
Rio de Janeiro	RJ	Southeast
São Paulo	SP	Southeast
Paraná	PR	South
Santa Catarina	SC	South
Rio Grande do Sul	RS	South
Mato Grosso do Sul	MS	Midwest
Mato Grosso	MT	Midwest
Goiás	GO	Midwest
Distrito Federal	DF	Midwest

Source: Authors based on Haddad et al. (2017).

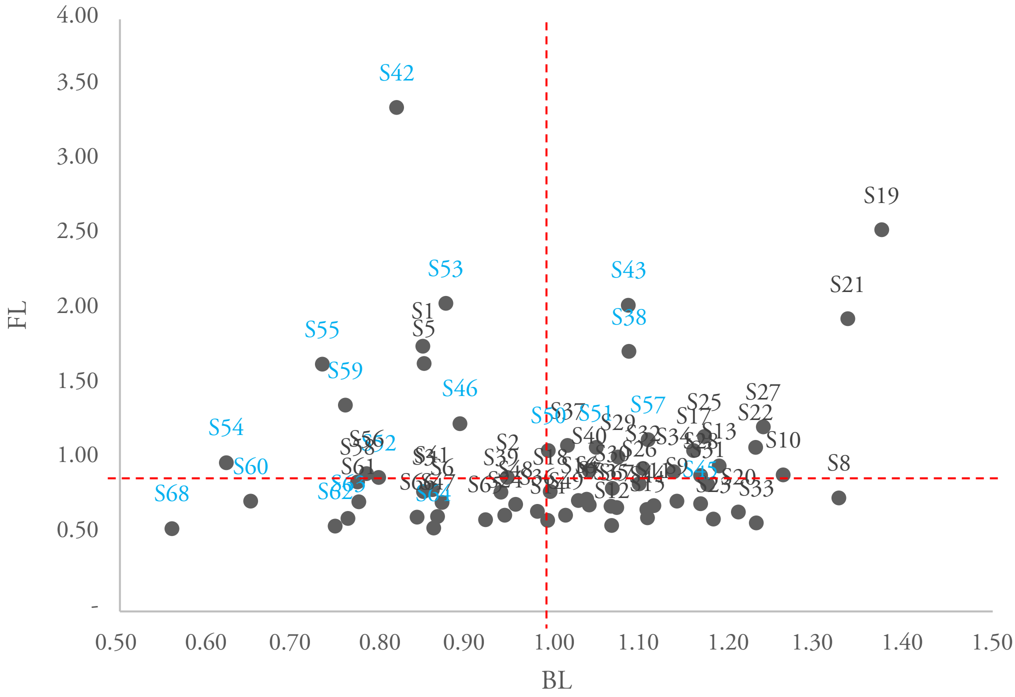
5. Results and discussion

5.1. A look at the interstate linkages

Figure 4 shows the average BL and FL for all Brazilian states (sum of regional results), according to the 68 SCN sectors. A BL greater than 1 indicates the sectors are dependent on interindustry supply in the national production system, while FL is greater than the dependency unit on the interindustry demand side. The role of services in the sectorial interconnectivity in the country can be seen by BL and FL greater than 1, as S38 (Electricity, natural gas, and other utilities), S43 (Ground transportation), and knowledge-intensive business services like S51 (Telecommunications) and S57 (Other professionals, scientific and technical activities). These results suggest that sectors support the supply chain from other upstream or downstream activities. In addition, these service sectors make it possible to add value along with the production network, which is essential for strategies for generating wealth in the territories.

At the regional level, Figure 5 presents BL and FL indicators. Part (a) considers interregional chains, excluding intraregional spillovers, while part (b) considers self-induced effects. Specifically, the analysis considers the regional capacity to provide services necessary for the generation of the local gross product (self-influence) or if there is greater dependence on the supply of other regions (spillover effects). In this regard, the spatial dispersion in the degree of interdependence across regions is a crucial point to regional development based on services' linkages. The comparison between both figures reveals that the wealthiest states in the Southeast (Sao Paulo, Rio de Janeiro, and Minas Gerais) have greater self-influence when compared to the other poorer states, mainly associated with the market size. Northeastern and Northern states are more dependent on the supply of intermediate inputs, with greater BL than FL. The first orders on regional hierarchies see an opposite profile, clarifying the potential of intraregional linkages in these states. The hollowing-out process – process innovation contributes to growth by increasing the range of technologies that a less skilled worker can operate – can occur depending on regional specialization, which increases their demand for other industries (Atienza et al., 2019). In part (a), interregional feedback shows that states with more diversified regional economies are at the top of the hierarchy, with FL superior to BL, revealing the potential for more pronounced networks inside the country.

FIGURE 4.
Linkages at the industry level (services in blue)



Source: Authors based on results, 2021.

Figure 6 shows the linkages according to the three sectoral groups, disaggregating the regional results presented in Figure 5. The regional hierarchy increases according to the linkage size in the manufacturing and tertiary industries due to the value-added generated by those large economic groups. The States of São Paulo, Minas Gerais, and Bahia present the largest chains ahead, revealing a dependence structure in the Brazilian interregional system. Three main findings are observed for the most prosperous regions of the country. First, they are self-sufficient regions to provide (supply) the productive linkages necessary to generate the regional gross product. Second, they are economic areas that can provide intermediate inputs to other regions (generally poorer and less diversified). Third, the bond of interdependence is stronger for tertiary activities - which are also the industries that contribute the most with added value. Finally, this finding suggests that the country's poorest areas, dependent on natural resources, have a less developed service delivery structure than rich and populated regions in the Southeast and South of Brazil. The three states in the Southeast (São Paulo, Rio de Janeiro, and Minas Gerais) and two others in the South (the Rio Grande do Sul and Paraná) present similar patterns to forward services linkages.

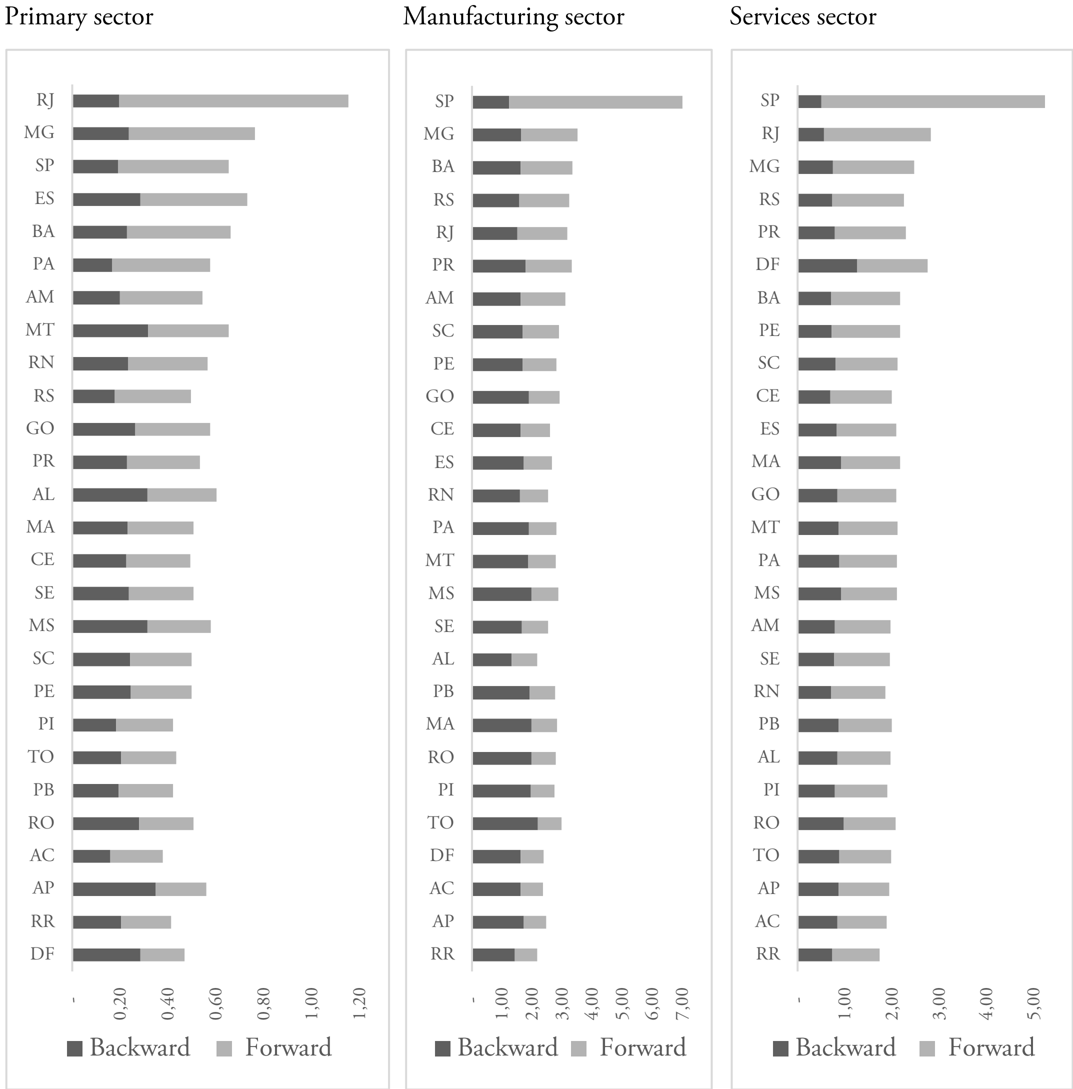
FIGURE 5.
Linkages at the subnational level (BL and FL)

a) Interregional spillovers

b) With intraregional spillovers

Source: Authors based on results, 2021.

FIGURE 6.
Decomposition of linkages by large groups sectors



Notes: The value of linkages increases as the level of interdependence in the intra and interregional supply chain increases.
Source: Authors based on results, 2021.

5.2. Networks at the subnational level

From a subnational perspective, Brazil has an advanced productive integration profile. The national integration of global production networks is still small compared to other countries. The foreign value-added in Brazilian exports was around 17% in 2018 (Perobelli et al., 2018). Even though globalization has grown, this relative closeness pattern indicates the potential for geography-based networks at the subnational level. As shown in Table 2, a tendency towards intrastate concentration exists within the country. There is a high level of intraregional flows of value-added for each macro-region, indicating the role of proximity in creating geography-based networks. The wealthier Southeast states demand 52.0% of subnational TiVA, whereas the poorer North accounts for 6.1%. At the same time, it is interesting to note that interregional flows to the Southeast represent about ¼ of the value-added sales of each macro-region.

TABLE 2.
Macro-regions networks of value-added flows (relative share)

		Demand-side					Total
		North	Northeast	Southeast	South	MidWest	
Supply-side	North	69.30%	5.40%	16.70%	5.20%	3.40%	100%
	Northeast	2.40%	78.60%	12.70%	3.30%	3.00%	100%
	Southeast	2.50%	5.70%	78.90%	8.90%	4.00%	100%
	South	1.90%	3.90%	23.40%	67.30%	3.40%	100%
	MidWest	3.60%	6.30%	25.60%	6.80%	57.70%	100%
	Total demand	6.10%	16.00%	52.00%	17.10%	8.90%	100%

Source: Authors based on results, 2021.

Figure 7 shows the share of trade in value-added that is retained in the home state in part (a), and the interstate flows in part (b). Some Brazilian states of the North (Pará – PA and Amazonas – AM), Midwest (Goias – GO, Mato Grosso – MT, and Mato Grosso do Sul – MS), and Southeast (Espirito Santo – ES) have a low share of value-added retained in the home region. This aspect is associated with the companies' decision to spread their activities in space and has been discussed as a horizontal (market) or vertical (efficiency) strategic trend (Fold, 2014). The differences in productivity levels and costs associated with serving local (intraregional) markets than external (interregional or international) markets can be essential aspects of the increasing networks. The large subnational extension and the quality of infrastructure are associated with transport costs, as increasing levels of cultural, institutional, and geographical heterogeneity not only lead to lower levels of interregional investment (Beugelsdijk et al., 2009, 2010) but also to different search strategies for production efficiency. Taking-home decisions are associated with minimizing costs and economies of scale (Hewings et al., 1998).

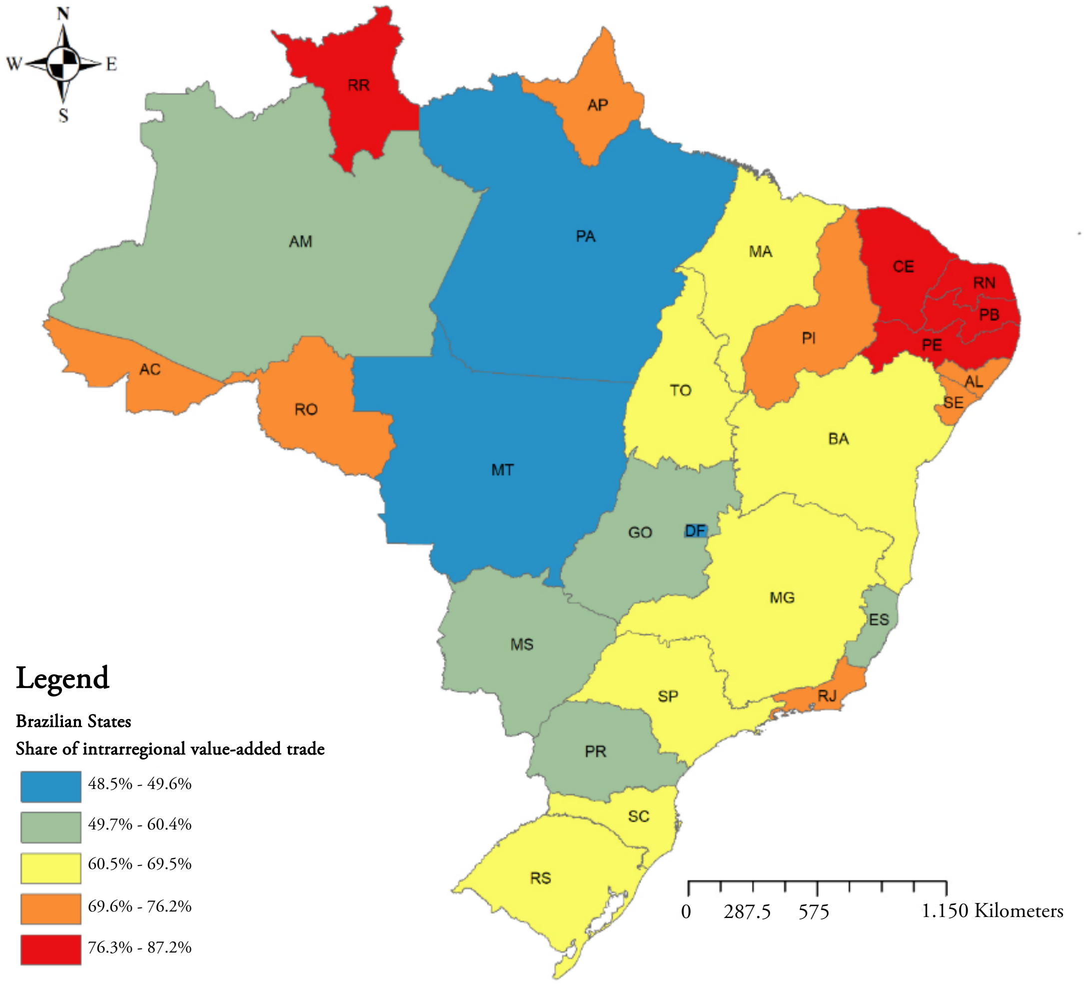
Outsourcing of intermediate inputs increases with the Brazilian regional hierarchy, as Sao Paulo concentrates most of the supply-side in networks inside the country (part b of Figure 7). This state is the largest buyer and supplier and their neighbour states. An intermediary supply level is seen in other states, especially those in the Southeast and those in the South. The remaining states are oriented to attend to home demand or become net importers from other countries. This is a consequence of the spatial pattern of the linkages analysed in the previous section.

Production networking induces changes in the industry location by improving or reducing internal linkages. Table 3 shows the TiVA for each macroregion and three large grouping sectors, considering the sum of columns and rows of the TiVA vector (Equation 6). The market size increases as the requirements for value-added reduce from the primary to tertiary sectors. In the North and Southeast, the value-added of primary sectors increases towards the international markets. No macro-regions have an intra-state orientation in primary industries, revealing an unequal supply of essential inputs processed outside regions. The geography of natural resources influences the location of agricultural and mining sectors.

In the manufacturing sectors, the geographic extension of the regional supply chain demonstrates a greater degree of spatial dispersion. The Northeast and Southeast are the only two macro-regions with more excellent intraregional absorption than the external demand, indicating a disconnected pattern. As far as the manufacturing sector is concerned, the place where these companies are located often depends on specific factors, such as the availability of essential resources or accessibility in any place or region, transport costs, labour supply, and agglomeration economies (Cuadrado-Roura, 2009). It can be noted that the Southern, Northern, and Midwestern states are more integrated with other regions within the country in these sectors, as shown by the largest share of TiVA to attend final foreign demand. Despite the higher value-added embedded by manufacturing, the wealthier Southeastern states tend to meet their need. This macro-region is more oriented towards manufacturing exports from the export-based side, although the Southeast is more representative in trade size.

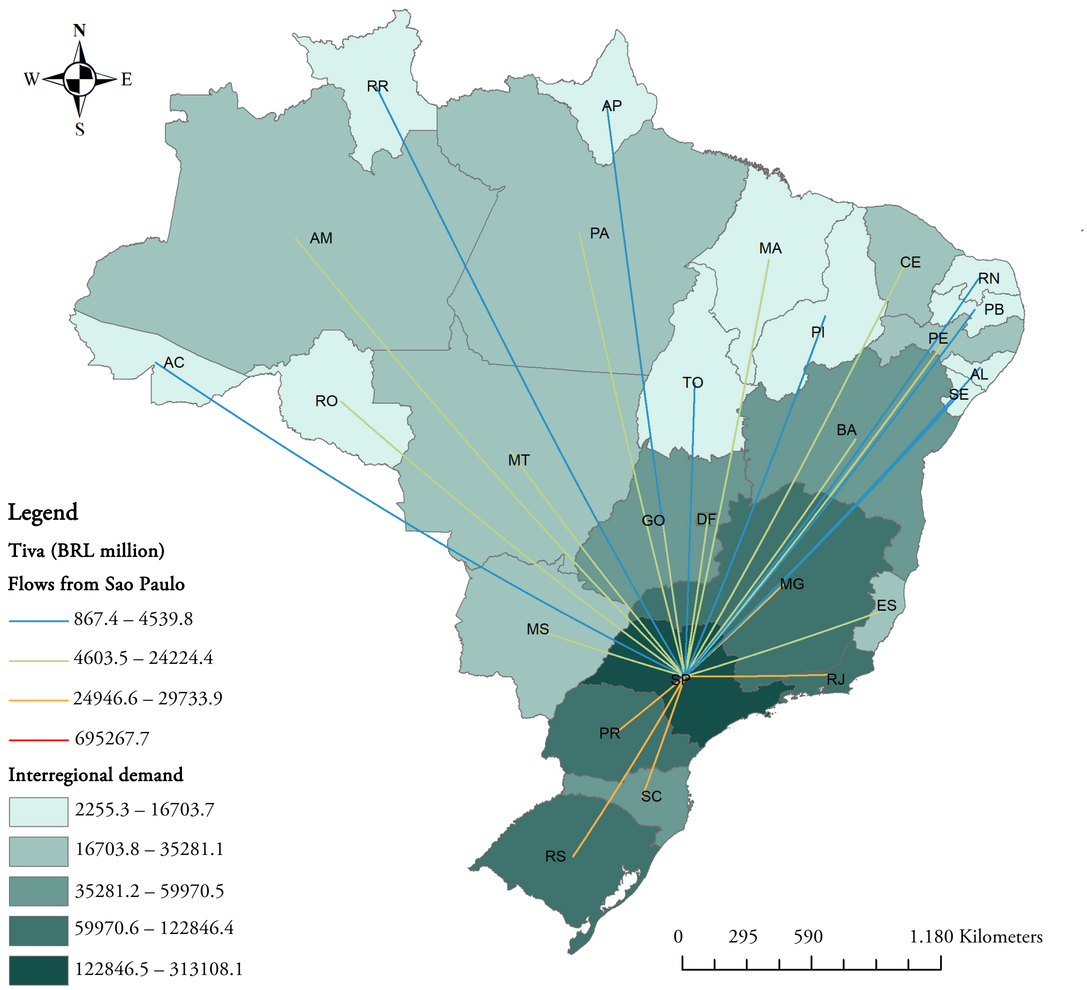
FIGURE 7.
Extension of networks (Intra and interstate relations)

a) Intrastate share



The role of services in value-added derive from the linkage structure shown in the last section. Services outsourcing is a form of functional fragmentation, increasing the density of transactions and linkages within an economy (Romero Luna et al., 2009). The overall impact of networks on the complexity of regional and national economic systems depends on the net effect of the distribution of services activities. The spatial-industrial configurations of the tertiary sector are strongly concentrated in Southeast states, representing 56% of total services in value-added from the whole economy. Sectoral patterns of innovation and the problems posed by the heterogeneity of companies (E. Lee & Yi, 2018; K. Lee et al., 2018) can be determinants of the disconnection of more impoverished regions. Expressed in value-added, the contribution of domestic services is more outstanding than flows between states. There are more domestic services in all macro-regions than exported (interregional or international). It is interesting to note the size of the self-induced intraregional structure.

b) Interstate flows



Source: Authors based on results. 2021.

5.3. Zoom-in: Services in value-added inside the country

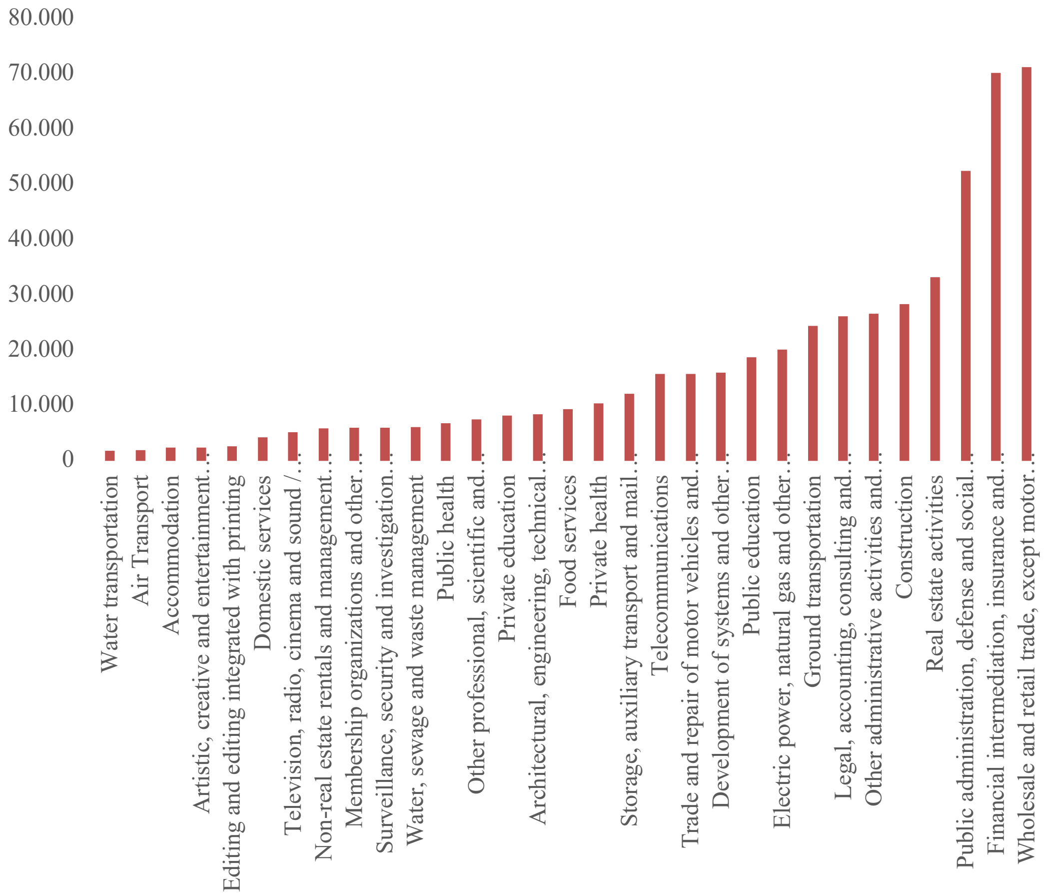
This section describes the nature and importance of tradable services at the regional level, whether to attend intraregional or external regions' demands. Figure 8 shows the hierarchies of services sectors in interregional TiVA. The commerce, finance, public administration, and real estate activities concentrate most of the services in value-added embedded across interstate flows inside Brazil. However, there is a relevant role in the service sector's potential to link activities of other types, associating it to the support, management, and physical interconnection of production. Therefore, many services have knowledge and skills that would be costly for verticalization, mainly for smaller companies (which are the majority in Brazil according to the National Companies Database, IBGE), with a tendency to co-location to consumer services.

TABLE 3.
Macroregional TiVA according to a large group of sectors

Origin	Primary sector			Secondary sector			Tertiary sector		
	Intrastate	Interstate	International	Intrastate	Interstate	International	Intrastate	Interstate	International
Midwest	4.271	19.482	12.692	7.212	15.098	3.921	172.667	97.682	13.425
	12%	53%	35%	27%	58%	15%	61%	34%	5%
Northeast	15.692	22.047	10.203	21.190	16.370	6.702	338.609	64.161	17.344
	33%	46%	21%	48%	37%	15%	81%	15%	4%
North	6.103	14.445	22.893	6.026	14.608	4.381	111.763	25.823	8.312
	14%	33%	53%	24%	58%	18%	77%	18%	6%
Southeast	60.871	38.224	75.552	165.228	93.895	52.885	1.201.877	251.640	120.781
	35%	22%	43%	53%	30%	17%	76%	16%	8%
South	12.485	23.562	13.928	35.049	64.642	18.590	311.785	87.393	26.321
	25%	47%	28%	30%	55%	16%	73%	21%	6%
Total TiVA	**99.421**	**117.760**	**135.268**	**234.705**	**204.614**	**86.478**	**2.136.701**	**526.699**	**186.184**

Source: Authors based on results. 2021.

FIGURE 8.
Services in interregional VA flows (BRL million)



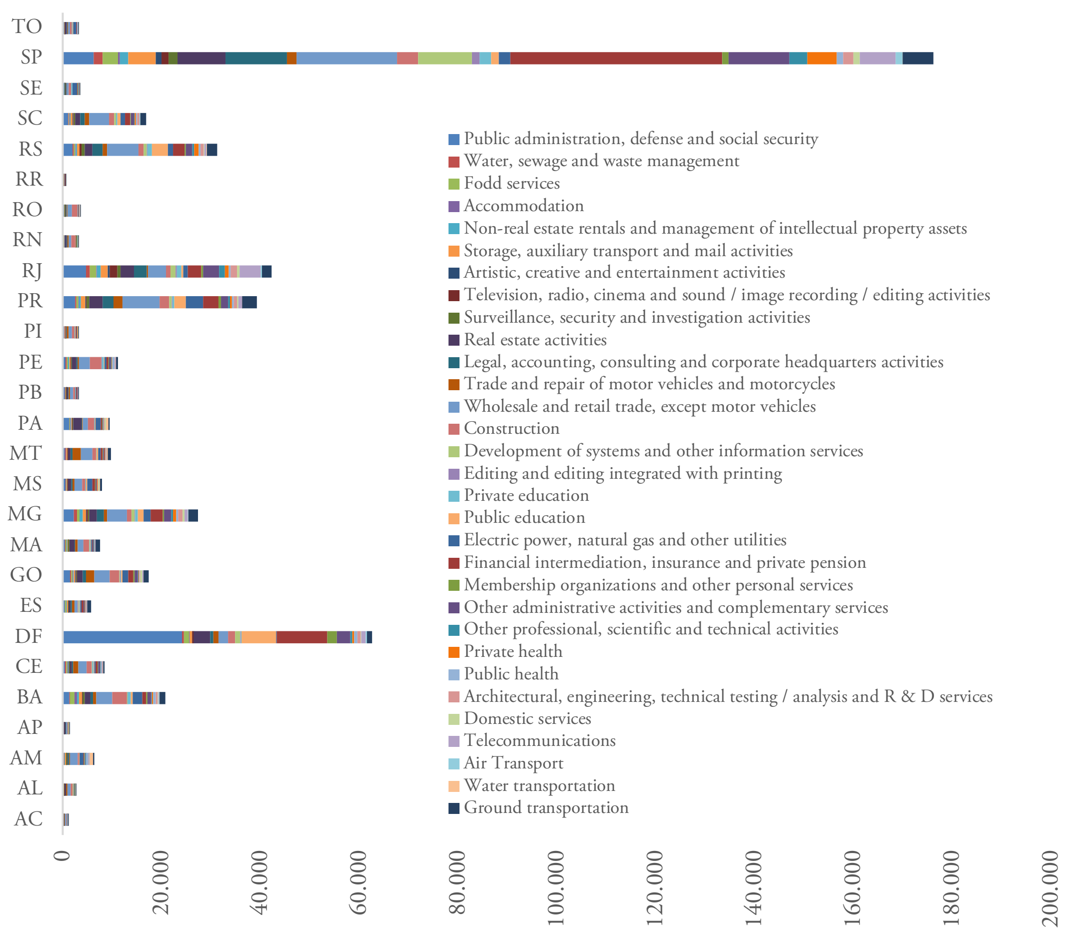
Source: Authors based on results. 2021.

Services operate in all stages of production, from conception until distribution. Nevertheless, the intensity of local value-added embedded into these steps differs considerably. As discussed, the creation and transfer of value-added are essential for regional development and the potential for linkages with other sectors and regions, directly and indirectly contributing to production and trade at the local level. The spatial organization of service provision is revealed by the hierarchical structure of the economic areas, where there is a high concentration of the provision of services incorporated into the interregional flows originating in São Paulo (Figure 9). Some of these service inputs are horizontal because they are necessary for any type of company in any value chain. In contrast, others are specific to certain value chains in the manufacturing sector. For example, financial services represent the largest share of supply from São Paulo to other states. There is a reproduction of international logic in business services, which explicitly distinguish between horizontal activities (consultancy, accounting, training) and vertical activities (investment research, risk analysis, insurance, etc.). Most of this group of activities does not require physical proximity between companies, where providers can take advantage of the economies of scale and agglomeration offered by the large urban centres of São Paulo.

The contribution of other states to the value-added service network is not negligible. The Southern, Southeastern, and Northeastern states also present proportionally similar (in size) and heterogeneous holdings in sectoral composition to domestic service networks. The complexity of regional economies can be assessed by assessing the content of services incorporated into production networks. To complement this zoom-in of services activities inside the country, we apply classical spatial clustering analysis based on services companies' locations. Specifically, we compute LISA indicators that show us the location and significance of clusters in the space. Numerous theories have been developed about the location decisions of firms. These decisions depend on several factors, including the availability of basic resources, transport costs, labour supply, and agglomeration economies (Cuadrado-Roura, 2013). In the case of firms in the service sector, the literature has found spatial concentration with the presence of specialized labour pools and externalities (Coffey & Polése, 1987; Haddad & Araújo, 2021).

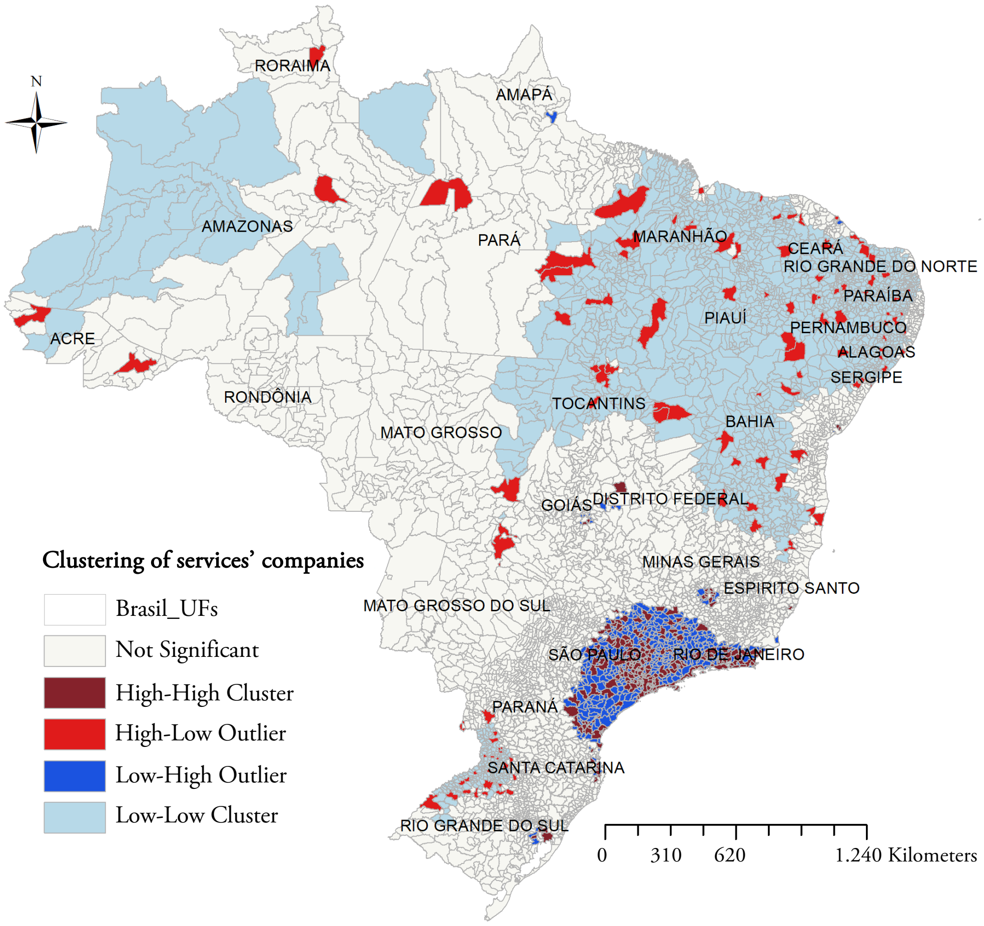
This spatial concentration of services firms can be observed in Figure 10, which shows the LISA indicator for companies in the country and its statistical significance. Companies are strongly concentrated in the Southeast states, mainly Sao Paulo and Rio de Janeiro. In the previous section, we found that these regions are the prominent productive linkages, as well as greater supply indicators. The data presented allowed us to contrast how value generation in services is also concentrated in specific areas of each state, as it increases urban agglomerations. The application of a spatial autocorrelation test made it possible to verify this premise and reject the hypothesis that value chain formation occurs in spatially random regions. Service companies' spatial distribution reveals a positive trend towards clustering, as shown by the Moran's I local index. There is a positive tendency to clustering services companies in the largest urban areas, mainly in Sao Paulo and Rio de Janeiro, as well the Rio Grande do Sul and Federal District (Brazil's capital).

FIGURE 9.
Services value-added activities at the state's level. (BRL millions)



Source: Authors based on results. 2021.

FIGURE 10.
Local Moran's I test



Source: Authors based on results. 2021.

6. CONCLUSIONS

Spatial variations at the subnational level are evidenced in Brazil, in which the production networks' architecture has been considered an aspect-oriented to regional development. The mobility of production factors regarding the service's activities could be conceived as an essential engine for dealing with location patterns across regional hierarchies as a matter of the strategic position of companies and local assets development opportunities (Atienza et al., 2020; Fold, 2014; Timmer et al., 2019). Therefore, intra-country spatial variations become relevant mechanisms to enhance the competitiveness of the regions and promote structural changes that allow the generation of quality linkages.

Our interstate input-output application allowed us to capture the relative dimension of tertiary industries' linkages, pointing out the opportunities for regional growth. We found that the spatial patterns of services' companies imply unequal regional opportunities for promoting strong high-tech linkages. The business services can be considered a key point to increase local capacities to the creation of long-run connections. Therefore, the higher average productivity in agglomerations results in the selection of companies to prioritizing large urban concentrations.

The spatial impacts resulting from the distribution of services raise doubts about the role of clusters and agglomerations to promote regional convergence. The higher share of services-related activities on the total value-added created and transferred across networks indicates the potential of geographic proximity. Regional functional specialization can be considered the key to connectivity through service linkages. Policies linked to services content in trade lead to the removal of essential trade frictions, helping to increase competitiveness and productivity at the regional level. Logistical, transport cost and trade facilitation issues explain the increase in trade flows and dispersion of the potential of large distance services' linkages. However, on the intraregional scale, the role of services becomes relevant in Brazil. The servicification of activities is based on a horizontal strategy to companies' operations, and the ability of tertiary activities to relocate based on urban characteristics reveals a geography pattern inside the country (Hauknes & Knell, 2009; Zighan et al., 2021).

Based on our results, the promotion of tertiary activities in peripheries areas towards diversification is interesting. The potential for the connectedness of services at the intrastate level can be an important starting point to promote innovative systems away from large urban areas in the richest Brazilian core regions. The experience of the Southeast in successful cluster services' sector is forwards related to the ability to move services supply chains, despite the non-dependency geography and resources-based to operate efficiently. The orientation towards the creation of agglomeration increases the potential for linkages at the subnational and international levels, becoming a powerful instrument for anchoring territorial development.

The study opens the way for research on the determinants and links between interindustry relations across services supply chains. The literature suggests that the advantages of location influence a region's ability to generate competitiveness and centralize the aggregation of value to production. However, it is notorious for examining how national production is shaped in inter-sectoral terms, where the present analysis allows us to show whether the production of export goods occurs entirely within the country. The supply of intermediate inputs and raw materials for the final product sold for other regions is based on the productive base at the national level. Inter-regional fragmentation, that is, the exchange of national production, plays a role when it focuses on the regions. Domestic verticalization is intimately linked to fragmentation at the international level, in which regional income trends have recently become more dependent on the extent to which subnational regions can contribute to value chains. The limitations of this analysis include the fact that we have not considered all the elements raised by the literature for the decomposition of the value-added and that the view to the sectors was not better evidenced, where it is possible to analyse the exports of the states towards the exterior.

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Annex

Table A1.
Industries of Interstate Input-Output Model for Brazil

Sector Code	Description	Industry
S1	Agriculture, including support for agriculture and post-harvest	Primary sector
S2	Livestock, including support for livestock	Primary sector
S3	Forestry production fisheries and aquaculture	Primary sector
S4	Extraction of mineral coal and non-metallic minerals	Primary sector
S5	Oil and gas extraction, including support activities	Primary sector
S6	Iron ore extraction, including beneficiation and agglomeration	Primary sector

TABLE A1. CONT.
Industries of Interstate Input-Output Model for Brazil

Sector Code	Description	Industry
S7	Extraction of non-ferrous metallic minerals, including processing	Primary sector
S8	Slaughter and meat products, including dairy and fishery products	Secondary sector
S9	Sugar manufacture and refining	Secondary sector
S10	Other food products	Secondary sector
S11	Beverage Manufacturing	Secondary sector
S12	Manufacture of tobacco products	Secondary sector
S13	Manufacture of textile products	Secondary sector
S14	Manufacture of clothing artifacts and accessories	Secondary sector
S15	Manufacture of footwear and leather goods	Secondary sector
S16	Manufacture of wood products	Secondary sector
S17	Manufacture of cellulose, paper and paper products	Secondary sector
S18	Printing and playback of recordings	Secondary sector
S19	Oil refining and coking plants	Secondary sector
S20	Manufacture of biofuels	Secondary sector
S21	Manufacture of organic and inorganic chemicals, resis and elastomers	Secondary sector
S22	Manufacture of pesticides, disinfectants, paints and various chemicals	Secondary sector
S23	Manufacture of cleaning products, cosmetics / perfumery and personal hygiene	Secondary sector
S24	Manufacture of pharmaceutical chemicals and pharmaceutical products	Secondary sector
S25	Manufacture of rubber and plastic products	Secondary sector
S26	Manufacture of non-metallic mineral products	Secondary sector
S27	Production of pig iron / ferroalloys, steel and seamless steel tubes	Secondary sector
S28	Non-ferrous metal metallurgy and metal casting	Secondary sector
S29	Manufacture of metal products, except machinery and equipment	Secondary sector
S30	Manufacture of computer equipment, electronic and optical products	Secondary sector
S31	Manufacture of maquis and electrical equipment	Secondary sector
S32	Machinery and mechanical equipment manufacturing	Secondary sector
S33	Manufacture of cars, trucks and buses, except parts	Secondary sector
S34	Manufacture of parts and accessories for motor vehicles	Secondary sector
S35	Manufacture of other transport equipment, except motor vehicles	Secondary sector
S36	Manufacture of furniture and products from different industries	Secondary sector
S37	Maintenance, repair and installation of machinery and equipment	Secondary sector
S38	Electricity, natural gas and other utilities	Tertiary sector
S39	Water, sewage and waste management	Tertiary sector
S40	Construction	Tertiary sector
S41	Trade and repair of motor vehicles and motorcycles	Tertiary sector
S42	Wholesale and retail trade, except motor vehicles	Tertiary sector
S43	Ground transportation	Tertiary sector

TABLE A1. CONT.
Industries of Interstate Input-Output Model for Brazil

Sector Code	Description	Industry
S44	Water transportation	Tertiary sector
S45	Air Transport	Tertiary sector
S46	Warehousing, auxiliary transport and mail activities	Tertiary sector
S47	Accommodation	Tertiary sector
S48	food	Tertiary sector
S49	Editing and editing integrated with printing	Tertiary sector
S50	Television, radio, cinema and sound / image recording / editing activities	Tertiary sector
S51	Telecommunications	Tertiary sector
S52	Development of systems and other information services	Tertiary sector
S53	Financial intermediation, insurance and private pension	Tertiary sector
S54	Real estate activities	Tertiary sector
S55	Legal, accounting, consulting and corporate headquarters activities	Tertiary sector
S56	Architectural, engineering, technical testing / analysis and R and D services	Tertiary sector
S57	Other professional, scientific and technical activities	Tertiary sector
S58	Non-real estate rentals and management of intellectual property assets	Tertiary sector
S59	Other administrative activities and complementary services	Tertiary sector
S60	Surveillance, security and investigation activities	Tertiary sector
S61	Public administration, defense and social security	Tertiary sector
S62	Public education	Tertiary sector
S63	Private education	Tertiary sector
S64	Public health	Tertiary sector
S65	Private health	Tertiary sector
S66	Artistic, creative and entertainment activities	Tertiary sector
S67	Membership organizations and other personal services	Tertiary sector
S68	Domestic services	Tertiary sector

Source: Based on National Accounting System. IBGE.

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Articles

Crecimiento del empleo 'intensivo en conocimiento' en ciudades de México, 2004-2019

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Resumen:

En este artículo se analizan los cambios que ha experimentado el empleo en Servicios Intensivos en Conocimiento (SIC) en las ciudades de México entre 2004 y 2019. Metodológicamente, se define el sector servicios según intensidad y tipo de conocimiento, y se aplican las técnicas shift-share dinámico y análisis de clúster. Los resultados indican que el crecimiento de los SIC es producto principalmente de las condiciones que cada ciudad ofrece, las cuales no solo están definidas por su tamaño sino por su localización geográfica y sus vínculos interurbanos. Sin embargo, el desempeño de los SIC pone en entredicho las capacidades competitivas de las economías urbanas del país en la economía global.

Palabras clave: Actividades intensivas en conocimiento; componentes del crecimiento; sistema urbano.

Clasificación JEL: O14; R11; R12.

Knowledge-Intensive Employment Growth in Mexican Cities, 2004-2019

Abstract:

This article analyzes the changes in employment in Knowledge Intensive Services (KIS) in Mexican cities between 2004 and 2019. Methodologically, the service sector is defined according to intensity and type of knowledge, and the dynamic shift-share and the cluster analysis are applied. The results indicate that the growth of KIS is mainly the product of the conditions that each city offers, which are not only defined by their size but also by their geographic location and interurban links. The performance of KIS though calls into question the competitive capacities of the country's urban economies in the global economy.

Keywords: Knowledge-intensive activities; components of growth; urban system.

JEL Classification: O14; R11; R12.

1. Introducción

Las Actividades Intensivas en Conocimiento (AIC), son una pieza clave en la economía global. Las AIC tienen una función central al operar como generadoras y articuladoras de distintas fuentes de conocimiento en diferentes escalas espaciales (Simmie & Strambach, 2006). Además, tienen una estrecha relación con el ámbito urbano (Camagni, 2003). Su crecimiento ha sido definido como un indicador del avance y éxito de la economía de las ciudades (Antonelli & Tubiana, 2020), y se han visto incrementadas

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y aceleradas como resultado del impulso tecnológico derivado, en parte, de la pandemia de COVID-19 (Lund et al., 2021); al tiempo que han tenido efectos disruptivos en general, por el desarrollo de la inteligencia artificial (IA), no solo en la industria o los servicios (Santiago, 2020), sino en el comportamiento social de los individuos y de la población en general (Zuboff, 2019).

El estudio del comportamiento de las AIC se orienta a analizar los servicios que representan en la actualidad la parte mayoritaria de actividad económica (Piketty, 2014) y, en particular, los servicios. La literatura sobre estos servicios se ha centrado en su distribución espacial (Pérez-Campuzano et al., 2016), su contribución económica (Brenner et al., 2018) o su participación en la estructura productiva (Berglund et al., 2020). Y se subraya el papel de las grandes ciudades, que concentran la mayor proporción del crecimiento (absoluto y relativo) de los SIC. Dicho crecimiento es atribuido a la combinación de factores locales y no locales que incentivan la generación de *spillovers* (Shearmur & Polése, 2007). Sin embargo, con algunas excepciones (Hansen & Winther, 2018; Song et al., 2010; Vilchis et al., 2022), el análisis del cambio de los SIC entre ciudades se ha llevado a cabo en forma agregada sin distinguir la proporción atribuible al desarrollo nacional, al desempeño de la industria y a las condiciones propias de cada ciudad. No distinguir entre estos componentes limita las posibilidades de precisar las condiciones que favorecen o desalientan el crecimiento del empleo en una ciudad (Martin et al., 2016).

El objetivo central de este trabajo es analizar las características económicas y espaciales del cambio (positivo y negativo) que ha experimentado el empleo en SIC en las ciudades de México entre 2004 y 2019. El trabajo es relevante por dos razones. Primero, el crecimiento de los SIC no se ha enfocado a las ciudades del sur global a pesar de su importancia (López & Ramos, 2013). Segundo, el crecimiento de los SIC no ocurre espacial y sectorialmente de forma aleatoria, de tal manera que considerar el conjunto de ciudades del sistema urbano nacional permite distinguir aquellas que reúnen las condiciones económicos y espaciales específicas que impulsan su desarrollo, y abrir distintas posibilidades para formular estrategias encaminadas al impulso de las ciudades como futuros motores de desarrollo en la economía del conocimiento.

El texto se organiza en cuatro apartados después de esta introducción. En el primero, se aborda conceptualmente la importancia de los SIC, su relación con la competitividad urbana y las características interurbanas de su crecimiento. En el segundo, se definen los SIC con base en el Sistema de Clasificación de América del Norte (SCIAN), la clasificación de ciudades, el instrumental estadístico y las fuentes de información empleadas para el trabajo. En el tercero, se exponen los resultados del análisis, destacando los diferentes componentes del cambio y participación y los clústeres identificados. En el cuarto, se presentan reflexiones finales sobre las implicaciones futuras del desempeño que mostraron los SIC en las economías locales. Finalmente, se enlistan las referencias bibliográficas que se citan en el texto.

2. Elementos conceptuales: competitividad, crecimiento y ciudades

2.1. El conocimiento como factor de competitividad

En un mundo en donde la economía de ciudades, regiones y países depende de la forma en que se han integrado en la economía global, su localización, diversificación o especialización resultan ser los factores que ofrecen ventajas o desventajas a unas y otras.

Las ventajas dependen no solo de su productividad o la tasa de salarios en relación con otras localizadas fuera del ámbito geográfico donde operan. Sus resultados están también determinados por las economías de aglomeración, tanto de urbanización como de localización externas a la empresa y a la industria en particular. Tales economías se logran a partir de asociaciones en proximidad (Camagni, 2003). En tal proceso participan organizaciones civiles, mercantiles, académicas, gubernamentales, de investigación y desarrollo, en un ámbito que propicia contactos cara a cara, relaciones sociales y culturales, e intercambio de conocimiento tácito e innovaciones que pueden desarrollarse en la forma de circuitos o redes o bien espaciales (geográficas) en forma de conjuntos, o clústeres localizados de actividad económica que intensifica el medio socio-cultural (Dicken, 2003, pp. 69–71) o, como insiste Camagni (2003) crea un *milieu innovador.*

2.2. Factores que explican el crecimiento de los SIC

Los SIC han sido definidos como una pieza clave en la economía global gracias a las funciones que desempeñan en los sistemas de innovación en distintas escalas (ciudad, región, nacional, internacional o global) (Simmie & Strambach, 2006). La localización y crecimiento de SIC en una ciudad se entiende como indicador del avance y el éxito en la economía del conocimiento, al existir una estrecha relación entre los niveles de innovación y la creciente especialización en ese tipo de actividades económicas (Antonelli & Tubiana, 2020; van Winden et al., 2007). Asimismo, el crecimiento positivo o negativo de los SIC en un sistema urbano apuntan a que éste no sigue la jerarquía urbana (Shearmur, 2010) sino que privilegia grandes ciudades (Chadwick et al., 2008; Eriksson & Hansen, 2013; González-López, 2009; Wood, 2006). Sin embargo, trabajos recientes han identificado que los SIC también muestran tasas de crecimiento sobresalientes en ciudades medias especializadas en sectores económicos dinámicos (Shearmur, 2010), localidades relativamente próximas a las grandes ciudades (Chadwick et al., 2008; Hansen & Winther, 2018), ciudades que configuran corredores industriales (Almejo et al., 2013) y regiones metropolitanas (Vilchis-Mata et al., 2021).

El crecimiento de los SIC en el conjunto de estas localidades se ha explicado a partir de: 1) factores 'locales' y 2) factores 'no locales'. Los primeros se vinculan principalmente con su demanda por otros sectores y otros segmentos de los mismos SIC (Araya et al., 2020; Vendrell-Herrero et al., 2020; Vilchis-Mata et al., 2021), así como por sectores orientados a la extracción de materias primas (Shearmur, 2010). La respuesta de los SIC a esta demanda puede ser realizada en el sitio o desde la distancia a partir del uso de los sistemas de comunicaciones y transporte, siendo esto último ejecutado principalmente por los localizados en las grandes metrópolis (Shearmur, 2010).

Adicional a lo anterior, se ha indicado que el crecimiento de los SIC en una ciudad se explica por externalidades tipo Jacobs, medidas a través de variables proxy tales como el grado de diversidad de la estructura económica local (Bishop, 2009), niveles de dotación de capital humano (Simon, 1998), complejidad y competitividad de los mercados a los que responde ese tipo de servicios (Howells, 2002), existencia de una sólida infraestructura institucional para el desarrollo de negocios (Parkinson et al., 2015) y dotación de amenidades urbanas que incentivan el intercambio de conocimiento formal e informal (Clark et al., 2002).

El segundo conjunto de factores, se asocia a características exógenas a la ciudad, e incluye elementos macroeconómicos tales como ciclos y crisis económicas (Shearmur, 2010; Sisti & Goena, 2020), interrelaciones entre unidades espaciales (Vilchis et al., 2022) y ventajas comparativas (Sobrino, 2016).

En la realidad ambos factores se interconectan, operan de manera simultánea y, en algunos casos, principalmente los locales, son susceptibles a la intervención gubernamental (Shearmur & Polése, 2007). El análisis de estos procesos adquiere mayor complejidad al identificarse que los anteriores factores cambian a través del espacio y el tiempo; es decir, lo que en un momento es importante para el desempeño positivo de los SIC en una ciudad puede no funcionar en otro momento y otra ciudad (Shearmur et al., 2007). Adicionalmente, tales factores operan de forma distinta según el tipo de SIC al que se haga referencia (Blažek & Kadlec, 2019). En otras palabras, el crecimiento de los SIC no ocurre en el vacío, sino que está estrechamente vinculado al resto de la economía y las condiciones sociales e institucionales de cada ciudad.

2.3. Componentes del crecimiento

La larga tradición en el análisis del crecimiento privilegia la variable empleo e indica que éste resulta de la combinación de tres componentes básicos: 1) el desarrollo nacional, 2) el desempeño de cada sector industrial y 3) las condiciones locales (Barff & Knight, 1988; Jones, 2012).

Los trabajos de Song et al. (2010) y Eriksson y Hansen (2013) han cuantificado la contribución de cada componente en el desempeño del empleo en SIC en ciudades de Estados Unidos y regiones de Suecia, respectivamente. Martin et al. (2016) han mostrado en su estudio la evolución del empleo en las ciudades y regiones del Reino Unido entre 1982 y 2013 y de qué manera específica la proporción del crecimiento del empleo es atribuible a las condiciones locales (componente local). Con lo anterior en mente, es posible suponer que factores locales y no locales, que explican los cambios de los SIC entre las ciudades, tienen distintos efectos y relaciones sobre los componentes de su crecimiento (nacional, estructura o mezcla industrial y local). En este trabajo nos preguntamos si al comparar el componte local del crecimiento del empleo en SIC entre las ciudades es posible identificar factores específicos (locales y no locales) que contribuyan a definir políticas urbanas diferenciadas dirigidas a promocionar este tipo de servicios. En el siguiente apartado exponemos la estrategia metodológica que hemos desarrollado para resolver dicha pregunta.

Cuadro 1.
Definición de SIC y SNIC

Actividad según 'intensidad' y 'tipo' de conocimiento	Subramas en SCIAN (subramas)	Definición
1. SIC	61131	Educación superior
A- SIC-Analítico	62231	Medicina especializada
	54171, 54172	Investigación y desarrollo
B- SIC-Sintético		
	51121, 54133, 54136, 54151, 54169	Ingeniería y alta tecnología
	54121, 54161, 55111	Administrativos
	54111, 54112, 54119	Legales
	52111, 52221, 52222, 52311, 52321, 52391, 52399	Financieros
	61121, 61141, 61143, 61163	Educación técnica
	62111, 62121, 62131, 62132, 62133, 62134, 62139, 62211, 62221	Medicina no especializada
	54162, 54193, 54194, 54199, 61171	Diversos
C- SIC-simbólico		
	51111, 51112, 51113, 51511, 51512, 51521, 51913, 54181, 54182, 54184, 54186, 54191, 54192, 61162, 71121, 71131, 71132, 71141	Medios masivos
	51211, 51219, 51221, 51222, 51223, 51224, 61161, 71111, 71112, 71113, 71119, 71151, 71211	Cultural
	54131, 54132, 54141, 54142, 54143, 54149	Diseño
2. SNIC		
	El resto de las subramas de los sectores: 51, 52, 53, 54, 55, 56, 61, 62, 71, 72 y 81	

Nota: 51: Información en medios masivos, 52: Servicios financieros y de seguros, 53: Servicios inmobiliarios y de alquiler de bienes muebles e intangibles, 54: Servicios profesionales, científicos y técnicos, 55: Corporativos, 56: Servicios de apoyo a los negocios y manejo de residuos y desechos, y servicios de remediación, 61: Servicios educativos, 62: Servicios de salud y de asistencia pública, 71: Servicios de esparcimiento culturales y deportivos, y otros servicios recreativos, 72: Servicios de alojamiento temporal y de preparación de alimentos y bebidas, 81: Otros servicios excepto actividades gubernamentales, 72: Servicios de alojamiento temporal y de preparación de alimentos y bebidas, 81: Otros servicios excepto actividades gubernamentales.
Fuente: Recuperado de Santiago (2020).

3. Estrategia metodológica

3.1. Definición de SIC y unidades espaciales de análisis

En este trabajo utilizamos la propuesta de Santiago (2020) que permite definir el sector servicios según su 'intensidad' y 'tipo' de conocimiento. Con base en el SCIAN los SIC se conforman por 75 sub-ramas, agrupadas en tres categorías, tomando como referencia el trabajo de Asheim (2012), a saber: 1) 'analíticos' (4 subramas), dedicados a la producción de conocimiento científico; 2) 'sintético' (36 subramas), orientados a la producción de conocimiento técnico; y 3) 'simbólico' (35 subramas), especializados en conocimiento artístico y cultural. La distinción por tipo de conocimiento permitirá conocer si cada uno tiene diferente comportamiento a través del tiempo y espacio. El resto de los servicios se consideran no intensivos en conocimiento (SNIC) y corresponden a las sub-ramas de los sectores 51, 52, 53, 55, 56, 61, 62, 71, 72 y 81 que no se identificaron como SIC (Cuadro 1).

Para el análisis se incluyen localidades (ciudades) que conforman el sistema urbano nacional (SUN) de México en 2012 (Sedesol & Conapo, 2012). Se trata de 382 de éstas con información en los censos económicos (CE) para el periodo de 2004 a 2019. Estas ciudades concentran 74.6 millones de habitantes (63.3% de la población del país). Se han clasificado en siete grupos según el tamaño de su población. Adicionalmente, se distingue entre ciudades del mismo tamaño según su localización central (C) o periférica (P). Las ciudades centrales son aquellas localizadas a una distancia no mayor de 1.5 horas en automóvil de una de las 11 ciudades de un millón y más habitantes (tamaños I y II). Las periféricas son aquellas que no cumplen con la anterior condición (Cuadro 2). Realizar esta última distinción permite tener una aproximación a la relación del desempeño de los SIC y al papel que juega el factor tecnológico.

Cuadro 2.
México: Clasificación de ciudades según tamaño y localización

Tamaño	Rango (millones)	n	2010		2020	
			Absoluto (millones)	%	Absoluto (millones)	%
México			112.34	100.00	126.01	100.00
SUN		382	81.18	72.26	92.08	73.07
I	2.00 y más	4	31.39	27.94	34.74	27.57
II	1.00 y 1.99	7	9.98	8.89	11.57	9.19
III	0.50 y 0.99	22	16.46	14.66	19.29	15.31
III-c		5	3.79	3.38	4.37	3.47
III-p		17	12.67	11.28	14.92	11.84
IV	0.25 y 0.49	22	7.78	6.92	9.09	7.21
IV-c		5	1.93	1.72	2.19	1.74
IV-p		17	5.84	5.20	6.90	5.47
V	0.10 y 0.24	40	6.19	5.51	7.60	6.03
V-c		13	2.07	1.84	2.37	1.88
V-p		27	4.12	3.66	5.22	4.15
VI	0.05 y 0.09	40	2.81	2.50	2.99	2.37
VI-c		16	1.09	0.97	1.10	0.87
VI-p		24	1.72	1.53	1.89	1.5
VII	0.015 y 0.049	247	6.57	5.85	6.80	5.39
VII-c		87	2.29	2.04	2.34	1.86
VII-p		160	4.29	3.82	4.46	3.54

Nota: SUN=Sistema Urbano Nacional; 'c'=ciudades centrales; 'p'=ciudades periféricas.
Fuente: elaboración propia, la población de 2010 con información del Censo de Población y Vivienda 2010 de INEGI; la población de 2020 del Sistema Urbano Nacional de Conapo. Ciudades 'centrales' (c) son aquellas que no están más allá de una distancia de 1.5 horas en automóvil sobre una carretera principal y ciudades 'periféricas' (p) son aquellas que están fuera de ese rango temporal.

3.2. Fuentes de información y técnicas de análisis

La variable utilizada para analizar los cambios de los SIC en las ciudades de México es el personal ocupado (PO). El PO de cada ciudad se obtiene de los microdatos de los CE de 2004, 2009, 2014 y 2019 disponibles en el Laboratorio de Microdatos de INEGI (Instituto Nacional de Estadística y Geografía) comparables entre sí (INEGI, 2020). Utilizar los CE tiene dos limitantes: 1) la información que ofrecen es exclusiva del empleo formal y deja fuera el informal y 2) al ofrecer información con base en establecimientos industriales existe la posibilidad de que las cifras del empleo 'intensivo en conocimiento' estén mezcladas con 'no intensivo en conocimiento'. La primera limitante es especialmente relevante para el caso de México, cuyo empleo informal representa poco más de 50% de la economía nacional (INEGI, 2018), y es muy probable que exista empleo informal ocupado en SIC. Sin embargo, se considera que esto último es menor dado que la mayor proporción del empleo informal se ocupa en actividades comerciales y se caracteriza por sus bajos niveles de calificación y habilidades (OECD, 2015). Aunque en el caso de los SNIC su contribución podría ser todavía mayor a la que se presenta en este trabajo. Sobre la segunda limitante una posible solución es utilizar encuestas de empleo, pero el nivel de desagregación sectorial y espacial que ofrecen esas fuentes de información en México no permiten estudiar el conjunto de ciudades que aquí se pretende. Aunque se reconocen estas limitantes consideramos que los resultados obtenidos a partir de su uso permiten alcanzar el objetivo central del trabajo.

Para conocer el comportamiento de los SIC y SNIC en el tiempo se utiliza como indicador el 'incremento porcentual' cuya expresión matemática es:

$$I_i = \left(\left((e_{i1}/e_{i0})^{(1/t)}\right) - 1\right) \times 100 \tag{1}$$

donde: I_i = el incremento porcentual del personal ocupado en la ciudad i entre el año inicial y el año final; e_{i0} = el personal ocupado en la ciudad i en el año inicial del periodo analizado; e_{i1} = el personal ocupado en la ciudad i en el año final del periodo analizado; t= magnitud del periodo de estudio.

En este trabajo utilizamos la propuesta formulada por Jones (2012), la cual es una variante del shift-share dinámico. Esta variante tiene la ventaja de que los resultados pueden ser acumulados y expresados en tasas de cambio (en lugar de valores absolutos). Los resultados permiten comparaciones entre ciudades al ponderar la contribución relativa de cada industria a la economía local en el período base. Por lo tanto, las bases de empleo de la industria relativamente más grandes serán más importantes para contribuir a efectos agregados de participación en el cambio. Esta técnica permite identificar los tres componentes básicos del cambio en el empleo: 1) efecto nacional, 2) efecto de la mezcla industrial y 3) efecto local. La técnica se describe algebraicamente en Jones (2012, pp. 1349–1351).

Una vez identificados los componentes del crecimiento de los SIC, se exploran las condiciones que enmarcan el 'efecto local'. Al igual que Martin et al. (2016, p. 290) el análisis se concentra en este último componente al asumir que refleja las condiciones localizadas de cada ciudad que no pueden ser explicadas por la tendencia nacional o atribuibles a la estructura de la industria. Para ello se lleva a cabo un ejercicio de análisis clúster (*cluster analysis*) combinando el método jerárquico y no jerárquico para su elaboración. El primer método se utiliza para definir la 'semilla' que es utilizada posteriormente en el método no jerárquico. Para el método no jerárquico se utiliza el algoritmo de *k*-medias y como medida de similitud la distancia euclidiana. El número óptimo de clústeres se establece a partir de los cambios en los coeficientes de aglomeración obtenido del método no jerárquico.

No existen series de datos a nivel ciudad para algunas variables independientes y todas las ciudades analizadas. Por lo tanto, se utilizan los valores de los indicadores más próximos al año inicial del estudio con el propósito de conocer las condiciones que sentaron las bases para el desarrollo de los SIC. En particular, se analizan las diferencias y las similitudes en términos de las características económicas, urbanas y laborales solo de 117 ciudades cuyo efecto local fue superior al promedio del sistema urbano. Las variables empleadas se presentan en el Cuadro 3, las cuales son estandarizadas en el ejercicio debido a sus distintas escalas. Aunque la aplicación del análisis de clúster puede ser discutida, principalmente por el uso del residual del efecto local como variable central para su definición, los resultados permiten tener una aproximación al perfil económico y espacial de las ciudades donde los SIC han presentado crecimiento, lo cual no sería posible solo utilizando la técnica del shift-share. En el siguiente apartado se presentan los resultados empíricos.

Cuadro 3.
Variables empleadas en el análisis de clúster

		Descriptivos				
Variables	**Indicador**	**Min.**	**Med.**	**Max.**	**d.s.**	**Fuente**
Componente del crecimiento						
1. Efecto local	Tasa de crecimiento	0.44	1.43	25.19	2.43	A
Jerarquía urbana						
2. Tamaño de ciudad	% de población	0.00	0.15	5.12	0.55	B
Conocimiento						
3. Capital humano	% población 18 años y más con educación posbásica	0.00	0.15	6.06	0.63	B
Actividades productivas						
4. Manufacturas	Cociente de localización	0.10	0.85	2.67	0.62	C
5. SIC	Cociente de localización	0.09	0.45	1.12	0.21	C
6. SNIC	Cociente de localización	0.25	0.89	2.78	0.38	C
7. Amenidades urbanas	Cociente de localización	0.19	1.44	15.92	1.59	C
8. Conectividad	Cociente de localización	0.00	0.81	5.62	0.82	C
9. Diversidad económica	Índice de diversidad económica	1.84	3.86	7.30	1.18	C
Riqueza/Proxy consumo						
10. Niveles de riqueza	Valor agregado per cápita	15.16	141.03	5400.16	500.57	C

Nota: A-Cambio-participación de este artículo; B-Censo de Población y Vivienda, 2000; C-Censos Económicos 2004 del Laboratorio de Microdatos, proyecto LM-727. El cociente de localización calculado en su forma convencional y el índice de diversidad económica con la fórmula 4 de Duranton y Puga (2000, p. 535). Ambos indicadores estimados con la variable: personal ocupado.
Fuente: elaboración propia.

4. Resultados. Cambios y participación de los componentes 2004-2019

4.1. Descriptivos generales

El empleo formal (personal ocupado) del país tuvo un incremento absoluto de 9.69 millones, al pasar de 13.63 a 23.32 millones de individuos entre 2004 y 2019. Ese crecimiento representó un incremento porcentual de 71.15%. Los SIC mostraron un ritmo de crecimiento ligeramente menor al promedio nacional durante dicho periodo: 70.5% al aumentar de 1.12 a 1.91 millones de empleados formales. Los SIC crecieron con incrementos absolutos y porcentuales relativamente similares durante los quinquenios de 2004-2009 y 2014-2019. Sin embargo, el ritmo de crecimiento de ese grupo de industrias se contrajo durante el quinquenio de 2009-2014 (Cuadro 4).

En términos de la estructura interna de los SIC la categoría de servicios con mayor crecimiento relativo fueron los SIC-analítico que casi duplicaron su empleo entre 2004 y 2019. En términos absolutos los SIC-sintético fueron los de mayor crecimiento, que representó poco más de 70% del incremento absoluto de los SIC durante dicho periodo. Las tres categorías tuvieron un crecimiento relativamente similar en el quinquenio inicial (2004-2009) y en los subsiguientes experimentaron crecimientos diferenciados.

Cuadro 4.
México: Empleo total, participación y cambio en SIC y SNIC: 2004-2019 (millones)

	2004	2009	2014	2019	2004-09	2009-14	2014-19	2004-19
	Absoluto				Cambio (absoluto)			
Total	13.630	16.607	19.145	23.328	2.976	2.539	4.183	9.698
Servicios	4.078	5.675	7.617	9.788	1.597	1.943	2.171	5.711
SIC	1.125	1.433	1.571	1.918	0.308	0.139	0.346	0.793
Analítico	0.140	0.175	0.269	0.280	0.035	0.094	0.010	0.139
Sintético	0.767	0.980	1.016	1.331	0.214	0.036	0.315	0.565
Simbólico	0.218	0.277	0.286	0.307	0.060	0.008	0.021	0.089
SNIC	2.953	4.242	6.046	7.871	1.289	1.804	1.825	4.918
	%				Cambio (%)			
Total	100.00	100.00	100.00	100.00	21.84	15.29	21.85	71.15
Servicios	29.92	34.17	39.79	41.96	39.16	34.24	28.50	140.05
SIC	8.25	8.63	8.21	8.22	27.36	9.69	22.04	70.50
Analítico	1.03	1.05	1.41	1.20	24.65	53.83	3.81	99.04
Sintético	5.62	5.90	5.31	5.71	27.86	3.69	30.99	73.67
Simbólico	1.60	1.67	1.49	1.32	27.34	3.04	7.42	40.95
SNIC	21.66	25.54	31.58	33.74	43.66	42.53	30.18	166.54

Fuente: Elaboración propia con información de Censos Económicos de INEGI.

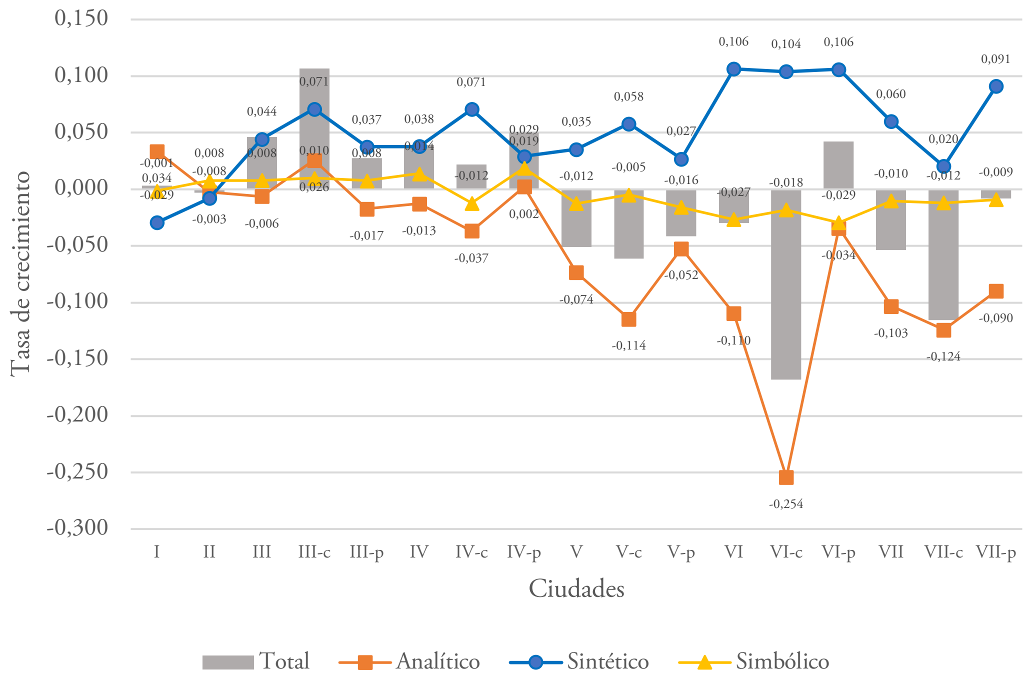
Los SNIC (Servicios No Intensivos en Conocimiento) tuvieron un crecimiento muy por encima del promedio nacional, como era de esperarse dada la tendencia de terciarización de la economía. Su incremento porcentual fue de 166.54%, que en términos absolutos significó un aumento de 4.9 millones de empleos, alcanzando 50.71% del empleo nacional (Cuadro 4). Los anteriores resultados indican que el crecimiento (positivo y negativo) de los SIC se encuentra asociado a los periodos de crecimiento y los momentos de crisis económicas, tal como ocurrió en 2008 y que se ve reflejado diferencialmente en el quinquenio 2009-2014.

4.2. Efectos de la 'mezcla industrial'

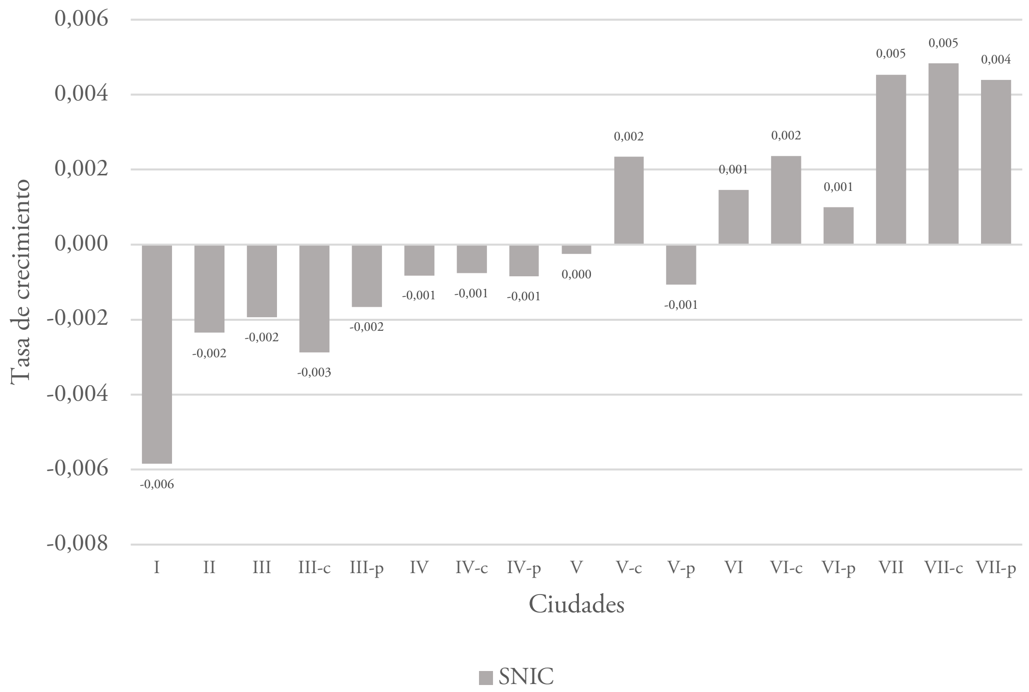
La Gráfica 1 muestra el balance de la contribución de la mezcla industrial al crecimiento de los servicios según su intensidad y tipo de conocimiento durante el periodo 2004-2019. Los cambios durante el periodo (2004-2019) indican aquellas ciudades donde los SIC tuvieron un desempeño positivo: grandes metrópolis (tamaño I) y ciudades intermedias (tamaños III y IV). Al distinguir la localización centro y periferia de esas ciudades, sobresale el efecto positivo que tuvo la mezcla industrial en las ciudades centrales de tamaño III y periféricas de tamaño IV. Un segundo conjunto son ciudades en las cuales los SIC tienen un efecto negativo: ciudades de tamaño II y las que ocupan la base de la jerarquía urbana (tamaño V, VI y VII). En estas ciudades el efecto negativo de la mezcla industrial ocurrió casi independientemente de la localización de las ciudades (Gráfica 1-a). Por otra parte, los SNIC, se caracterizan por tener una mezcla industrial opuesta a los SIC. Es decir, las ciudades donde los SIC tienen pérdidas los SNIC muestran valores positivos (Gráfica 1-b).

GRÁFICA 1.
Sistema Urbano: Contribución del componente 'mezcla industrial' al crecimiento de SIC y SNIC: 2004-2019

(a)



(b)

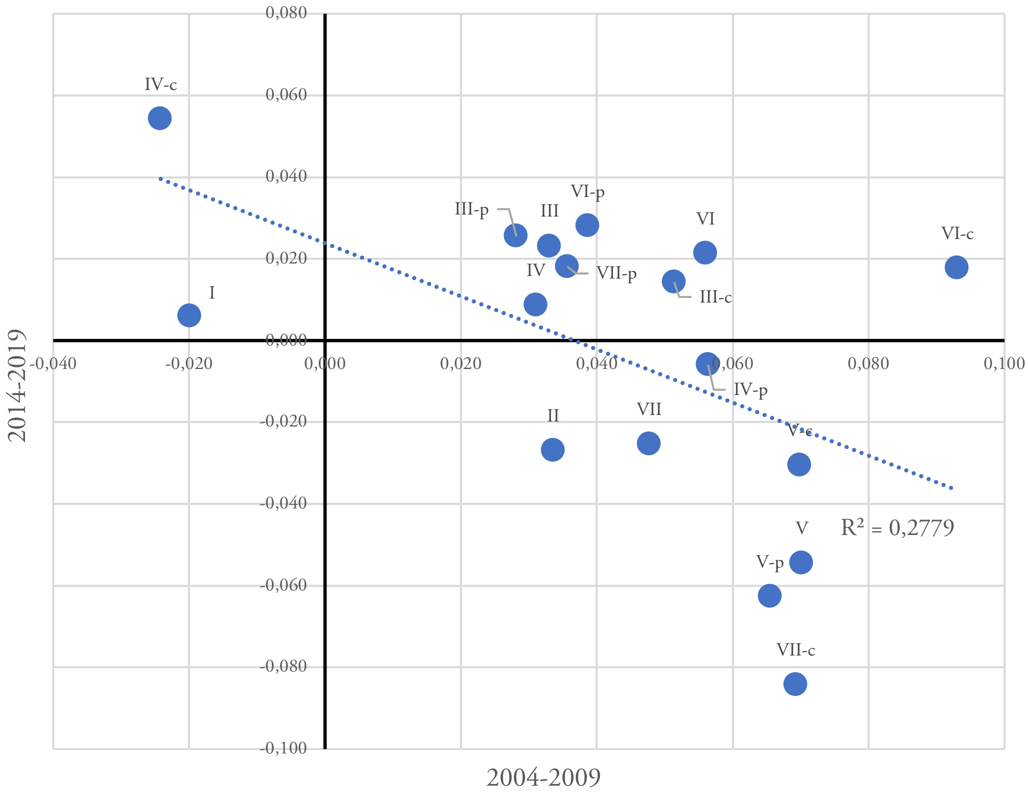


Nota: El Total es resultado de la suma de la contribución de los SIC analítico, sintético y simbólico en cada ciudad.
Fuente: elaboración propia con información de microdatos de los Censos Económicos de INEGI, proyecto LM-727.

En cada uno de los anteriores conjuntos de ciudades el efecto de su mezcla industrial es resultado de la combinación del desempeño que tuvieron los SIC según el tipo de conocimiento que desarrollan. En el primer conjunto, las metrópolis nacionales fueron impulsadas por los SIC-analítico mientras que en las ciudades intermedias fueron los SIC-sintético y simbólico. En el segundo conjunto, el desempeño negativo en las ciudades de tamaño II es atribuible a los SIC-analítico y sintético, y en el resto de las ciudades a los SIC-analítico y simbólico. Destaca que los SIC-sintético presentaron crecimiento en todas las ciudades del conjunto independientemente de su localización (Gráfica 1-a).

¿El efecto de la mezcla industrial ha beneficiado o afectado a las mismas ciudades a lo largo del periodo de análisis? La relación negativa que existe entre el efecto de la mezcla industrial de los SIC del quinquenio final (2014-2019) y el quinquenio inicial (2004-2009) indica que las ciudades que inicialmente fueron beneficiadas por la dinámica de crecimiento de esos servicios al final del periodo habían perdido esa ventaja (Gráfica 2). La mezcla industrial durante el quinquenio final (2004-2019) es resultado de la "sacudida" que tuvo el sector previo al periodo 2009-2014, la cual tuvo efectos diferenciados según el tipo de conocimiento que desarrollan los SIC a través de los conjuntos de ciudades. Los anteriores resultados indican que el efecto de la 'mezcla industrial' de los SIC no sigue la jerarquía y la localización de las ciudades en el país. Es decir, son otros los elementos que explican el desempeño de los SIC que, junto con los hallazgos de los subsiguientes apartados, son analizados en el apartado final del artículo.

Gráfica 2.
Sistema Urbano: 'Mezcla industrial' de SIC, 2004-2009 vs 2014-2019



Fuente: elaboración propia con información de microdatos de los Censos Económicos de INEGI, proyecto LM-727.

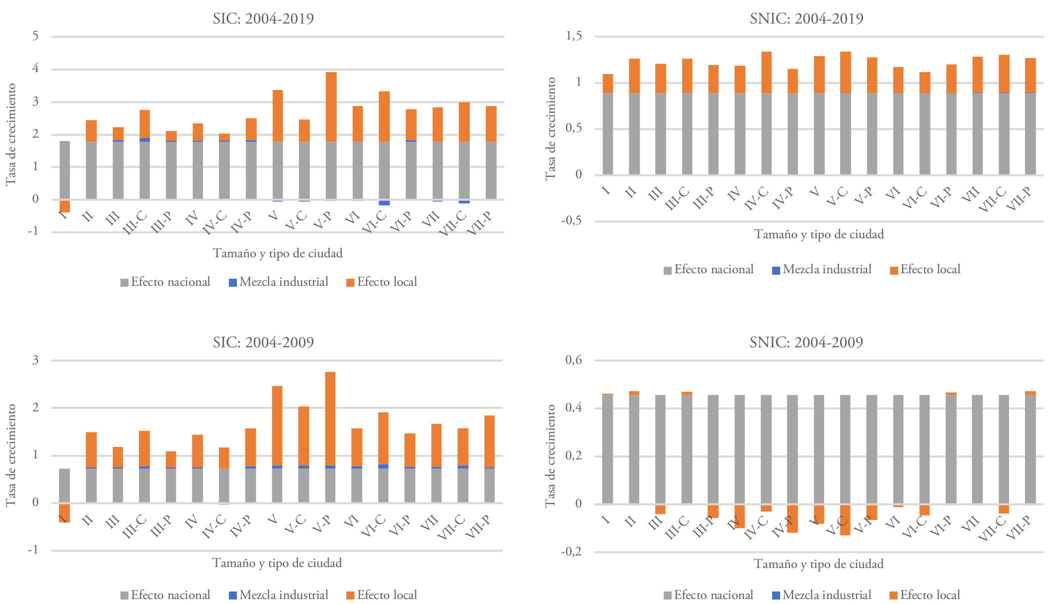
4.3. El 'Efecto local'

En el Cuadro 5 se muestra la participación de las condiciones locales al crecimiento de los SIC durante el periodo 2004-2019. Siguiendo a Jones (2012), las celdas del cuadro muestran el efecto de la relocalización del empleo por industria, ya sea dentro (valores positivos) o fuera (valores negativos) de cada grupo de ciudades. Los efectos locales de cada quinquenio son sumados en la última columna para conocer el comportamiento general de los servicios según 'intensidad' y 'tipo' de conocimiento que desarrollan. Los resultados de esa columna indican dos rasgos en el comportamiento de los SIC. Primero, la pérdida de empleo que esos servicios tuvieron en las ciudades de tamaño I. Segundo, el incremento que tuvieron los SIC en el resto de los conjuntos de ciudades (II al VII). En el primer caso, la pérdida ocurrió en todas las categorías de SIC. En el segundo, las tres categorías de SIC avanzaron positivamente en prácticamente todas las ciudades independientemente de su localización centro-periferia. Destaca que la categoría de SIC-analítico fue la de mayor crecimiento y decrecimiento en las ciudades con un efecto local positivo y negativo, respectivamente. Los SNIC, por su parte, han tenido un incremento relativamente similar a través de todos los conjuntos de ciudades.

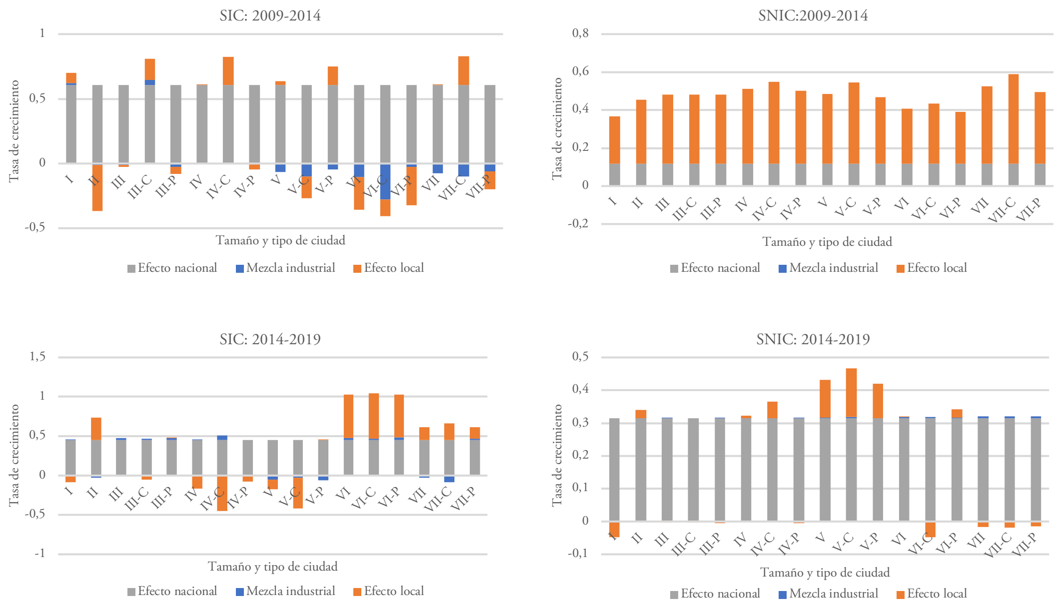
El análisis de los cambios en la estructura interna de los SIC en los tres quinquenios indica que los dos rasgos descritos previamente no han sido constantes en el tiempo. En 2004-2009, con excepción de los SIC localizados en las grandes metrópolis, las tres categorías de esos servicios presentaban un proceso de expansión. Esto último espacialmente se revirtió en los SIC-sintético y simbólico y continuó en los SIC-analítico en el quinquenio 2009-2014. En el último quinquenio (2014-2019) solo los SIC-sintético avanzaron en las ciudades de tamaño I y II y retrocedieron en prácticamente el resto. Los SIC-analítico se han concentrado en las ciudades de tamaño II y las que ocupan la base de la jerarquía urbana (V, VI y VII). Los SIC-simbólico han incrementado su presencia en ciudades de rangos II, III y VII, principalmente. En el caso de los SNIC sobresale su comportamiento relativamente opuesto al de los SIC especialmente en el quinquenio de contracción económica (2009-2014) cuando los SNIC crecieron con tasas relativamente similares en prácticamente todo el sistema urbano nacional.

La Grafica 3 muestra el acumulado de los efectos nacional, industrial y local de los SIC para grupos de ciudades. Resalta la reducida aportación que tiene la mezcla industrial en el crecimiento de los SIC en prácticamente todas las ciudades y la importancia de las condiciones locales como principal componente del crecimiento (positivo y negativo) durante el periodo (2004-2019). Con el propósito de delinear las características de las condiciones locales que impulsaron el desarrollo de los SIC se realiza un ejercicio de clúster análisis con las ciudades que tuvieron efecto local positivo.

GRÁFICA 3.
Sistema Urbano: Resumen del análisis Shift-Share de SIC y SNIC: 2004-2019



Gráfica 3. cont.
Sistema Urbano: Resumen del análisis Shift-Share de SIC y SNIC: 2004-2019



Fuente: elaboración propia con información de microdatos de los Censos Económicos de INEGI, proyecto LM-727.

4.4. Perfil económico-espacial del crecimiento de los SIC

En esta sección se exploran las condiciones que enmarcan el 'efecto local' del crecimiento que registraron los SIC a través del sistema urbano de México entre 2004 y 2019. Para ello, se lleva a cabo un ejercicio de análisis de conglomerados (*clúster*). El resultado del ejercicio permite identificar que nueve clústeres o grupos de ciudades explican casi 70% (Coeficiente de Aglomeración=0.682) de las variaciones en los valores de las variables indicadas previamente. La Gráfica 4 indica los valores medios de las variables empleadas para construir los clústeres. El análisis del perfil de las variables utilizadas para el análisis de clústeres indica la presencia de 7 *outliers* entre las 117 ciudades seleccionadas, los cuales fueron omitidos debido a su gran influencia sobre la construcción de los clústeres. A continuación, se describen las particularidades de cada clúster de ciudades, el número entre paréntesis indica el número de ciudades que conforma cada uno de ellos y su representación espacial se hace en el Mapa 1.

CUADRO 5.
Sistema Urbano: Contribución del componente 'efecto local' al crecimiento de SIC y SNIC: 2004-2019

Tamaño de ciudad	Rango (millones)	n	2004-2009					2009-2014					2014-2019					2004-2019				
			SIC				SNIC	SIC				SNIC	SIC				SNIC	SIC				SNIC
			Total	A	B	C		Total	A	B	C		Total	A	B	C		Total	A	B	C	
I	2.00 y más	4	-0,380	-0,190	-0,146	-0,044	0,006	0,078	-0,098	0,102	0,075	0,247	-0,088	-0,058	0,034	-0,063	-0,045	-0,389	-0,346	-0,011	-0,033	0,209
II	1.00 y 1.99	7	0,740	0,384	0,384	-0,028	0,017	-0,359	-0,177	-0,179	-0,003	0,334	0,286	0,088	0,000	0,198	0,025	0,667	0,294	0,206	0,167	0,377
III	0.50 y 0.99	22	0,428	0,072	0,247	0,109	-0,040	-0,014	0,214	-0,113	-0,115	0,362	-0,008	-0,031	-0,057	0,080	-0,004	0,406	0,255	0,077	0,074	0,318
III-c		5	0,749	0,294	0,278	0,177	0,013	0,163	0,234	-0,103	0,032	0,363	-0,050	-0,053	-0,116	0,119	-0,003	0,861	0,476	0,058	0,328	0,373
III-p		17	0,345	0,012	0,238	0,094	-0,054	-0,056	0,208	-0,115	-0,149	0,361	0,005	-0,024	-0,040	0,069	-0,004	0,294	0,196	0,083	0,015	0,303
IV	0.25 y 0.49	22	0,683	0,332	0,213	0,138	-0,097	0,007	0,200	-0,072	-0,121	0,391	-0,162	-0,069	-0,113	0,019	0,007	0,527	0,464	0,028	0,036	0,301
IV-c		5	0,452	0,079	0,255	0,118	-0,029	0,220	0,196	-0,064	0,089	0,430	-0,451	-0,168	-0,091	-0,192	0,049	0,221	0,107	0,099	0,015	0,450
IV-p		17	0,792	0,448	0,202	0,142	-0,115	-0,046	0,201	-0,075	-0,173	0,381	-0,069	-0,035	-0,119	0,085	-0,006	0,677	0,614	0,008	0,055	0,260
V	0.10 y 0.24	40	1,668	1,071	0,389	0,207	-0,079	0,031	0,215	-0,122	-0,063	0,366	-0,117	0,064	-0,121	-0,060	0,115	1,581	1,350	0,147	0,085	0,402
V-c		13	1,233	0,723	0,329	0,181	-0,127	-0,168	0,043	-0,213	0,002	0,427	-0,384	-0,140	-0,097	-0,147	0,148	0,681	0,627	0,019	0,036	0,447
V-p		27	1,975	1,344	0,414	0,217	-0,063	0,146	0,317	-0,085	-0,086	0,348	0,008	0,163	-0,129	-0,025	0,104	2,129	1,823	0,200	0,106	0,389
VI	0.05 y 0.09	40	0,799	0,636	0,092	0,072	-0,008	-0,247	-0,063	-0,095	-0,089	0,287	0,551	0,520	0,020	0,011	0,001	1,103	1,093	0,017	-0,007	0,280
VI-c		16	1,090	0,979	0,010	0,101	-0,044	-0,127	0,128	-0,168	-0,087	0,316	0,576	0,480	0,010	0,085	-0,047	1,538	1,587	-0,149	0,100	0,225
VI-p		24	0,709	0,503	0,146	0,060	0,010	-0,300	-0,159	-0,051	-0,090	0,273	0,548	0,541	0,026	-0,019	0,026	0,957	0,885	0,120	-0,049	0,309
VII	0.015 y 0.049	247	0,895	0,519	0,161	0,215	-0,001	0,001	0,087	0,050	-0,137	0,407	0,164	0,180	-0,150	0,134	-0,016	1,060	0,786	0,061	0,213	0,389

CUADRO 5. CONT.

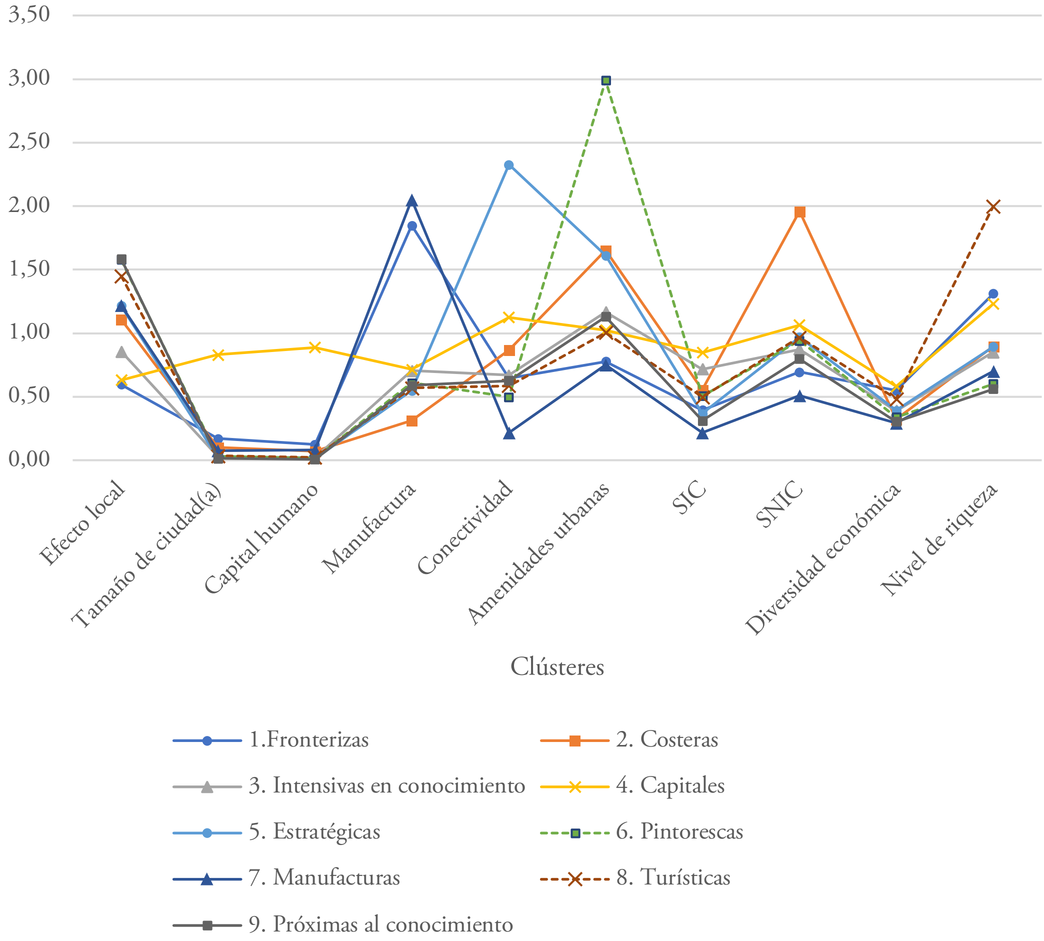
Sistema Urbano: Contribución del componente 'efecto local' al crecimiento de SIC y SNIC: 2004-2019

Tamaño de ciudad	Rango (millones)	n	2004-2009					2009-2014					2014-2019					2004-2019				
			SIC				SNIC	SIC				SNIC	SIC				SNIC	SIC				SNIC
			Total	A	B	C		Total	A	B	C		Total	A	B	C		Total	A	B	C	
VII-c		87	0,784	0,185	0,229	0,370	-0,035	0,224	0,217	0,193	-0,186	0,469	0,211	0,224	-0,215	0,202	-0,019	1,218	0,625	0,207	0,386	0,414
VII-p		160	1,078	0,809	0,123	0,147	0,016	-0,139	0,009	-0,036	-0,111	0,377	0,147	0,147	-0,103	0,103	-0,015	1,086	0,964	-0,016	0,139	0,378

Nota: SIC= Servicios Intensivos en Conocimiento, A= Analítico, B=Sintético, C=Simbólico y SNIC=Servicios No Intensivos en Conocimiento. Se realiza la distinción en el tamaño de las ciudades según su localización, donde c= Ciudades Centrales y p=Ciudades Periféricas.

Fuente: elaboración propia con información de microdatos de los Censos Económicos de INEGI, proyecto LM-727.

Gráfica 4.
Perfiles de variables de elaboración de clústeres (valores medios)



Nota: las 7 ciudades *outliers* del ejercicio fueron: San Miguel El Alto y Magdalena (Jalisco), Salinas de Hidalgo (San Luis Potosí), Guaymas (Sonora), Motozintla (Chiapas), Miahuatlán (Oaxaca) y Tacámbaro (Michoacán). La semilla inicial que se obtuvo con el método jerárquico = 3. Coeficiente de Aglomeración = 0.682.
(a) Indica el tamaño promedio de las ciudades de cada clúster expresados en términos de su participación en el total de las 382 ciudades que se analizan.
Fuente: Elaboración propia con información de Microdatos de los Censos Económicos 2004 y Censo de Población y Vivienda 2000.

MAPA 1.
México: Clúster de crecimiento de SIC, 2004-2019

Fuente: elaboración propia con información de los resultados del Cuadro 7.

1. *Ciudades fronterizas* (7). Su principal característica es su localización. La estructura económica de éstas indica una fuerte presencia de manufacturas que se desarrollan en una economía diversificada. Son ciudades con una importante dotación de capital humano y alto valor agregado per cápita, lo cual podría sugerir altos niveles de productividad. En estos casos los SIC aprovecharon la proximidad de estas ciudades con Estados Unidos y la orientación productiva local para incrementar su presencia durante el periodo analizado. Ejemplos de este conjunto de ciudades son: Mexicali, Piedras Negras, Nogales, San Luis Rio Colorado, Camargo y Sabinas.

2. *Ciudades costeras* (4). Principalmente localizadas en la costa del Pacífico y cuya principal actividad económica es el turismo de playa. Su estructura económica local se caracteriza por servicios de baja calificación, muy posiblemente vinculados a la atención de turistas, pero generadores de alto valor añadido. El crecimiento de los SIC en estas ciudades podría ser resultado de la demanda de servicios para la actividad turística del lugar, principalmente hotelera. En este grupo de ciudades se encuentran los destinos turísticos de Puerto Vallarta, Los Cabos y Huatulco.

3. *Ciudades intensivas en conocimiento* (16). Este grupo está conformado por ciudades menores a 100 mil habitantes con una sobresaliente especialización en SIC, dentro de una estructura económica local diversificada. Además, son ciudades relativamente alejadas de las grandes urbes del país. Estas particularidades sugieren que el crecimiento de los SIC en ellas fue resultado de la demanda local, lo que generó la expansión de los mercados de dichos servicios fuera de las grandes urbes. Ejemplos de las ciudades que conforman este clúster son: Tulancingo, San Cristóbal de las Casas, Dolores Hidalgo, Arandas y Sayula.

4. *Ciudades capitales* (6). Son ciudades donde se combina su condición de capital estatal y su peso demográfico, el cual oscila en el millón de habitantes (tamaños de ciudades II y III del Cuadro 2). Gracias a la combinación de esas dos características cuentan con infraestructura que les permite establecer vínculos internacionales, ser sedes de instituciones generadoras de conocimiento (universidades y centros de investigación), tener una estructura económica diversificada y, en algunos casos, contar con sectores industriales altamente especializados (automotriz, aeronáutica, arte y cultura). El crecimiento de los SIC en estas ciudades puede ser atribuido a economías de urbanización. Este grupo está constituido por las ciudades de Querétaro, San Luis Potosí, Pachuca, Xalapa, Zacatecas y Mazatlán.

5. *Ciudades estratégicas* (11). El resultado positivo de los SIC en estas ciudades puede ser explicado por las funciones de logística. Se trata de importantes puertos comerciales y de pasajeros, cuya función estratégica es ser paso obligado a otras ciudades de mayor tamaño e importancia regional. Estas funciones están reflejadas en su especialización en los sectores de transporte y logística. Es el caso de las ciudades de Manzanillo, Cozumel, Navolato, Tula, Pabellón de Arteaga, Ocotlán de Morelos, Ixtepec y Comalapa.

6. *Ciudades pintorescas* (13). Este conjunto de ciudades se caracteriza por ser pequeñas localidades urbanas que pertenecen al conjunto de tamaño VII que cuentan con alta dotación de amenidades locales, atractivos turísticos, cualidades ambientales y/o una imagen urbana pintoresca. Estas cualidades, que en algunos casos se combinan con su proximidad a una gran urbe, parecen ser atractivas para cierto sector de empleos creativos y con alto contenido de conocimiento, los cuales buscan evitar los costos de habitar en las grandes metrópolis, aprovechar los beneficios de su proximidad a ellas y/o disfrutan de las cualidades del entorno que ofrecen. Ejemplos de estas ciudades son: Cuautla, Ajijic, Ahualulco, Jocotepec, Cintalapa, Teocaltiche, Puerto Escondido, Miahuatlán y Tres Valles.

7. *Ciudades de manufacturas* (14). Conjunto de ciudades cuya principal característica es su especialización en manufacturas. Existen ciudades orientadas a la producción de automóviles, textiles, alimentos y/o artesanías. El crecimiento de los SIC en estas ciudades es resultado de su respuesta a la demanda local, que ofrece oportunidades para el desarrollo de ciertos segmentos de SIC altamente especializados. Entre este grupo de ciudades se encuentra: San Francisco del Rincón, Tepeji de Ocampo, Ciudad Acuña, Yurécuaro, San Miguel El Alto, Izamal, Peto, Tekax y Ticul.

8. *Ciudades turísticas o culturales* (15). El rasgo principal de estas ciudades es su perfil turístico orientado hacia el arte y la cultura. La actividad turística de estas ciudades, soportada en su capital arquitectónico y/o simbólico, se desarrolla en una estructura económica diversificada, con niveles de consumo relativamente altos y cierta dotación de servicios no intensivos en conocimiento. El crecimiento de los SIC en estas ciudades puede atribuirse a la concentración de empleos creativos, artistas y diseñadores que responden a la demanda de turistas y habitantes locales. Ciudades de este conjunto son: Guanajuato, Huamantla, Abasolo, San José del Cabo, Ixmiquilpan, Felipe Carrillo Puerto, Heroica Caborca, Heroica Ciudad De Cananea y Puerto Peñasco.

9. *Ciudades próximas al conocimiento* (24). En este caso son localidades urbanas de tamaño VII (entre 15 mil y 50 mil habitantes) con dos rasgos distintivos: 1) su relativa especialización en transporte y logística y 2) su proximidad a una ciudad del clúster 3 (ciudades intensivas en conocimiento). Estas características indican que los SIC localizados en el clúster 3 han generado cierta derrama (*spillovers*) de conocimiento en las localidades urbanas aledañas a ellos. Este rasgo es indicativo de dos características del crecimiento de los SIC: 1) la importancia de la proximidad espacial a "donde está ocurriendo la acción" para su desarrollo y 2) su crecimiento tiene efectos que no se restringen al ámbito local.

Los anteriores resultados indican la heterogeneidad de las condiciones en las que ocurre el crecimiento de los SIC. El análisis de las características internas de los clústeres indica que, aunque todas las ciudades tuvieron resultados positivos en términos de su 'factor local', los que tuvieron mejores desempeños en términos de SIC fueron aquellas que pertenecen a los clústeres 9, 6 y 8, según orden de importancia. En el siguiente apartado presentamos las reflexiones finales sobre los anteriores hallazgos.

5. Discusión y reflexiones finales

Los resultados indican que el crecimiento de los SIC no sigue sistemáticamente la jerarquía urbana y la localización centro-periferia de las ciudades. El desempeño de los SIC, sin embargo, tampoco ocurre de forma azarosa. Se identifican tres conjuntos de ciudades según el desempeño de los componentes 'mezcla industrial' y 'efecto local', considerando que el 'efecto nacional' es idéntico para todas. Primero, las ciudades donde los dos efectos son positivos: ciudades de tamaño intermedio (conjuntos III y IV). El crecimiento de los SIC en esas ciudades sugiere que éste es producto de la respuesta que hacen a la especialización productiva que generalmente caracteriza a esas urbes (Duranton & Puga, 2000). Sin embargo, el efecto sobresaliente de la mezcla industrial en las ciudades periféricas (IV-p) y centrales (III-c) indica dos lógicas distintas. En el primer caso, se trata de una respuesta que hacen los SIC directamente "en el lugar" donde se desarrolla la actividad productiva (Shearmur, 2010). El segundo caso está vinculado con las grandes metrópolis del país.

En el segundo conjunto, las ciudades se caracterizan por una mezcla industrial negativa y un efecto local positivo. Se trata de las ciudades de entre uno y dos millones de habitantes (tamaño II) y aquellas que ocupan la base del sistema urbano (tamaños: V, VI y VII). El comportamiento de los componentes del shift-share indica que son las ciudades que se han visto principalmente afectadas por la contracción que vivió el sector derivado de la crisis económica de 2008. A pesar de esto último son ciudades donde las condiciones locales han tenido resultados sobresalientes en el impulso de SIC orientados a la producción científica (analítico) y el desarrollo del arte y la cultura (simbólico), principalmente. La diversidad de condiciones a través de las cuales en estas ciudades se impulsa, deliberada o involuntariamente, a los SIC dentro de sus economías se ve reflejado en los perfiles de clústeres identificados en este trabajo. En este caso toma especial relevancia la asociación entre el crecimiento de los SIC (simbólico) y el sector turístico con distintos enfoques: playa, cultural y ambiental. Esto último indica la importancia que tienen las condiciones estéticas y ambientales del entorno urbano para el crecimiento de esos servicios (Clark et al., 2002) y amplía las posibilidades de la existencia de articulaciones productivas a través de las cuales se presenta el crecimiento de los SIC en el ámbito urbano más allá de las manufacturas (Sisti & Goena, 2020; Vendrell-Herrero et al., 2020).

El tercer conjunto incluye las grandes metrópolis (tamaño I) caracterizadas por una mezcla industrial positiva y un efecto local negativo. Este resultado sugiere que el desempeño positivo de los SIC en esas ciudades es principalmente una respuesta a la demanda externa (regional y/o nacional) si se considera su centralidad (Shearmur & Doloreux, 2008) y que las condiciones locales (efecto local) no fueron favorables para el desarrollo de esos servicios. Esta respuesta "a la distancia" se da apoyada en el uso de las tecnologías de la información y comunicación que ofrecen dichas ciudades y de las cuales son usuarios intensivos los empleados en SIC (Delgado & Mills, 2020). El desempeño positivo de las grandes metrópolis y las ciudades de tamaño intermedio centrales a ellas (III-c) –señalado previamente- en las tres categorías de SIC (analítico, sintético y simbólico) sugiere la posible configuración de sistemas de innovación locales y regionales en diferentes áreas de la economía del conocimiento (van Winden et al., 2007), lo cual parece no estar restringido a la región central del país (Vilchis et al., 2022) ya que los resultados apuntan a la participación de otras grandes ciudades del país en dicha configuración. Corroborar estas últimas ideas, sin embargo, requiere llevar a cabo investigaciones con otras herramientas (cualitativas y cuantitativas) que permitan identificar las características de dichos sistemas y distinguir algunas de sus contribuciones (positivas y negativas) en el sistema urbano del país.

Por último, una lección general del trabajo es que al igual que otros estudios se advierte que los SIC no operan en el vacío económico y social (Araya et al., 2020; Corrocher & Cusmano, 2014). Los resultados obtenidos indican que el crecimiento de los SIC no solo está definido por el tamaño de las ciudades sino por la localización geográfica y los vínculos que existen entre ellas, para lo cual el factor tecnológico juega un papel central. A pesar del carácter exploratorio del estudio, una de sus principales limitantes, permite identificar que existen distintas posibilidades para la inserción de algunas ciudades del país en la economía del conocimiento. Para ello es necesaria la implementación de políticas industriales e innovación que trabajen en distintas escalas espaciales (Breznitz, 2021), cuyo principio debe partir del impulso al desarrollo de capital humano incrementando el nivel y la calidad de escolaridad de la población, además de fortalecer los vínculos productivos específicos que se están desarrollando entre SIC y otras industrias locales. Avanzar en la definición y la aplicación de tales políticas permitirá impulsar las economías urbanas del país como futuros motores de desarrollo en la economía del conocimiento.

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Resources and Book Reviews

The Great Reset. 2021 European Public Investment Outlook

Cerniglia, F., Saraceno, F. y Watt, A. (Eds.) (2021)
Open Book Publishers
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El libro "The Great RESET. 2021 European Public Investment Outlook" constituye una excelente referencia dirigida a aquellos investigadores interesados en ahondar en el inédito papel atribuido a la inversión pública en la Unión Europea (UE) de la mano del Plan de Recuperación Next Generation EU (NGEU) para contrarrestar los efectos de la pandemia y, asimismo, generar nuevas oportunidades ligadas a un modelo de crecimiento sostenible que promueva la cohesión económica, social y territorial. A través de esta obra, el lector tendrá oportunidad de reflexionar, de la mano de grandes expertos internacionales, acerca del estratégico papel que la inversión está llamada a jugar en el presente, y sobremanera en el futuro. En palabras del profesor Olivier Blanchard, "this book is simply essential reading".

La estructura del libro es una combinación de ensayos, en los que se analiza con gran pormenor la inversión pública en la UE desde dos ángulos distintos pero complementarios: por un lado, describiendo la evolución de la inversión pública en Europa y en un amplio espectro de países europeos (Francia, Alemania, Italia, Polonia y España), con especial atención a la respuesta política dada a la pandemia y a los respectivos planes de recuperación económica en el marco del NGEU; por otro, analizando los retos suscitados por la pandemia en materia de inversión pública y los ámbitos estratégicos a los que debe ir dirigida la misma para que la EU pueda afrontar los desafíos de hoy y del futuro en un contexto geopolítico especialmente convulso.

La primera parte del libro comienza con el capítulo a cargo de A. Brasili, A. Kolev, D. Revoltella y J. Schanz, quienes ponen de relieve la existencia de amplias brechas de inversión pública en la UE en las últimas dos décadas, potenciadas por los objetivos, cada vez más ambiciosos, de transición digital y verde. En un contexto extraordinariamente favorable de bajos costes de financiación y de suspensión provisional de las reglas fiscales en la EU, los autores ponen especial énfasis en que los gobiernos nacionales hagan un buen uso de los fondos que permita a las economías europeas reconstruir más y mejor. Dentro del amplio número de estudios de caso que incluye la primera parte del libro, quisiera hacer alusión al caso español, abordado por J. Villaverde y A. Maza. En su análisis de la inversión pública en España de 2000 a 2020, destacan que, en el año 2020, debido a una postura política más relajada y anti-cíclica de Bruselas, el esfuerzo inversor creció un 2,6%, alcanzando, de esta forma, un nivel mayor que la media de 2000-2009. Se apunta, asimismo, que de cumplirse la previsión de inversión pública recogida en el Plan de Recuperación, Transformación y Resiliencia español para el periodo 2021-2026, de en torno al 4% del PIB, España aspiraría a cerrar la brecha con la media de la UE y, algo aún no menos importante, a conseguir que las inversiones netas sean positivas por primera vez desde 2011.

La segunda parte del libro arranca con un capítulo específico dedicado al efecto *crowding in-out* de la inversión pública, escrito por L. Durand, R. Espinoza, W. Gbohoui y M. Sy. En el mismo se destaca el papel de la inversión pública como motor de crecimiento, así como su capacidad para ampliar el stock de capital y mejorar la productividad, elementos, sin duda claves, para afrontar las dañinas consecuencias de la pandemia. Los autores ofrecen, asimismo, una interesante reflexión sobre la existencia de un peligroso *trade-off* entre eficiencia y velocidad en la materialización de las inversiones asociadas a los fondos del NGEU.

Siguiendo con la segunda parte del libro, los siguientes capítulos abordan algunas de las prioridades de gasto establecidas por el NGEU. Una de ellas, claramente estratégica, es la inversión en transformación digital, tema abordado en el capítulo 10 por D. Rückert, R. Veugelers, A. Virginie y C. Weiss. A partir de datos de la Encuesta de Inversión del Banco Europeo de Inversiones, los autores constatan una creciente polarización digital en el seno de la UE. Especialmente revelador resulta el hecho de que una parte sustancial de las empresas de la muestra no utiliza ninguna tecnología digital y, sobremanera, que dichas empresas "no digitales" no consideren prioritaria la inversión en transformación digital para contrarrestar los efectos de la reciente crisis sanitaria. Su recomendación va dirigida a la eliminación de obstáculos a las competencias y a la infraestructura digital, así como a la creación de condiciones apropiadas para fomentar la inversión en transformación digital.

El libro continúa con otra de las prioridades de gasto en inversión, como es la lucha contra el cambio climático y la transición energética. La UE se ha comprometido a reducir las emisiones de gases de efecto invernadero en 2030 al menos un 55% respecto a 1990, y a ser neutral desde el punto de vista climático para 2050. El primer objetivo no puede alcanzarse sin una ingente inversión, preocupación sobre la que versa el capítulo 11 a cargo de C. Jaeger, D. Mangalagiu y J. Teitge. Los autores sostienen que la respuesta sin precedentes de la UE a la pandemia podría contribuir significativamente a cumplir el objetivo 2030. Con todo, existen grandes desafíos pendientes. Uno de ellos, si no el más importante, es que las actuales ayudas de la UE tienen fecha de caducidad y que los países tendrán que empezar a devolverlas en 2028, antes, por tanto, de poder generar un rendimiento razonable. De ahí su recomendación de extender los planes de expansión del flujo de inversión pública de la UE para la generación de renovables más allá de 2023. Por lo que respecta al objetivo 2050, el capítulo 12, de M. Holzner, K. Weber, M. U. Zahid y M. Zangl, propone la construcción de una Ruta de la Seda europea que incluya una red ferroviaria de alta velocidad de casi 11.000 kilómetros, para contribuir a reducir de manera significativa las actuales emisiones de gases de efecto invernadero asociadas al transporte aéreo y por carretera.

Como en ediciones anteriores del *Outlook*, el libro dedica un último capítulo a la política de cohesión, cuya autoría corresponde en esta ocasión a G. Coco y R. Lagravinese. Este trabajo se suma a la discusión acerca de la contribución del gasto en política de cohesión a la inversión pública. Sus estimaciones son realmente reveladoras, al obtener para el periodo 2014-2020 una contribución de apenas dos terceras partes. Resultan, también, especialmente significativas las grandes diferencias obtenidas entre los estados miembros, lo que probablemente explica la heterogeneidad del impacto estimado de la política de cohesión. El estudio no se queda ahí, abordando, también, la capacidad de la política de cohesión para aumentar la inversión global a nivel regional a partir de una muestra compuesta por las regiones de la UE que han sido máximas receptoras del fondo a lo largo del tiempo. Los resultados, además de muy dispares, sugieren la ineficiencia de la política de cohesión para impulsar la inversión pública en algunas regiones europeas, lo que podría interpretarse como una señal indirecta de la falta de adicionalidad de la política de cohesión en el componente de inversión pública en algunos territorios.

En definitiva, nos encontramos ante una excelente obra académica que no nos dejará indiferentes, y que a buen seguro contribuirá a reavivar el clásico debate sobre el papel de la política fiscal en la UE.

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