INTRODUCTION

The SARS-CoV-2 epidemic and the ensuing economic crisis are a defining test for health systems and countries’ economic resilience and regions. The economic fallout will long outlive the health crisis, and the vulnerability of regions will persist long after a vaccine becomes available (UNCTAD, 2020). The world economy will contract 5.2% in 2020, the deepest recession since the Second World War,
and emerging markets will shrink by 2.5%. This year, Latin America GDP will fall by 7.2% and will grow by 3.0% in 2021. The economic blow will be the greatest where the pandemic has been the most severe, and countries and industries need to plan the routes for prompt recovery (World Bank, 2020).

A critical question arises about the capacity of economies to withstand the recession and the time it will take them to recover to pre-crisis levels of economic activity. Policymakers in developed and emerging markets need to assess the industries’ and regions’ economic resilience to overcome this grave blow. We need to understand what makes some places and industries more able to manage adverse economic shocks than others. To answer some of these questions, we propose a new definition of economic resilience based on Martin’s (2012) works, Reggiani et al. (2002) and Delgado et al. (2016). We aim to contribute to the emerging literature of economic resilience (Martin, 2018; Martin & Sunley, 2020) by extending the basic notion of economic resilience from mere resistance and recovery to account for positive spillovers to related industries in neighboring regions.

This study defines resilience as the inherent ability to withstand adverse shocks, bounce back the regional economy to pre-crisis levels while exercising positive spillovers to related industries in neighboring regions. This extended notion of resilience, more in line with Mardaneh et al. (2020), allows us to typify regional employment or production growth after the shock relative to the national level and to derive specific policy measures to encourage recovery and overcome the crisis.

The definition of industrial clusters proposed by Porter (2008) and Delgado et al. (2016) are useful constructs to examine resilience: the capacity of closely related industries to boost economic development and re-generate employment after adverse shocks (Ketels, 2013; Ketels & Memedovic, 2008). Brown and Greenbaum (2016) explore employment resilience, concentration, and diversity over time in Ohio, and find that regions with more diverse industrial structures performed better after adverse economic shocks. Bristow and Healy (2018) argue that regions with the highest levels of innovation recover faster from adverse economic shocks, particularly those from the economic crisis of 2008. Despite these valuable efforts, few contributions investigate the conditions that explain industries’ resilience within the automotive cluster. What regional structural and locational forces within the automotive sector drive regional resilience and growth? What is the role of geographical proximity of neighboring states on the path to regional recovery? How structural effects interplay with local differential effects to promote growth?

This study investigates industries’ employment and production resilience within the automotive cluster in Mexico during the Sub-Prime crisis using the spatial shift-share approach by Ramajo and Márquez (2008). We examine the automotive cluster in Mexico during the Sub-Prime crisis as a benchmark case to identify resilient industries within this cluster and across regions. The crisis of 2008–2009 was then the most potent blow to the Mexican economy since the crisis of 1929. Though it makes up an admittedly imperfect model, the Sub Prime shock becomes the closest analytical case to derive valuable policy lessons to surmount the economic crisis in the aftermath of SARS-CoV-2. This study hypothesizes that resilience is variable dependent. Regions with faster recovery of production or employment than the national average and positive spillovers have a differential impact on neighboring regions.

The classification of industries at the class level (6 digits) mimics industrial clusters’ classification developed by Delgado et al. (2016) for the United States. It allows us to investigate resilience and the dynamics of production and employment more consistently. This type of classification has already been implemented in academic research. It guides international efforts to examine the dynamics of clusters and employment and product creation in countries such as India (Kapoor, 2018); Spain (McGowan & San Millán, 2019); the Basque country (Azúa, 2015), and Mexico (Mendoza-Velázquez, 2017; Nuño, 2019). Having a standard cluster definition allows consistent comparisons of industrial dynamics at the regional level and across countries.
The work comprises five sections: the first describes the automotive cluster and industries in Mexico; the second presents a brief literature review focused about resilience. The third section presents the method to identify and measure resilience and describes the spatial shift-share approach by Ramajo and Márquez (2008) to measure Mexico’s automotive cluster’s spatial interrelationship. The fourth section presents the data and results; the fifth section discusses findings and policy implications. The last section concludes.

2 | THE AUTOMOTIVE CLUSTER AND THE MAGNITUDE OF THE SHOCK IN MEXICO

Several analysts consider the automotive industry as the anchor of Gross Domestic Product (GDP) in emerging markets and developed economies (Kaitwade, 2020). In North America, Mexico has become the number one supplier of auto parts to the US, with more than 1,500 auto supplier factories and over 5,000 companies. The trade totals about $70 billion trade every year (Iliff, 2020a, 2020b). Almost 90% of auto exports go to the US. The sector concentrates about 20% of foreign direct investment (FDI), accounting for about 15% of all light-vehicle sales, around 2.6 million vehicles in 2019 (Gachuz, 2011; Mendoza-Velazquez, 2017).

The automotive sector in Mexico contributes about 3% of the total Gross Domestic Product (GDP) and 18% of manufacturing GDP. This sector also contributes to employment and production, and it has multiplier effects on the energy, steel, electronics, and rubber sectors (Maldonado-Aguirre, 2009). The automotive cluster’s value chain integrates and brings together several states in the country. As seen in Table 1, automotive industries in Mexico depend on inputs provided from several other industries. Among the most important providers to the automotive cluster are primary metal industries (SCIAN 336), groceries, food & beverages (SCIAN 436); computer communication & electronic equipment (SCIAN 334); manufacture of metal products (SCIAN 332) and manufacture of electrical appliances and power generation equipment (SCIAN 335). The automotive industry also offers output to sectors such as cargo motor transport (484); passenger land transport (485); repair and maintenance services (811); manufacture of machinery and equipment (333); manufacture of electrical appliances and power generation (335); among the most important. A more detailed analysis of this industry based on technical coefficients shows that the automotive sector interrelates with other industries: tourist transport (487); fishing, hunting, and trapping (114); freight motor transport (484); plastic and rubber industry (326) and the chemical industry (325). While this information allows us to analyze the actual industrial interrelations pattern, examining industrial resilience within the cluster goes beyond a cross-sectional approach and requires a dynamic focus.

Before the economic shock caused by the SARS-CoV-2 pandemics, Sánchez-Ramirez et al. (2011) warned of the potential vulnerability of the automotive sector to adverse external shocks in Mexico. They found that agglomeration, the export-oriented nature of automotive industries, and the lack of adequate public policies had weakened the automotive cluster after the global crisis of 2008. The Ministry of Economics has, in contrast, reported a rapid recovery of automotive industries after the sub-prime crisis that is because of its high-tech and innovation-driven functioning (SE, 2016).

The Sub Prime crisis of 2008–2009 is the closest and yet dissimilar reference to a significant recession of such magnitude. The drastic contraction of demand for automobiles led then to a substantial fall in the value of imports: from $144.9 billion at the beginning of 2008 to $107 billion at the end of the same year (Mendoza-Cota, 2011). The automotive sector’s employment reached 524,186 people in 2007, a contraction to 450,157 jobs in 2008 and 428,806 jobs in 2009, a loss of 95,380 jobs, directly attributed to the Great Recession. In 2011, the sector was again employing 562,839
workers, exceeding the pre-crisis levels, and reaching up to 686,349 jobs in 2013 (Covarrubias & Bouzas-Ortiz, 2016). The factors that contributed to the relatively rapid recovery of jobs are not entirely apparent. However, they undoubtedly include the high competitiveness and innovation of the automotive cluster. The potential of positive regional knowledge and innovation spillovers to related industries in neighboring regions can also explain the capacity to maintain employment and recovery after the crisis.

The spread of the SARS-CoV-2 outbreak is admittedly a new and substantially different crisis shock that led to a complete lockdown of the automotive cluster. The mandatory public health measures reduced the speed of the outbreak and have saved many lives but have also disrupted the whole North American value chain (Kaitwade, 2020), all on the eve of the U.S.-Mexico-Canada trade agreement (USMCA). The light-vehicle output fell 94%, to 22,119 vehicles, compared to May of the previous year. Exports also fell by 95% during the same month, to 15,088 units, and auto sales in the

| No | 3 digit NAICS-Industry | Input | 3 digit NAICS-Industry | Output |
|----|------------------------|-------|------------------------|--------|
| 1  | 431 Wholesale groceries, food, beverages and tobacco | 166,738.95 | 484 Freight motor transport | 24,370.05 |
| 2  | 331 Basic Metallic Industries | 130,913.45 | 485 Land transportation of passengers, except by rail | 22,166.30 |
| 3  | 332 Manufacturing of metallic products | 93,877.37 | 811 Repair and maintenance services | 13,757.28 |
| 4  | 326 Plastic and rubber | 87,821.64 | 333 Manufacture of machinery and equipment | 12,005.24 |
| 5  | 333 Manufacture of machinery and equipment | 64,540.77 | 335 Manufacture of accessories, electrical appliances | 8,923.98 |
| 6  | 335 Manufacture of accessories, electrical appliances | 56,494.04 | 334 Manufactures of computer, communication | 6,748.48 |
| 7  | 334 Manufacture of computer, communications, equipment | 55,767.72 | 236 Building | 6,159.49 |
| 8  | 561 Business support services | 39,506.08 | 237 Construction of civil engineering works | 4,883.66 |
| 9  | 461 Retail trade of groceries, food, beverages, tobacco | 32,625.14 | 431 Wholesale of groceries, food, beverages, tobacco | 4,806.95 |
| 10 | 325 Chemical Industry | 32,080.76 | 531 Real estate services | 3,125.98 |
| 11 | 484 Freight motor transport | 29,167.57 | 461 Retail trade of groceries, food, beverages, tobacco | 3,065.25 |
| 12 | 313 Manufactures of textile inputs and textile finishing | 28,851.73 | 332 Manufactures of metal products | 3,018.59 |
| 13 | 327 Manufacture of non-metallic mineral-based products | 19,132.72 | 326 Plastic and rubber industry | 2,879.66 |
| 14 | 541 Professional, Scientific and Technical services | 14,237.13 | 212 Mining of metallic and non-metallic minerals | 2,502.94 |
| 15 | 221 Generation, Transmission and distribution of energy | 13,132.05 | 238 Specialized construction work | 2,199.11 |

Source: Own calculations based on data from INEGI (2013).
domestic market fell by 65% in March and April. Production resumed in June 2020 to just around 30% capacity levels (Iliff, 2020b). Mexico now faces tremendous pressure to reactivate the manufacturing capacity to satisfy the US and Canadian markets while keeping the right balance with health and safety protocols (Iliff, 2020a, 2020b).

The extent of damage to the automotive industry due to SARS-CoV-2 is still-to-be known in terms of production and employment losses. Projections are not too optimistic. Despite its massive importance in Mexico and its regions, we know little about the economic resilience of the automotive cluster. We need to identify the resilient industries within the automotive cluster and assess how closely related industries will cope with the recessive effects. This paper aims to shed some light on the resilient industries within the automotive cluster and the possibility of positive spillovers to related industries in neighboring regions during the recovery.

3 | A BRIEF REVIEW OF THE LITERATURE ON ECONOMIC RESILIENCE

This paper studies the resilience of industries in Mexico's automotive cluster. The investigation of the 2008 crisis' effects and industries' capacity to overcome the recession provides valuable policy lessons and identification of resilient regional industries to overcome the economic disruption caused by the SARS-CoV-2 quarantine measures. We aim to identify the resilient industries within the automotive cluster and investigate whether these industries’ steadfast resilience can lead to regional economic and employment growth after the crisis.

The economic geography literature does not yet count a universal and widely accepted definition of regional resilience or local economic resilience, nor how to measure it and its implication for policy intervention (Martin, 2012, 2018; Martin & Sunley, 2020). Gong et al. (2020) note that the concept of resilience is place-sensitive, multi-layered, conflict-ridden, and highly contingent on shocks.

Based on the evolutionary perspective of economic geography, this study defines resilience as the capacity of industries to resist and recover employment and production to pre-crisis levels after a recession. The recovery includes the ability to generate positive economic spillovers to related industries in neighboring local economies (Boschma & Martin, 2007, 2010; Delgado et al., 2015; Reggiani et al., 2002; Simmie & Martin, 2010). This definition accounts for the spatial distribution of industrial activities across regions to explain geographical differences in resistance to recessionary shocks (Martin, 2012). This definition focuses on the resilience of individual actors, i.e., industries within a cluster. However, alternative definitions focus on the entire economic system (Healy & Bristow, 2020).

Our notion of resilience acknowledges industries' capacity within a cluster to recover after an adverse economic shock and the role of geographical proximity of neighboring states on regional-sectoral change. Thus, spatial effects complement the local perspective with global processes. The presence and number of suppliers and buyers enhance the resilience of industries in a cluster. Various agglomeration channels, input-output, and knowledge linkages mold industries' resilience within clusters (Delgado et al., 2016). The presence of related industries within the automotive cluster and specialization allows for a broader set of complementarities and inter-industry collaboration that also increase resilience. We propose a notion of resilience more oriented to examining the distributional effects of recovery, the contagion of resilience.

Slaper et al. (2018) ground the concept of resilience on the notion of diversification of related industries in a cluster instead of mere specialization. Resilience allows for complementarities and inter-industry collaboration. Holm and Østergaard (2015) report that high specialization of ICT industries relates to lower resilience. Previous studies in Mexico suggest that, on average, specialization
relates negatively to employment growth, both regionally and within clusters (Mendoza-Velazquez et al., 2018). This may happen when regions are subject to industrial rigidities (Boschma, 2005).

We aim to contribute to the growing literature on resilience, considering the role of spatial distribution, interdependence, and specialization of industries in the process of resistance and recovery from shocks. This variation in the notion of resilience goes beyond a theoretical proposition. We operationalize the concept of resilience employing empirical measures and tools available to economic geographers (Markusen, 2003) and stretch the boundaries of its understanding in policy and practice (Martin & Sunley, 2020). We also expect to contribute to the evolutionary economic geography literature and how economic processes work across territories more broadly (Henning, 2019).

The methods employed in the literature to examine resilience concentrate on bivariate analysis or the use of composite indexes (Bristow & Healy, 2020). The spatial shift-share analysis adopted in this paper allows detecting the patterns and factors that give rise to employment or production disparities between different regions. The method allows identifying spatial structures in the traditional model and tests for spatial dependence of industries in neighboring regions (Nazara & Hewings, 2004; Ramajo & Márquez, 2008). Spatial shift-share examines the evolution of economic activity in a pooled model where data, e.g., on employment and production, distributes across regions at two different periods. The approach analyzes economic trends and acknowledges that results are variable dependent (Webber et al., 2018). The focus on highly dynamic industries in the automotive cluster allows us to test the configuration of resilience within an innovative cluster and explore the regional contribution to resilience (Bristow & Healy, 2020). We would expect that industries within the whole automotive cluster present different degrees of recovery, spillovers, but only some will show resilience.

4 | METHODOLOGY

We ground our notion of resilience on the spatial shift-share approach by Nazara and Hewings (2004), Ramajo and Márquez (2008) and Mitchel et al. (2005). This study defines resilience as the ability to withstand adverse shocks and recover to pre-crisis levels while exerting positive spillovers to related industries in neighboring regions. The basic shift-share approach by Dunn (1960) allows to examine the growth patterns of employment and production. It also allows extensions to consider spillover effects at the national, sectoral, and regional levels. States act as inter-spatial units, interconnected within a country (Isard, 1960). Decomposition effects of employment and product correlate spatially on the performance of surrounding regions. In the classical shift-share decomposition approach, the country exerts an influence on the regions (states). However, one region does not interconnect with other regions (there is no horizontal interaction). Ramajo and Márquez (2008) extend the basic shift-share analysis to account for local spatial effects: net effects, structural effects, and differential effects.

The spatial shift-share analysis allows detecting the patterns and factors that give rise to employment disparities between different regions. Regional employment growth of the automotive cluster is denoted by $g = e^{t+1} - e^t$, while national employment growth of the automotive cluster is given by $G = E^{t+1} - E^t$, where $e$ and $E$ denote regional and national employment in the automotive cluster, respectively, from time $t$ to $t + 1$. Dunn (1960) decomposes $g$, regional growth for a specific industry $i$, into two parts:

$$ (g_i - G) = (G_i - G) + (g_i - G_i) $$

where $G_i$ denotes employment growth in the specific industry at the national level. The term $(g_i - G)$ corresponds to the net change, which is decomposed into a structural effect $(G_i - G)$, which measures the
regional net change attributed to regional patterns. This effect is positive (negative) when the sector at the national level grows more (less) than the total national growth of the automotive cluster. The second term is a differential effect, i.e., \((g_i - G_i)\), that measures the relative advantage (differential growth) of industry \(i\) in a region regarding the national. The differential effect captures employment gains because of specialization. If sector \(i\) is more (less) important than its national growth, employment grows (shrinks). This first equation is useful to examine the national sector’s performance and influence in a region. However, it does not allow other regions to interact with one and another.

Effectively, Equation (1) only considers global effects. The equation does not consider the possibility of horizontal spillovers, region-to-region interactions. Hence, to incorporate a spatial structure in the traditional model and acknowledge the spatial dependence of industries in neighboring regions, Ramajo and Márquez (2008) introduced a spatial matrix to Equation (1) as follows:

\[
g_i = G + (Wg_i - G) + (g_i - Wg_i)
\]

where \(G_i \equiv Wg_i\) is a spatial variable with \(W\) a \(n \times n\) matrix of spatial interactions. Anselin and Rey (2014) note that \(W\)’s spatial weights are a vital component in any dependence analysis. \(Wg_i\) represents the growth rate of sector \(i\) in neighboring regions (instead of just \(G\), the national growth rate of sector \(i\)). Formally, the spatial weights \(w_{ij}\) in matrix \(W\) summarize the dependence structure of the neighbors:

\[
W = \begin{bmatrix}
w_{11} & \cdots & w_{1n} \\
\vdots & \ddots & \vdots \\
w_{n1} & \cdots & w_{nn}
\end{bmatrix}
\]

The spatial weights \(w_{ij}\) are nonzero when \(i\) and \(j\) are neighbors and zero when they are not. The region cannot be its neighbor, so the elements of the main diagonal of \(W\) are zero, \(w_{ii} = 0\). The existence of a neighboring relationship between the spatial unit corresponding to line \(i\) and column \(j\) is \(w_{ij} = W_{ij}\), \(j = 1\). The spatial weights matrix expresses neighbors’ relation as a binary relation, with weights of 1 and 0. Formally, each spatial unit is represented in the matrix by row \(i\), and the potential neighbor by columns \(j\), with \(j \neq i\).

We follow Ramajo and Márquez (2008) proposal for extracting spatial effects out of the traditional shift-share (Equation 1) using the following spatial decomposition:

\[
g_i = Wg + (Wg_i - Wg) + (g_i - Wg_i)
\]

This approach eliminates two global effects: the structural and shift effect by effectively substituting \(G=\sqrt{Wg}\) and \(G_i=\sqrt{Wg_i}\). The first term in Equation (3), \(Wg\), is the national effect. The second term, i.e., \((Wg_i - Wg)\) is the Local Structural Effect (LSE), the change attributed to the greater (or lesser) average growth of industry \(i\) to the national average growth of neighboring regions. \(LSE\) is the change that results from the greater or lesser dynamism of the industry at the local neighborhood level among industries. \(LSE\) measures the influence of fast (slow) growth activities within a region. Meanwhile, the Local Differential Effect (LDE), defined by the third term of Equation (3), i.e., \((g_i - Wg_i)\), represents the relative advantages in the area of region \(i\), with respect to the average position of this industry’s neighboring regions.

Summing up the three common effects in Equation (1) with the three neighborhood terms in Equation (3) we have:

\[
g_i + G_i = \left[ G + (G_i - G) + (g_i - G_i) \right] + \left[ Wg + (Wg_i - Wg) + (g_i - Wg_i) \right]
\]
and re-arranging terms, Equation (4) becomes:

\[
(g_i - G) + (g_i - Wg) = [(Gi - G) + (g_i - Gi)] + [(Wgi - Wg) + (gi - Wgi)]
\]

(5)

Equation (5) shows the standard terms and the new local neighborhood terms proposed by Ramajo and Márquez (2008). This identity has three effects: Net Local Change \((NLC)\), defined by \((g_i - Wg)\), quantifying the growth differential between the regional industry \(i\) and the average growth in neighboring regions. A negative value shows industry \(i\) is not as dynamic in the region with respect to its neighbors. In contrast, a positive value indicates that this region's industry is competitive with the cluster's average behavior in neighboring regions. The Local Structural Effect \((LSE)\) is \((Wg_i - Wg)\) comprises the dynamism of industry \(i\) in the neighboring regions, compared to the average growth of total aggregates in adjacent regions. \(LSE\) reflects the industrial induced effect that operates at the local level. Finally, the Local Differential Effect \((LDE)\), i.e., \((g_i - Wg)\) in Equation (5), represents the change attributable to the actual difference in the behavior of the industrial \(i\) in one region with respect to the same industry in neighboring regions. A positive value signals advantage of industry \(i\) in the region regarding the average behavior of industries and the average behavior of adjacent regions. Therefore, the specification of the spatial shift-share proposed by Ramajo and Márquez (2008) expressed in terms of net change \((NC)\) and local net change \((NLC)\) from Equation (5) is:

\[
NC_i + NLC_i = [SE_i + DE_i] + [LSE_i + LDE_i]
\]

(6)

\(LSE\) and \(LDE\) effects capture geographic location’s influence on an industry’s growth changes in a region and the effect of geographical proximity of neighboring states on regional industrial change. Thus, spatial effects integrate two components: the local perspective with global processes. In this sense, the traditional shift-share provides the tools to analyze the difference between the growth of a specific regional industry and the average national aggregate due to structural factors or residual factors. The approach offers a diagnosis at the local level on the importance of geographic neighborhood via the matrix of space weights \(W\).

The classification of regional growth patterns among structural and differential effects expands previous taxonomies by Boisier (1980) and Mitchell et al. (2005). The typology assesses regions’ capacity to withstand adverse shocks and recover while revealing the existence of spillovers to and from neighboring regions. The total share effect can be positive or negative, depending on the size and magnitudes of Structural and Differential Effects. Table 2 shows regional industries’ taxonomy based on the national and local change decomposition in Equation (6). The first three columns of the table present the typology of regions with total positive share effects. Type I regions represent the most favorable case of full industrial resilience: with both positive structural effects \((SE)\), that reflect the capacity to recover from adverse shocks, and positive differential effects \((DE)\), identified with spillovers to and from related industries in neighboring regions.\(^1\)

The next three columns of Table 2 present the typology of regions with total negative share effects. These are regions with vulnerable and no resilient industries. Industries present a negative total share effect because of both negative structural effects, a region of slower growth than the national average, i.e., vulnerability, and negative differential effect, i.e., negative or no positive spillovers to and from neighboring regions (no resilience). Table 2 also divides Type II and Type III industries by the total share effect, positive in the left part of the table and negative on the right. It distinguishes the type of vulnerability and resilience and potential public policy measures to recover or achieve regional industrial resilience.
| Type of industry | Total effect | Description, policy measure and type of resilience | Type of industry | Total effect | Description, policy measure and type of resilience |
|------------------|--------------|---------------------------------------------------|------------------|--------------|---------------------------------------------------|
| Type I           | DE+ & SE+    | Region of faster growth than the national average, with industry composition and local factors providing advantages. Evidence of positive spillovers to and from neighboring regions. **Policy measure:** Ensure continuation of industry in the region, neighboring regions, preserve and reinforce value chain. **Highly Resilient Industry:** industry grows (recovers) faster in the region than at the national level after the shock, with positive spillovers to/from neighboring regions. | Type IV          | DE− & SE−    | Region of slower growth than the national average, with local and industrial factors at a disadvantage with respect to the national level. Negative local effects from and to neighboring regions. Limited growth potential. |
| Type II A        | DE− SE+ IDE < SEi | Region of faster growth than the national average due to a favorable composition of industry employment or production that compensates for unfavorable local factors. **Policy measure:** The regional policy should focus on improving local infrastructure. Reinforce and maintain the value chain of the industry in the region. Requires some interregional coordination to attain resilience. Promote openness of economic channels to and from neighboring regions to revert or minimize negative differential effect. **Potential for Resilience:** Strong industry, no vulnerability. Reinforce positive spillover and value chain to encourage knowledge transmission to and from neighboring regions. | Type II B        | DE− SE+ IDE > SEi | Region of greater growth than the national average but with negative gravity from performance in neighboring regions, due to local factors at disadvantage. **Policy Measure:** Regional policy should focus on improving local infrastructure (such as transport systems) in the region; maintaining the value chain and competitive factors to ensure decisive increase in the relative national share. Requires strong decisive interregional coordination. **Low Resilience:** Strong region, but needs reinforcing positive spillovers and value chain to encourage knowledge transmission to and from neighboring regions. Promote openness of economic channels to and from neighboring regions to revert or minimize the negative differential effect. |
| Type of industry | Total effect | Description, policy measure and type of resilience | Type of industry | Total effect | Description, policy measure and type of resilience |
|------------------|--------------|--------------------------------------------------|------------------|--------------|--------------------------------------------------|
| Type III A       | DE+ SE−      | Region of lower growth than the national average, with local factors that compensate for the unfavorable performance of the industry | Type III B       | DE+ SE−      | Region of slower growth than the national average, due to the industry's unfavorable performance, but compensated by advantageous local factors |
|                  | | **Policy measure:** Regional policy should focus on developing growth industries to offset the concentration of industries that are either static or in decline |                  | | **Policy Measure:** Regional policy should focus on developing growth industries to offset the concentration of industries that are either static or in decline |
|                  | | Government should support these with emergency credits to withstand the crisis and economic incentives, e.g., fiscal |                  | | The policy requires significant effort to develop static or declining industries |
|                  | | **No Resilience.** Vulnerable region due to weak recovery performance but with greater positive spillovers to/from dynamic neighboring regions. Requires some effort to develop growth industries to achieve resilience |                  | | **No Resilience.** Vulnerable region due to weak recovery performance, but with weaker relative positive spillovers to and from neighboring regions (not sufficient to revert negative share) |

*Note:* DE is the differential effect, while SE is the structural effect.

*Source:* Adapted and extended based on Boisier (1980) and Mitchell et al. (2005).
5  |  DATA DESCRIPTION AND ANALYSIS OF RESULTS

We investigate regional industries’ resilience employing the Mexican Cluster Mapping data provided by *Sintonía-UPAEP* (Nuño, 2019) and two rounds of the Economic Census (EC) in Mexico. We get industrial data for the 2008 and 2013 rounds of the EC published by the National Institute for Geography and Statistics (INEGI, 2009) in Mexico. The database contains 20 sectors, 94 subsectors, 304 branches, 617 sub-branches, and 1,049 activity classes. The data from the EC is compatible with the North American Industry Classification System (NAICS). However, to ensure full consistency with NAICS and all industries' alignment at the class level, the study includes a detailed arrangement of the database to eliminate discrepancies, align aggregation levels and mnemonics, and other residual inconsistencies. These adjustments to the Mexican database ensure a compatible comparison between Mexico and US industries. Then, following the definition of closely related industries by Delgado et al. (2016), we extract data for employment and production (constant prices, 2010 = 100) of the automotive cluster for each of the 32 states in Mexico, for the rounds 2008 and 2013. Table 3 lists the activity classes that integrate the automotive cluster.

5.1  |  Spatial shift-share

The first step in identifying the growth pattern and ultimately resilience of specific automotive industries is to investigate the evidence in favor of spatial autocorrelation using Moran Index tests. Table 4 below shows the Moran global statistic resulting from multiplying the standardized spatial weights matrix \( W \) by employment growth rate and production growth rate.

Concerning employment, this study identifies two industrial activities of the automotive cluster in Mexico with some degree of spatial dependence at the 95% confidence level: manufacture of cars and trucks (activity 336,110) and manufacture of interior seats and accessories for motor vehicles.

**Table 3** Activity classes within the automotive cluster (NAICS)

| Activity classes | Definitions |
|------------------|-------------|
| 1 SC_331510      | Casting of iron and steel parts |
| 2 SC_331520      | Casting of non-ferrous metal parts |
| 3 SC_336110      | Manufacture of cars and trucks |
| 4 SC_336120      | Truck and Tractor Truck Manufacturing |
| 5 SC_336210      | Manufacture of bodies and trailers |
| 6 SC_336310      | Manufacture of gasoline engines and their parts for automotive vehicles |
| 7 SC_336320      | Manufacture of electrical and electronic equipment and parts for motor vehicles |
| 8 SC_336330      | Manufacture of parts of steering and suspension systems for automotive vehicles |
| 9 SC_336340      | Manufacture of brake system parts for automotive vehicles |
| 10 SC_336350     | Manufacture of parts of transmission systems for motor vehicles |
| 11 SC_336360     | Manufacture of interior seats and accessories for motor vehicles |
| 12 SC_336370     | Manufacture of die-cut metal parts for automotive vehicles |
| 13 SC_336390     | Manufacture of other parts for automotive vehicles |
| 14 SC_336999     | Manufacture of other transport equipment |

Source: Industries within the automotive cluster according to Delgado, Stern, and Porter (2016).
The pattern of spatial autocorrelation suggests positive spillovers and the clustering of employment in neighboring regions. States with high employment positively relate to other states with high employment in these industries. For production, the spatial analysis identifies two additional activities with significant degrees of spatial dependence (at 90% confidence): Manufacture of parts of steering and suspension systems for automotive vehicles (336,330); and manufacture of parts of transmission systems for motor vehicles (336,350). The negative spatial autocorrelation suggests some competition in neighboring regions: states with high output in these industrial activities.

### Table 4  Spatial autocorrelation test 2008–2013, automotive cluster

| 6 digits | Activity class                                           | Employment |             | Production |             |
|----------|---------------------------------------------------------|------------|-------------|------------|-------------|
| SC_331510 | Casting of iron and steel parts                         | -0.0176    | .3670       | -0.0119    | .2534       |
| SC_331520 | Casting of non-ferrous metal parts                      | -0.0354    | .4124       | -0.0362    | .3064       |
| SC_336110 | Manufacture of cars and trucks                          | **0.1327** | **.0423**   | **-0.1317** | **.1221**   |
| SC_336120 | Truck and Tractor Truck Manufacturing                    | -0.0116    | .2258       | -0.0109    | .2047       |
| SC_336210 | Manufacture of bodies and trailers                      | -0.0624    | .4364       | -0.0896    | .3459       |
| SC_336310 | Manufacture of gasoline engines and their parts for automotive vehicles | -0.0362    | .3926       | -0.0466    | .3600       |
| SC_336320 | Manufacture of electrical and electronic equipment and parts for motor vehicles | -0.0311    | .4699       | -0.0359    | .4743       |
| SC_336330 | Manufacture of parts of steering and suspension systems for automotive vehicles | 0.0389     | .2425       | **-0.0608** | **.0885**   |
| SC_336340 | Manufacture of brake system parts for automotive vehicles | 0.0241     | .2619       | -0.1172    | .2397       |
| SC_336350 | Manufacture of parts of transmission systems for motor vehicles | -0.0148    | .1205       | **-0.0123** | **.0916**   |
| SC_336360 | Manufacture of interior seats and accessories for motor vehicles | **0.1104** | **.0640**   | -0.0716    | .3889       |
| SC_336370 | Manufacture of die-cut metal parts for automotive vehicles | 0.0522     | .1693       | -0.0062    | .2715       |
| SC_336390 | Manufacture of other parts for automotive vehicles       | -0.0397    | .3014       | -0.0356    | .3897       |
| SC_336999 | Manufacture of other transport Equipment                 | -0.0756    | .2813       | -0.0137    | .1948       |
| TOTAL    |                                                         | -0.0192    | .2501       | 0.0516     | .1007       |

*aMoran’s Index is analogous to a conventional correlation index. Spatial autocorrelation reflects the degree to which the activities of a geographic unit are similar to other activities in nearby geographic units: \( I = \frac{\sum (y_i - \bar{y}) (y_j - \bar{y}) w_{ij}}{S_0} \), with \( \bar{y} \) as the sample mean. Here \( n \) is the number of spatial units; \( y_i \) refers to employment or production; \( W \) is a matrix of spatial weights with zeros in the diagonal, and \( S_0 \) is the sum of all \( w_{ij} \). The numerator contains the covariance in adjacent spatial units (Lee & Li, 2017).

*bTests for \( H_0: \) random data versus \( H_1: \) spatially clustered data. A positive value shows data is spatially-clustered and negative values show competition.

Source: Own elaboration with data from INEGI (2013).
are close to other states with low output growth. Overall, the estimations rule out the hypothesis that these activities' spatial distribution is random, and industries agglomerate geographically. Ten kinds of activity do not present any degree of spatial dependence on employment or production; their distribution does not relate to location decisions. Hence, to investigate the capacity of states to withstand adverse shocks, their vulnerability and resilience ultimately, the spatial shift-share analysis that follows considers these four industrial activities within the automotive cluster: 336,110 and 336,360 for employment and activities 336,330, 336,350 for production.

5.2 | Total Effect (TDE)

To identify the type of vulnerability, recovery and resilience of the four industries identified above, with evidence of spatial autocorrelation, we now apply the spatial shift-share technique of Ramajo and Márquez (2008). The first block of industries in Table 5 shows the Total Differential Effect (TDE) for these four industries in terms of production and employment. Column 1 shows that Puebla's state experienced positive production changes in class 336,330 (manufacturing parts of steering and suspension systems for automotive vehicles). Similarly, only Mexico City has positive changes in the productive structure in the Manufacture of Parts of Transmission Systems for Motor Vehicles class 336,350 (column 2). Positive changes in production or employment reveal states with the most significant advantage, relative to other states, for each class of activity in the cluster. A great capacity for recovery.

Concerning employment, we find a more diversified structure. In the Manufacture of Automobiles and Trucks (class 336,110), Aguascalientes, Guanajuato, Jalisco, Mexico City, Morelos, State of Mexico, and San Luis Potosí show positive changes in the productive structure (column 3). Positive changes are also a feature of class 336,360 Manufacture of Interior Seats and Interior Accessories for Motor Vehicles. The values are positive for Baja California, Coahuila, Guanajuato, Morelos, San Luis Potosí, Tamaulipas, Tlaxcala, and Zacatecas—see column (4).

5.3 | Differential Effect (DE)

DE effects relate to the performance of neighboring regions and confirm spatial spillovers from and/or to neighboring regions. The calculations show that the states of Guanajuato, Puebla, Querétaro, and Sonora have positive differential production effects for industrial class 336,330 (manufacturing of steering and suspension systems, see column 5). Mexico City for class 336,350 Manufacture of Parts of Transmission Systems for Motor Vehicles (see column 6). For employment growth, the states of Aguascalientes, Guanajuato, Jalisco, Mexico, Mexico City, Morelos, and San Luis Potosí show positive employment effects in industries in class 336,110 Manufacture of Cars and Trucks (column 7).

The states of Baja California, Coahuila, Guanajuato, Morelos San Luis Potosí, Tamaulipas, Tlaxcala, and Zacatecas (column 8), show positive employment effects in class 336,360, Manufacture of Seats Interior Accessories for Motor Vehicles. These states show a positive change in production or employment, respectively, because of actual differences in the same industrial class in neighboring regions. A positive value signals advantage of such an industrial class in the state regarding the industry's average behavior in adjacent regions.
| State                | Total effect TDE | Differential | Structural effect (SE) |
|----------------------|------------------|--------------|-----------------------|
|                      | Production | Employment | Production | Employment | Production | Employment | Production | Employment |
|                      | (1)        | (2)         | (3)        | (4)         | (5)        | (6)         | (7)        | (8)         |
| Aguascalientes       | −          | −           | +          | −           | −          | +           | −          | +           |
| Baja California Sur  | −          | −           | −           | −           | −          | −           | −          | +           |
| Baja California     | −          | −           | −           | +           | −          | −           | −          | +           |
| Campeche             | −          | −           | −           | −           | −          | −           | −          | +           |
| Chiapas              | −          | −           | −           | −           | −          | −           | −          | +           |
| Chihuahua            | −          | −           | −           | −           | −          | −           | −          | +           |
| Coahuila             | −          | −           | −           | +           | −          | −           | −          | +           |
| Colima               | −          | −           | −           | −           | −          | −           | −          | +           |
| Mexico City          | −          | +           | +           | +           | −          | +           | +          | −           |
| Durango              | −          | −           | −           | −           | −          | −           | −          | +           |
| Guanajuato           | −          | −           | +           | +           | +          | −           | +          | −           |
| Warrior              | −          | −           | −           | −           | −          | −           | −          | +           |
| Gentleman            | −          | −           | −           | −           | −          | −           | −          | +           |
| Jalisco              | −          | −           | +           | −           | −          | +           | −          | +           |
| Mexico               | −          | −           | +           | −           | −          | +           | −          | +           |
| Michoacan            | −          | −           | −           | −           | −          | −           | −          | +           |
| Morelos              | −          | −           | +           | +           | −          | +           | −          | +           |
| Nayarit              | −          | −           | −           | −           | −          | −           | −          | +           |
| New Lion             | −          | −           | −           | −           | −          | −           | −          | +           |
| Oaxaca               | −          | −           | −           | −           | −          | −           | −          | +           |

(Continues)
| State            | Total effect TDE | Differential | Structural effect (SE) |
|------------------|------------------|--------------|-----------------------|
|                  | Production (1)   | Employment (2) | Production (5)   | Employment (6) | Production (9) | Employment (10) | Production (11) | Employment (12) |
|                  | 336330<sup>a</sup> | 336350<sup>b</sup> | 336110<sup>c</sup> | 336360<sup>d</sup> | 336330<sup>a</sup> | 336350<sup>b</sup> | 336110<sup>c</sup> | 336360<sup>d</sup> |
| Puebla           | +                | −             | −                  | −                | +                | −                  | +                | −                |
| Queretaro        | −                | −             | −                  | +                | +                | −                  | −                | +                |
| Quintana Roo     | −                | −             | −                  | −                | −                | −                  | −                | +                |
| San Luis Potosi  | −                | −             | +                  | +                | −                | −                  | +                | −                |
| Sinaloa          | −                | −             | −                  | −                | −                | −                  | −                | −                |
| Sonora           | −                | −             | −                  | −                | −                | −                  | −                | −                |
| Tabasco          | −                | −             | −                  | −                | −                | −                  | −                | −                |
| Tamaulipas       | −                | −             | −                  | +                | −                | −                  | −                | +                |
| Tlaxcala         | −                | −             | −                  | −                | −                | −                  | −                | +                |
| Veracruz         | −                | −             | −                  | −                | −                | −                  | −                | +                |
| Yucatan          | −                | −             | −                  | −                | −                | −                  | −                | +                |
| Zacatecas        | −                | −             | −                  | +                | −                | −                  | −                | +                |

<sup>a</sup>336,330 Manufacture of parts of steering and suspension systems for automotive vehicles.

<sup>b</sup>336,350 Manufacture of parts of transmission systems for motor vehicles.

<sup>c</sup>336,110 Manufacture of cars and trucks.

<sup>d</sup>336,360 Manufacture of interior seats and accessories for motor vehicles.

Source: Own elaboration.
5.4 | Structural Effect (SE)

The Structural Effect (SE) measures the relative importance of an industry in a region to encourage employment or production growth in a period (Boisier, 1980). In this study, we relate the SE to industries’ capacity to recover above the national level after a given adverse shock to the region. SE also shows whether states are subject to specialization effects. A positive (negative) structural effect shows (no) employment or production specialization and high (low) capacity to recover (vulnerability) after an adverse shock. Table 5 shows that the structural effect of employment and output growth is negative for all states in industrial classes, 336,330 Manufacture of Parts of Steering and Suspension Systems, and 336,110 Manufacture of Cars Trucks (columns 9 and 11 respectively). For all the states in Mexico, specialization of employment and production in these classes reveals slow growth and vulnerability after a given adverse shock compared to the average growth in adjacent states’ industrial automotive cluster.

Interestingly, all states show a positive structural effect for class 336,350 Manufacture of Parts of Transmission Systems for Motor Vehicles (column 10) and class 336,360 Manufacture of Seats Interior Accessories for Motor Vehicles (column 12). The results show positive recovery effects of industrial production and employment contagion after a given adverse economic shock in all Mexican States. The question is whether the magnitude of these structural effects is high enough to compensate for the lack of spillovers or reinforce the positive effects of spatial autocorrelation in the regions.

Table 6 shows the classification of industries following the typology presented in Table 2 and the results in Table 5 for each of the industries reporting spatial effects. Figure 1 shows states with Type I and Type IIA effects for industrial growth. Type I cases are states with both positive Differential Effects and a positive Structural Effects, as for activity class 336,360, Manufacturing of Seats, and Interior Accessories for Motor Vehicles (column 12). The results show positive recovery effects of industrial production and employment contagion after a given adverse economic shock in all Mexican States. The question is whether the magnitude of these structural effects is high enough to compensate for the lack of spillovers or reinforce the positive effects of spatial autocorrelation in the regions.

Table 6 shows that industrial class 336,110 in most states mostly develops Type IIIA and Type IV characteristics (see the first column and Figure 2). Type IIIA states present a relatively an unfavorable
industry performance, insufficient employment growth than neighboring regions but benefit from some positive spillover effects. Regional policy in these states should focus on developing static or declining firms to improve the potential for recovery and overcome the concentration of industries at a disadvantage. Type IV states are states with both unfavorable industrial performance, slower

## Table 6
Spatial Shift-share typology. Analysis of the automotive cluster, 2008–2013

| State                  | Employment Activity | Employment Class | Production Activity | Production Class |
|------------------------|---------------------|------------------|---------------------|------------------|
| Aguascalientes         | IIIA                | IIB              | IV                  | IIB              |
| Baja California Sur    | IV                  | IIB              | IV                  | IIB              |
| Baja California        | IV                  | I                | IV                  | IIB              |
| Campeche               | IV                  | IIB              | IV                  | IIB              |
| Chiapas                | IV                  | IIB              | IV                  | IIB              |
| Chihuahua              | IV                  | IIB              | IV                  | IIB              |
| Coahuila               | IV                  | I                | IV                  | IIB              |
| Colima                 | IV                  | IIB              | IV                  | IIB              |
| Mexico City            | IIIA                | IIA              | IV                  | I                |
| Durango                | IV                  | IIB              | IV                  | IIB              |
| Guanajuato             | IIIA                | I                | IIIIB               | IIB              |
| Guerrero               | IV                  | IIB              | IV                  | IIB              |
| Hidalgo                | IV                  | IIB              | IV                  | IIB              |
| Jalisco                | IIIA                | IIB              | IV                  | IIB              |
| Mexico                 | IIIA                | IIB              | IV                  | IIB              |
| Michoacán              | IV                  | IIB              | IV                  | IIB              |
| Morelos                | IIIA                | I                | IV                  | IIB              |
| Nayarit                | IV                  | IIB              | IV                  | IIB              |
| Nuevo León             | IV                  | IIB              | IV                  | IIB              |
| Oaxaca                 | IV                  | IIB              | IV                  | IIB              |
| Puebla                 | IV                  | IIB              | IV                  | IIB              |
| Querétaro              | IV                  | IIA              | IIIA                | IIB              |
| Quintana Roo           | IV                  | IIB              | IV                  | IIB              |
| San Luis Potosí        | IIIA                | I                | IV                  | IIB              |
| Sinaloa                | IV                  | IIB              | IV                  | IIB              |
| Sonora                 | IV                  | IIB              | IIIIB               | IIB              |
| Tabasco                | IV                  | IIB              | IV                  | IIB              |
| Tamaulipas             | IV                  | I                | IV                  | IIB              |
| Tlaxcala               | IV                  | I                | IV                  | IIB              |
| Veracruz               | IV                  | IIB              | IV                  | IIB              |
| Yucatán                | IV                  | IIB              | IV                  | IIB              |
| Zacatecas              | IV                  | I                | IV                  | IIB              |

Source: Own elaboration.
employment growth relative to the national level, and limited positive effects from spillovers (local factors at a disadvantage). Industry 336,110 in Type IV states has limited growth potential. Industrial class 336,110 reveals a need of massive encouragement of productive and social infrastructure. The
industry in this class shows high employment vulnerability to adverse shocks and no evidence of resilience. Finally, states classified as Type IIIB are cases with some advantage in local factor overridden by the very weak performance to recover the level of employment before adverse shocks. These states require a much greater effort to develop industries and to further encourage positive spillover effects.

5.5 Production

Concerning production, Table 6 shows how industrial class 336,350 Manufacture of Parts of Steering and Suspension Systems for Automotive Vehicles distributes across states by type I and type IIB. Only Mexico City classifies as a type I region, a resilient state with faster growth than the national average and industrial advantages in the composition and local factors (see column 4 in Table 6). Mexico City shows high production resilience. The remaining 31 states show a type IIB classification, e.g., regions with some recovery growth relative to the national level, but at a greater local disadvantage from neighboring regions’ performance. For most states in Mexico, industrial policy for this industry class should focus on incentives of diverse types to encourage decisive production recovery after the economic distress. Policy actions should also strengthen regional coordination to enhance positive spillovers.

Regarding activity class 336,330, Manufacture of Parts of Steering and Suspension Systems for Automotive Vehicles, Table 6 show states that fall into Type IIIA, IIIB and Type IV categories. These are industries with a performance below average regarding the nation. While Type IIIA states benefit from some positive spillovers from and to neighboring regions, Type IV regions are at a local disadvantage. Both types of cases show vulnerable regions, even when Type IIIA and B states would gain some resilience by developing growth industries. Only the state of Puebla shows a type IIIA category (see column 3 of Table 6, under production). Puebla is a state where this industrial activity shows a relatively faster productivity growth than Type IIIB states, with favorable local factors. Other states such as Guanajuato, Querétaro, and Sonora fall into the IIIB typology. These states show a low recovery of production than the average of their neighbors, but advantageous local factors offset the overall performance.

Type IIIB states take advantage of their neighbors' spatial structure to grow and look for incentives to promote production. Otherwise, their production recovery would depend on the recovery of neighboring states. Activity class 336,330 is a highly vulnerable industry in the rest of the states (28), who falls into the Type IV category. Regions of relatively slower growth than the national average during the recovery from the subprime crisis, with disadvantaged local and industrial factors with little potential (see column 4 in Table 6). The regional policy could focus on developing this industry, compensating the stagnation or decline; supporting micro and small entrepreneurs, promoting investment, generating fiscal stimuli; training human resources, and promoting access to credit, among other policies (Unger, 2018). This industry would need decisive supporting economic schemes to sustain their survival during the crisis and later, after the turmoil, focused industrial policies to encourage growth.

6 DISCUSSION

This study evaluates the resilience of regional employment and production in Mexico’s automotive cluster after the Sub-Prime Crisis. We investigate the role of spatial spillovers and growth as driving forces of recovery, vulnerability and economic resilience of Mexican regions (Stimson et al., 2006).
Identifying industrial patterns and dynamics of recovery experienced in the face of adverse shocks, such as those in the Sub-Prime crisis, provides useful policy lessons in the aftermath of the economic disruption caused by SARS-CoV-2.

We define resilience as the ability of an industry to withstand adverse shocks and bounce back regional employment and production growth to pre-crisis levels (or more) while exercising positive spillovers to related industries in neighboring regions. This definition extends the notion of resilience by Martin (2012) and Delgado et al. (2016) to include spatial autocorrelation and is more in line with Mardaneh et al. (2020). The resulting taxonomy of regional industrial growth allows us to typify regional employment or production growth regarding the national average after the shock and deriving specific policy measures to encourage recovery and overcome the crisis. Out of the fourteen industries examined at the class level comprising the automotive cluster in Mexico, we identify four industries with spatial dependence and potential for regional resilience.

This study also employs the concept of industrial clusters to examine the capacity of the automotive industries in Mexico to generate employment, promote competitiveness and boost economic development (Ketels, 2013; Ketels & Memedovic, 2008). Besides examining the potential to increase productivity, stimulate innovation, and generate new business opportunities, the analysis of resilience in this study offers a solid base to analyze spatial autocorrelation (Slaper et al., 2018). Brown and Greenbaum (2016) explore employment resilience, concentration, and diversity over time in Ohio, and find that regions with more diverse industrial structures performed better after adverse economic shocks. Bristow and Healy (2018) argue that regions with the highest levels of innovation recover faster from adverse economic shocks, particularly those from the economic crisis of 2008.

The typology of industrial dynamics and resilience obtained in this study grounds on the spatial shift-share analysis by Ramajo and Márquez (2008) and Mitchel et al. (2005). The advantage of the spatial shift-share and typology analysis in this study resides on its relative simplicity, compared to other methods, and the adoption of a widely accepted industrial cluster classification among practitioners and policymakers worldwide (Delgado et al., 2016). The typology characterizes the potential for employment and production resilience, depending on the intrinsic characteristics of industrial classes and the spatial interaction with neighboring states (Martin, 2018; Nazara & Hewins, 2004). Several states classify as Type I, high resilience, recovering employment and production growth above the national average, together with positive spillover effects to and from neighboring states after adverse shocks. The industrial activities in these states appoint themselves as economic engines to restore the growth of employment and production of the automotive cluster in Mexican states. These industries can attract new businesses and investments because of their employment and production specialization and their ability to grow and withstand adverse shocks. These industries also have the ability to cluster and correlate with neighboring regions.

The resistance to shocks, recovery, evidence for positive spillovers, and ultimately resilience, are not homogeneous traits of industries in the regions. The typology differentiates states regarding dynamics and degrees of vulnerability. The results uncover the high resilience of industrial class 336,360 in the states of Baja California, Coahuila, Guanajuato, Jalisco, Mexico City, State of Mexico, Morelos, San Luis Potosí, Tamaulipas, Tlaxcala, and Zacatecas. These states showed great capacity to overcome adverse shocks and restore employment after the sub-prime crisis. The states also benefited from positive spillovers to and from neighboring regions for the period 2008 to 2013.

In terms of production, the states of Puebla and Mexico City are the highly resilient cases with recoveries above the national level after the shock and evidence of spillovers. The rest of the states show slower growth of both employment and production than the national average and different degrees of locational advantage. Recovery of these states after an adverse shock depends on the feasibility of
Policy strategies and even inter-regional coordination. Mendoza-Cota (2011) showed that the Sub-Prime crisis in the US automotive industry affected Mexico’s exporting capabilities. Such a crisis led to a severe recession of the manufacturing industry, particularly in the northern and border states.

Policy lessons should consider the particular resilience characteristics of each type of industry in the still ongoing crisis due to the COVID-19 pandemics. Economic incentives (monetary or in-kind) in highly resilient Type I industries should ensure the continuation of those industries in the region by giving preference to access credits, fiscal aids, or others in the area and neighboring areas to preserve and strengthen the value chain.

For Type IIA industries, i.e., industries with the potential for resilience with SE < DE. The regional policy should focus on several measures to maintain and reinforce the capacity to be resilient: (a) improving local infrastructure; (b) reinforcing and maintaining the value chain of the industry in the region; (c) reinforce or implement effective measures of interregional coordination and (d) promoting openness of economic channels, to and from neighboring regions, to revert adverse differential effects. Similarly, type IIB industries with low resilience could focus on improving local infrastructure (transport systems) in the region and maintaining the value chain and competitive factors to improve their rank in the national share. Type III industries have limited possibilities to overcome the crisis. However, governments should attempt to re-activate and stop a further decline of these industries could be attempted once economic activities resume.

Identifying the type of regional industrial dynamics in this study is a useful tool for achieving resilience and recovery of lost employment and production in the aftermath of adverse shocks. While resilience highly depends on the shock (Thorén, 2014), the patterns of industrial resilience observed during the Sub-Prime crisis can provide valuable insights into the likely evolution of the current economic crisis by the SARS-CoV-2 outbreak. To our knowledge, this is one of the first studies to establish industrial policy recommendations to surmount the crisis in the automotive cluster in Mexico for the years ahead.

The results on vulnerability and resilience in this study depend on the level of aggregation and the specific cluster classification method. We acknowledge the analysis of industrial resilience is also variable dependent (Webber et al., 2018). Resilience relies on the units of measurement, time frequency, data structure, method of analysis, regional space, and the type of cluster (local vs. traded). Further studies on resilience should also consider the role of institutions, local and national governments. The investigation of a broad range of economic and social determinants of regional industrial resilience remains an area for future research too.

7 CONCLUSIONS

This study extends the notion of economic resilience from mere resistance and recovery to account for spillovers from and to neighboring regions after adverse shocks. The study identifies automotive industries with the potential to surmount adverse shocks to employment and production in the aftermath of the COVID-19 outbreak, based on the dynamics observed during the Sub-Prime Crisis in Mexico from 2008 to 2013. The study derives valuable policy lessons to restore and encourage economic recovery for industries comprising the automotive cluster.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.
ENDNOTE

1 In the case of Greece, Christofakis et al. (2019), establish that positive local actions (DE) are the benchmark for resilience. More specifically, local advantages seem to carry over to peripheral regions with rural development potential and a high participation rate in the agricultural sector. Based on these results, a final observation from the analysis is that more traditional activities appear to be more resilient. Unlike the case of Greece, in Mexico there is a strong integration of the national economy with that of the United States, its main trading partner, reflected in manufacturing, mainly the automotive sector. In particular, as a result of this important international integration, Mexico has faced external shocks (such as the Great Recession) that have profoundly affected its productive structure. We identify both DE and SE as factors jointly contributing to our definition of resilience.

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