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Articles

Structural change and deindustrialization at the northern border of Mexico

Cambio estructural y desindustrialización en la frontera norte de México

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Abstract

This research aims to analyze the manufacturing industry of the northern border of Mexico to identify its development trends in the period of 1999 to 2019. It is hypothesized that its performance has been of high specialization, which makes the presence of deindustrialization as a pattern of structural change difficult. To reach the objective and test the hypothesis, a structural change index, a specialization coefficient and a model with panel data was calculated to analyze the determinants of the specialization coefficient. The results suggest that there is no process of deindustrialization on the northern border, due to the high specialization in manufacturing that is explained by variables that favor manufacturing such as the GDP of the United States, the real exchange rate, investment and the employed population.

Keywords: structural change, deindustrialization, northern border of Mexico, specialization coefficient, manufacturing industry.

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Resumen

Esta investigación tiene como objetivo analizar la industria manufacturera de la frontera norte de México para identificar las tendencias de su desarrollo en el periodo de 1999 a 2019. Se plantea la hipótesis de que su desempeño ha sido de alta especialización, lo que hace difícil la presencia de desindustrialización como patrón de cambio estructural. Para alcanzar el objetivo y contrastar la hipótesis se calcularon un índice de cambio estructural, un coeficiente de especialización, y un modelo con datos panel para analizar los determinantes del coeficiente de especialización. Los resultados sugieren que no existe un proceso de desindus-

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trialización en la frontera norte, por la alta especialización en la manufactura, que se explica por variables que favorecen a la manufactura como el producto interno bruto (PIB) de Estados Unidos, el tipo de cambio real, la inversión y la población ocupada.

Palabras claves: cambio estructural, desindustrialización, frontera norte de México, coeficiente de especialización, industria manufacturera.

Introduction

The concept of structural change has been widely used in the development economics literature to explain economic progress as a result of increases in productivity and the generation of wealth, where various sectors of the economy participate with different intensities. This process gained strength when industry became the "engine of economic growth" (Kaldor, 1967) through technological innovation, i.e., the manufacture of machines and machine systems, which resulted in returns to scale and accelerated capital accumulation processes.

Industrialization revolutionized productivity, increased consumption and diversified the economic structure; these processes in turn led to changes in the technical and territorial division of labour. With the relocation of the industry in the 1960s and 1970s, with the objective of reducing production costs through wages and other fiscal prerogatives, northern Mexico was identified as an opportune location to promote the installation of manufacturing industries, given its strategic location due to its proximity to the main market in the world: the United States of America.

The maquiladora industry in the northern region of Mexico was installed with the Border Industrialization Programme (Programa de Industrialización Fronteriza - PIF) and represented, in principle, the solution to unemployment after the end of the Bracero Programme in the 1960s, when large sectors of the population unemployed (Barajas & Almaraz, 2011). The presence of these companies, along with other economic activities such as agriculture and commerce, facilitated the growth of the border economy at rates that were higher than those for the rest of the country.

The industry sector in northern Mexico is a combined product of industrial location strategies by transnational companies and the need for this region to expand. Thus, the border industry that assembles parts and components of a variety of products, e.g., furniture, clothing, auto parts, electrical and electronic products, and medical products, has grown. After decades of operating in this region, the industry sector in Mexico has not managed to fully integrate because the percentage of components of national origin has remained very low, close to 2%, which is why the maquiladora industry has not contributed industrial development in Mexico.

As a consequence of relocation and according to Martínez Cuero (2016, 2018), transnational industry and global production chains can transform the economic activity of countries and production relations and generate the emergence of new defined spaces from their actions. The presence of these companies in the industrial sector along the northern border of Mexico has allowed the creation of qualified jobs, technology transfer and a greater flow of foreign currency. In this sense, Contreras and Munguía (2007) argue that the growth of the manufacturing industry in northern Mexico has been due to the expansion of the maquiladora industry. An industry composed of transnational companies (whose products were destined for export to the

United States) on the Mexico-United States border was a regional guarantee of successful performance due to salary and transportation costs and the fiscal benefits such industries enjoyed until the North American Free Trade Agreement (NAFTA) came into force.

When analysing the industrialization statistics for Mexico in the context of structural change to identify its relative weight in the composition of products and employment within the gross domestic product (GDP), with the objective of identifying a pattern of deindustrialization, relative stagnation as a result of the breakdown of the productive chain through growing outsourcing is evident, as is the increasing importance of trade and services in the composition of GDP. When analysing this process along the northern border of Mexico, these trends do not coincide with the rest of the country because, due to the nature of industry in Mexico, i.e., part and component assembly, this sector is very dependent on the U.S. market.

Given its scarce integration into the national economy, particularly with industry in Mexico, various authors, such as Calderón-Villarreal and Hernández-Bielma (2016), Delgado Wise and Márquez Covarrubias (2007) and Cypher (2011), point to the maquiladora industry as deindustrializing *per se*; however, the assembly process contributes to manufacturing jobs, which define the labour market, the other explanatory variable of structural change.[1] Although the maquiladora industry pays low salaries, the pay has always been above the national average. In addition, the employment generated by the maquiladora industry has been an explanatory variable of economic growth and development along the northern border of Mexico.

In 2019, the maquiladoras located in this region exported 61.0% of the country's manufacturing goods. Due to their fiscal and productive functions, the low technological level with which they operate and their intrafirm trade, it is of great interest to analyse the structural changes in and specialization of the border economy since the 1990s, a time when the presence of these processes was intensified with the commercial opening of the country.

Therefore, the aim of this study is to demonstrate whether there is a process of deindustrialization in the border states of northern Mexico that has modified the structure of the economy and regional specialization characterized by the maquiladora industry. The *general objective* of this research is to identify, through the construction of indicators and econometric modelling, the general trends of industrial development along the northern border of Mexico. The *hypothesis* is that industrial development along the border is markedly different from that for the Mexican manufacturing industry as a whole, both for the degree of specialization and for the level of concentration, making the presence of deindustrialization as a pattern of structural change difficult.

This article consists of four sections. The first section provides a theoretical discussion on deindustrialization, the second provides a statistical analysis of border industrialization, the third section is composed of the methodology, and in the fourth section, the results of the indices and the econometric model are discussed. The introduction and conclusions constitute the operational components of the article, where the content and main findings of the research are presented.

[1] The assembly of parts and components is the final phase of manufacturing; if it cannot be done with machinery, workers complete tasks manually, a very important component in the cost structure. On the US-Mexico border, costs were reduced through cheap labour and transportation costs and a preferential fiscal policy.

Theoretical discussion on deindustrialization

According to Rodrik (2016), the modern world is a product of industrialization, which has allowed the sustainable growth of productivity in Europe and the United States, thus creating the difference between rich and poor countries. Urbanization and the creation of new social categories and consumption habits have been possible thanks to the capacity of structural change produced by industry.

The development of the manufacturing industry has historically been a determining factor in achieving better living standards through new products and complex machine systems. As a result of the technological advances generated by industry, the ability to incorporate unskilled workers into production processes with better wages increased significantly (Lewis, 1954). This behaviour of the manufacturing industry had effects on economic thinking, leading to the qualification of "growth machinery" due to its ability to induce rapid and sustained economic growth (Kaldor, 1967).

Economic development has been observed as a phased process (Rostow, 1990), where countries start at a level of low per capita income but, through economic growth and increased competitiveness, can achieve better levels of income. Historically, these results are presented through a *structural change* where productive resources are reallocated from the agricultural sector to the manufacturing industry (Atolia et al., 2018). In this sense, structural change has a positive connotation when moving from a developing economy to a developed economy (Calderón-Villarreal & Hernández-Bielma, 2016, p. 156).

Structural change is explained as follows: *1*) the process of relocation of the workforce to higher productivity activities; *2*) a renewal of the technological structure; and, *3*) a transformation of the structure of society. From these three dimensions, structural change can be observed as a dynamic and continuous process that allows an increase in the productive efficiency of the entire economic system as well as the creation, disappearance and increase in the quality and diversification of existing sectors in the economy (Maldonado Atencio, 2019).

This strong capacity for transformation originating in industry does not end with the consolidation of industry but is in constant evolution through new, more sophisticated and productive activities that draw the thin line that divides industrial activities and the disappearance of services. That is, industry through outsourcing favours the transfer of labour and capital from the industrial sector to the service sector, whose evolution is expressed as a deterioration of industrial activity, giving rise to the process of deindustrialization (Asyraf et al., 2019).

Deindustrialization has been commonly defined in the literature as the fall in value added and employment in the manufacturing sector in GDP, as mentioned by authors such as Rodrik (2016), Tregenna (2015) and Cáceres (2017). This loss of relative contribution is normal in developed economies, but what happens when deindustrialization occurs early in countries that have not managed to consolidate industry?

In developed countries, deindustrialization is the result of high growth in manufacturing productivity, reflected in an increase in the demand for services as a response to an increase in society's consumption. However, premature deindustrialization has been conceptualized as a decrease in industrial competitiveness in the economies of developing countries (Asyraf et al., 2019), which is expressed as a deterioration of the standard of living due to the low quality of services and trade that is not very

diversified, due to the low quality of manufacturing, which cause increases in imports and open competition with national industry.

According to Cuadrado Roura (2016), deindustrialization in developed economies is explained by three factors: *1*) the combination of increases in industrial productivity and decreases in the relative demand for industrial goods in relation to that for services; *2*) the role of international trade and comparative advantages between countries; and, *3*) the outsourcing of services by industrial companies and the generalized process of outsourcing of the manufacturing sector.

The deindustrialization of developed countries is seen as a symptom of the success of economic development (Rowthorn & Wells, 1987). However, the appearance of deindustrialization in developing economies is a negative phenomenon that slows economic growth, reduces the capacity of the economy to generate employment and restricts the possibilities of convergence with the income levels of advanced economies (Maldonado Atencio, 2019). This type of deindustrialization is premature because it reorients the productive structure of the economy to the service sector without having consolidated the transition of developing countries towards the per capita income of developing countries. According to Palma (2019), to self-perpetuate growth, industrialization is needed that is capable of playing a role in pushing the productive frontier in a sustained manner and generating the cumulative causation of positive feedback.

Kunst (2020) documents four facts about premature deindustrialization: *1*) this process mainly affects unskilled jobs (quantity and payment); *2*) the loss of unskilled jobs occurs mainly in the formal sector; *3*) this loss occurs in response to the replacement of intensive occupations by automation through information and communication technologies (ICTs); and, *4*) this phenomenon occurs mainly in high- and middle-income countries.

According to Lever (1991), there are four ways to explain the deindustrialization process:

1. A decrease in employment or production intt the manufacturing industry.
2. A change in the proportion of total employment or production in the manufacturing industry in favour of the service sector.
3. A decrease in exports of manufactured products in the country.
4. An inability to buy imports that help sustain manufacturing production, resulting in a greater decline in the manufacturing industry.

The first two definitions explain that deindustrialization represents a change in hegemony within total production, transitioning from industry to the service sector; however, this change can be observed as part of economic growth because industry continues to grow, although with less dynamism than the service sector. Although there are cases in which industry registers lower rates of labour growth without affecting growth in production, this result is defined by the technological capacity of the country, which positively affects total factor productivity.

The third and fourth definitions refer to the decrease in the export capacity of manufactured goods of the country to be analysed, that is, to the percentage share of the industry in total exports; this has not occurred in Mexico, given the strong presence of the automotive industry and the electrical and electronic industry in exports, in which the maquiladoras along the northern border of Mexico participate intensely.

In Mexico, according to Calderón-Villarreal & Hernández-Bielma (2016), deindustrialization began to manifest in the first half of the 1980s and was accentuated with the entry into force of NAFTA, which led to outsourcing and a "spurious" industrialization model. According to Palma (2019), the industrialization process in Mexico and countries in Central America is based on maquila exports, a process that, unlike Asian countries, is characterized by lower levels of productivity.

González Arévalo (2017) points out that manufacturing imports in 2000 were 117.92% higher than manufacturing production; by 2015, manufacturing imports were 199.67% higher than manufacturing production. The percentage share of manufacturing GDP in total GDP for these same years decreased from 19.7 in 2000 to 16.8 in 2015, indicating that the impressive growth of exports from 2005 to 2015 has not had a significant influence on the GDP growth rate but has favoured a process of deindustrialization.

Vázquez Galán and Corrales (2021), when analysing the data on the participation of the manufacturing industry in the creation of real added value and jobs, the speed of structural change *and* per capita income, find that *i*) at the national level, there has been a premature deindustrialization initiated by the fall of industrial participation in the economy and low per capita income; and, *ii*) in the state of Nuevo León, there has been a natural deindustrialization as a result of the evolution of its industry, i.e., a transition to a tertiary economy.

However, the maquiladora industry on the border with the United States, since the opening of trade, has experienced significant growth in both plants and jobs generated, which has resulted in the disappearance of tariff privileges, for which several industrial sectors have benefited. According to Mendiola (1999) and Bendesky et al. (2004), the textile industry, which had been regulated by quotas, increased the exports of the maquiladoras specializing in this sector through trade liberalization, which attracted textile companies from the Caribbean basin and even Asia (Mendiola, 1999, p. 17); however, with wage competition in the early 2000s, many border maquiladoras relocated to China and India (Bendesky et al., 2004, p. 283). This results in a short-term crisis for the maquiladora industry along the Mexican border.

Likewise, Covarrubias Valdenebro (2014) and Camacho (1999) establish that the automotive industry has been one of the pillars of the economic growth of manufacturing. With the opening of trade, the construction of automobile factories increased, and with it, employment and car and truck exports increased. One of the regions that benefitted comprised Guanajuato, Aguascalientes, Querétaro and San Luis Potosí, where Japanese and American companies were established. Similarly, on the northern border, in the states of Sonora, Chihuahua, Coahuila and Baja California, the transnational automotive industry made significant investments in both expansion and new plants that strengthened the manufacturing industry in the region.

Signs of deindustrialization along the northern border can be seen after NAFTA came into force, which, according to Dussel Peters et al. (1997), led to market losses for the national industry due to imports that modified production chains, with negative impacts on its market segments, a phenomenon that was combined with the authorization of the government to sell a percentage of maquiladora industry production in the national market (Mendiola, 1999, p. 15). All the analyses on deindustrialization emphasize trade openness as an explanatory variable of the analysed phenomenon; however, along the border, there is no national manufacturing industry that lost markets because maquiladoras account for the largest percentage.

In recent years, when deindustrialization was intensely manifested as the enormous weight of trade and services within the GDP, the maquiladora industry along the border has continued to thrive due to the performance of companies that depend on global production chains. At the time of drafting this article, there is a significant shortage of microchips for the automotive industry because of meeting the needs of electronics in the manufacture of cell phones, computers and televisions, for which, with the COVID-19 pandemic, demand increased (González, 2021). These manufacturers are very widespread among maquiladoras, particularly those along the border that assemble Japanese televisions, and do not exhibit signs of deindustrialization due to this shortage.

In this context of scarce integration into the national economy but given the importance of the border maquiladora industry for economic performance, this study investigates the main explanatory variables of performance: added value, employment, and international trade, among others. The results allow us to draw conclusions on the trends and foreseeable future of the manufacturing industry along the northern border of Mexico.

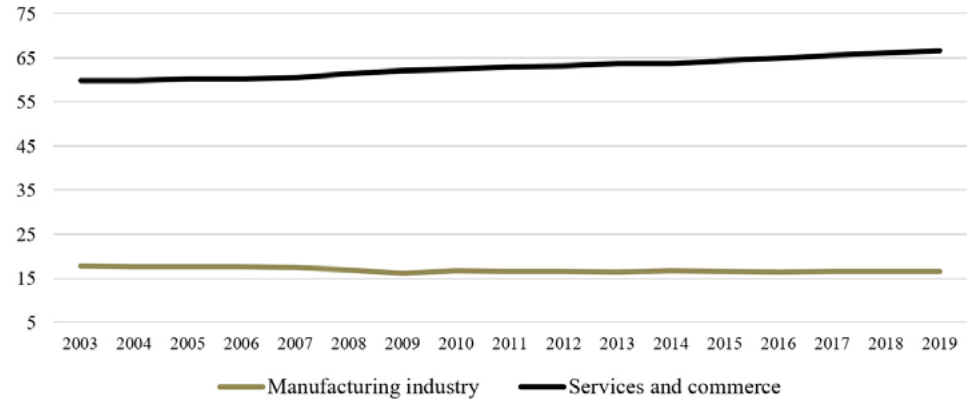
Statistical evidence of deindustrialization?

With data from the International Monetary Fund (IMF), Cuadrado-Roura (2021) finds that in the period between 1970 and 1995, employment in manufacturing in the most advanced economies fell by almost 10 percentage points (from 28% to 18%, on average) and that the average employment in manufacturing in this group of countries was only slightly above 13%. For Mexico, Vázquez Galán and Corrales Corrales (2021) point out that manufacturing has maintained a low contribution to the economy, which has decreased the generation of added value, reaching, in 2017, only 16.6% of the total value; in contrast, the service industry accounted for 65.6% of the value added.

Given these findings, the first analysis in this study is performed using aggregate data on the behaviour of GDP, employment, exports and other explanatory variables that determine industrial activity. In this sense, it is rational to review the Mexican economy to identify whether there is a similar pattern of behaviour both nationally and regionally. The loss in relative weight of the industrial sector in the composition of GDP and employment is the main explanatory variable of deindustrialization.

Figure 1 shows, through the historical series of GDP from 2003 to 2019, an increase in the percentage share of trade and services in total production, increasing from 59.8% in 2003 to 66.6% in 2019. The manufacturing industry maintained a constant contribution to the generation of GDP: from 17.8% in 2003 to 16.6% in 2019.

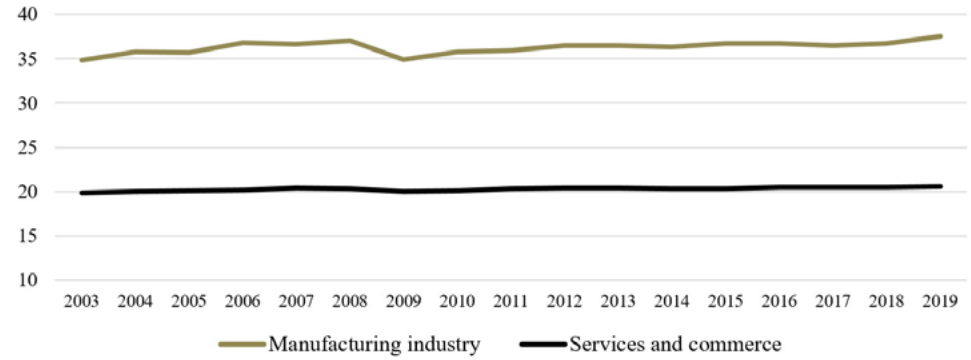
Figure 1. Evolution of the manufacturing industry, commerce and services in the national GDP. Percentage share



Source: prepared by the authors with data from the System of National Accounts (SNA) (Sistema de Cuentas Nacionales - SCN) of Inegi

When comparing the aggregate GDP of the six entities that compose the northern border with the national border (Figure 2), a growth in their participation in the manufacturing industry is identified, i.e., 34.8% of the total in 2003 and 37.5% in 2019. In the services and commerce sector, the border maintained a stable contribution: from 19.9% in the first year of analysis to 20.6% in the last year. This reflects the importance of the manufacturing industry in the border economy, whose weight in the national manufacturing industry is also indisputable.

Figure 2. Evolution of the manufacturing industry, commerce and services in the GDP of the northern border states with respect to the national total. Percentage share

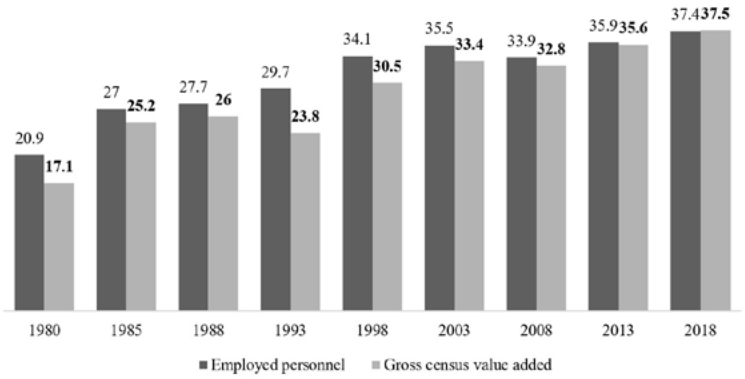


Source: prepared by the authors with data from the System of National Accounts (SNA) (Sistema de Cuentas Nacionales - SCN) of Inegi

When analysing employment (Figure 3), growth from the 1980s to 2018 is notable (from 20.9% to 37.4%), explained by the growth of maquiladora plants and their broad demand for workers for part and component assembly. Likewise, the growth in the gross census value added stands out (17.1% in 1980 to 37.5% in 2018); that is, a reduction in the gap between the two variables analysed is observed, indicating growth in wealth by personnel employed in the industry.

These changes observed in the statistics for the northern border of Mexico from 1980 to 2018 were driven by border industrialization through the maquila model, which, with the entry into force of NAFTA, boosted the performance of the border region. A review of the previous statistics on employment and value added indicates, by definition, an industrialization process, without the prefix *de-*, which indicates trends contrary to industrial growth, whose results have strengthened the economies along the Mexican-United States border.

Figure 3. Participation of employed personnel and gross census value added (the northern border with respect to the national border). Percentage share



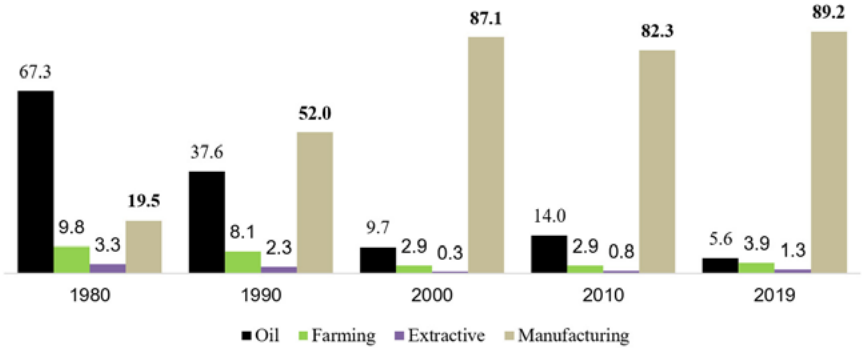
Source: prepared by the authors based on the 1981, 1986, 1989, 1994 economic censuses by Inegi. For the years 1999, 2004, 2009, 2014 and 2019, prepared by the authors based on the economic censuses by Inegi (2019)
Note: the year in the figure corresponds to the year of the census

Another explanatory variable of deindustrialization in economies is exports. As pointed out by Castillo and Neto (2016), for middle- or low-income economies, deindustrialization is accompanied by an increase in low-productivity industries, that is, sectors that are intensive in natural resources and low-productivity services, such as wholesalers, retailers and restaurants, which is reflected in the specialization of international trade through exports.

When analysing the data of oil and nonoil exports by Mexico (Figure 4), an increase in the percentage share of manufactured goods is observed; in 1980, oil exports represented 67.3% of the total, decreasing to 5.6% by 2019. In contrast, manufactured products became determinants of Mexican exports, increasing from 19.5% at the beginning of the 1980s to 90% in 2019. In four decades, manufactured goods became the main source of Mexican exports.

Given the importance of manufactured goods in exports, it is necessary to determine the weight of the goods produced by the maquiladora industry. For the period from 2007 to 2019, the goods produced by the maquiladoras represented, on average, between 80% and 90% of total exports (Figure 5). These data confirm the importance of the northern border in the pattern of industrial specialization and international trade in Mexico, given that the largest percentage of maquiladoras are located in this region of the country.

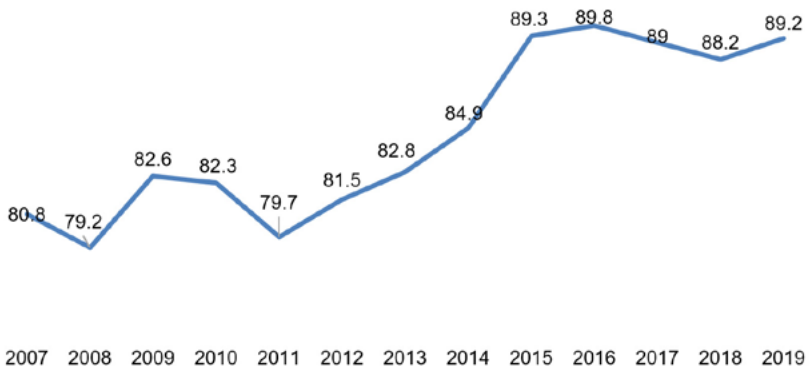
Figure 4. Oil and non-oil exports. Percentage share



Source: prepared by the authors with data from the Economic Information Bank (Banco de Información Económica - BIE) of Inegi

After analysing the explanatory variables of the pattern of industrialization along the northern border of Mexico, there does not seem to be enough evidence to argue the opposite of industrial development based on the maquiladora industry, whose participation in manufacturing exports has been decisive for the development of that region. A second level in the analysis, i.e., to identify the pattern of border industrialization, whose results contribute to explaining the loss of importance in contribution to GDP, is conducted through the construction of indicators and a panel data model. The following section presents the methodology to obtain these calculations.

Figure 5. Share of maquiladora exports among total goods exported. Percentage share



Source: prepared by the authors with data from the Economic Information Bank (BIE) (Banco de Información Económica - BIE) of Inegi

Methodology and data

To confirm the trends in the performance of the border manufacturing sector, the use of two indices and an econometric panel data model is proposed. First, the index of structural change (ISC) developed by Schiavo-Campo (1978) was calculated, which, despite its date of creation, is still valid in the statistical analysis of structural change. The justification for implementing this index is that it enables determining whether structural change has favoured the development of manufacturing or, failing that, whether the change is due to a loss of importance of manufacturing and, therefore, the presence of deindustrialization as a trend of industrial border development.

The index is represented as follows: $ISC = \frac{\sum^{n}_{i=1} | p_{it} - p_{i\,(t+k)} |}{2}$ (1)

where i = the productive branch or sector, p_i = the share of product or sector i in the total product, and $(t + k)$ = the period or unit of time; the numerator is divided by 2 to avoid double counting. Given that the index is nonparametric, it is necessary to use either the growth rate of the total product or the growth rate of sector i 's share in the total product (Δp_{it}) to identify whether the structural change has been favourable or not. In this study, the growth rate of the value p_{it} is used. The ISC results have to be compared over time, and the value over time has to show an ascending pattern to establish the presence of a structural change. That is, in each period, the gap between p_{it} and $p_{i(t+k)}$ must be increasing; otherwise, the existence of a structural change cannot be verified. Given the above, the following are possible results in the presence of structural change:

- If the ISC and the Δp_{it} decrease, then there is an unfavourable structural change. The gap between p_{it} and $p_{i(t+k)}$ is explained by a more than proportional increase in total product than by the increase in the share of manufacturing.
- If the ISC and the Δp_{it} increase, there is a favourable structural change. In this case, the gap between p_{it} and $p_{i(t+k)}$ is explained by a more than proportional increase in the share of manufacturing than by the increase in total product.

For the construction of the ISC, the national GDP and the GDP of the northern border states were used. The data were obtained from the economic censuses of 1999, 2004, 2009, 2014 and 2019 (Inegi, 2019).

To strengthen the results and the possible conclusions derived from the ISC, the specialization coefficient (SC) was calculated, for which the manufacturing GDP of each state and the national GDP were taken as variables. The calculation of this coefficient serves to analyse the evolution of the sectoral specialization of the border states and to contrast what is suggested by the ISC.

The coefficient is expressed as follows: $SC_{i,t} = \left(\frac{GDPman_{i,t}}{GDP_{i,t}}\right) \Big/ \left(\frac{GDPman_{Nac,t}}{GDP_{Nac,t}}\right)$ (2)

There are two possible results of this coefficient:

- $SC_{i,t} < 1$: when the coefficient is less than one, there is no specialization of the economy in the sector to be compared.
- $SC_{i,t} >$: when the coefficient is greater than one, there is specialization of the economy in the sector to be compared.

The data were obtained from the Inegi Economic Information Bank, with values at 2013 prices.

Finally, a model with panel data is proposed, with the objective of analysing the determinants of the SC of manufacturing along the northern border; the results from this model may yield more information on the variables that dictate the behaviour of the SC. Some authors, such as Ocegueda Hernández et al. (2009) and Gutiérrez Lagunes et al. (2018), highlight the importance of the degree of specialization of the northern border states in manufacturing and its important contribution to total production. Therefore, to build the model, the empirical literature is used to establish macroeconomic variables that influence the manufacturing sector.

According to Lanteri (2014) and Ibarra (2016), one of the variables that has the greatest influence on the manufacturing sector is the real exchange rate because it is a determinant of international trade and prices of local products destined for external markets. For example, depreciation in the real exchange rate is more likely to improve the competitiveness of goods produced in the country. Likewise, trade in manufacturing inputs has become a reference point for the competitiveness of the sector; therefore, the real exchange rate is considered a determinant of the SC along the northern border of Mexico.

In addition to the real exchange rate, empirical evidence reported by Ocampo and Parra (2003), Moreno-Brid et al. (2006) and Fraga-Castillo and Moreno-Brid (2014) suggest that the *terms of trade* variable is decisive in the production of manufacturing and is an important part of the competitiveness of the sector. This variable is also taken as a determinant because the northern border states maintain constant interactions with the external market, especially with the United States.

Along with the terms of trade, the integration of the northern border states with the United States economy allows the use of the GDP of the United States as an explanatory variable, as suggested by Navarro Chávez and Ayvar Campos (2008), Sánchez Juárez and Campos Benítez (2010) and Carbajal Suárez et al. (2016). Likewise, variables such as the employed population and gross fixed capital formation have been included to explain the behaviour of the manufacturing sector in studies developed by Carbajal-Suárez and Carrillo-Macario (2016) and Sánchez Juárez (2016).

The variables used for the panel data model are presented below:

- GDP of the United States (GDPUSA). The values were obtained in millions of dollars at constant 2010 prices. The information was obtained from World Bank statistics and converted to the natural logarithm.
- Gross fixed capital formation (GFCF). The data were deflated with the National Producer Price Index (NPPI). To avoid information bias, the data were transformed based on 2010. The natural logarithms were obtained. The data were obtained from the Inegi Economic Information Bank.

- Personnel employed in the manufacturing industry (PEM). The data were obtained from Inegi, and the natural logarithm was calculated.
- Real Exchange Rate Index (RERI). This index is reported by the Bank of Mexico and is constructed with the consumer price index for 49 countries.
- Terms of Trade Index (TTI). This index is published by the Bank of Mexico; herein, the nonoil index was used to avoid information bias.
- Dummy. This variable refers to the economic crisis of 2008.

The model is as follows:

$$SC_{it} = \alpha + \beta_1 GFCF_{i,t} + \beta_2 RERI_{i,t} + \beta_3 TTI_{i,t} + \beta_4 GDPUSA_{i,t} + \beta_5 PEm_{i,t} + \beta_6 dummy_{i,t} + v_{i,t} \quad (3)$$

Given that a panel model can vary in specifications, three tests were used to evaluate different specifications: the F test under the null hypothesis (H0) of the existence of a common intercept ($\alpha_1 = \alpha_2 = \alpha_3 ... = \alpha_{n-1}$); the Breusch and Pagan test (Breusch & Pagan, 1980) under the H0 that the error variance does not change, that is, $Var(u_i) = 0$; and the Hausman test (Hausman, 1978) under the H0 that the generalized least square (GLS) estimators are consistent because $[Cov(X_{i,t}, u_{it})] = 0$.

Temporality was delimited according to the availability of the data, that is, 2007-2019. The cross-section dimension is constituted by the six border states. Because there was a short data series, unit root tests of the ordinary least squares models were not necessary. The short temporality is also a limitation of the study; therefore, the results should be interpreted with caution. Likewise, because the financial economic crisis in the United States occurred during the study period, a dichotomous variable was added for 2008, the year for which a decrease in national GDP was reported. Table 1 provides the descriptive statistics for the data at the state level.

Table 1. Descriptive statistics for border states, 2007-2019

Variable	Statistics	Baja California	Coahuila	Chihuahua	Nuevo León	Sonora	Tamaulipas
GDP	Mean	486 754	542 243	483 278	1 152 950	504 945	478 951
	Standard deviation	55 031	54 700	59 108	139 940	63 418	23 806
GDP -manufacturing	Mean	114 634	211 814	123 419	276 322	122 826	109 290
	Standard deviation	18 259	26 565	20 430	28 341	11 818	5 476
GFCF	Mean	1 860	5 433	4 204	5 194	6 708	5 971
	Standard deviation	451	3 053	1 743	1 867	2 096	3 490
Employed manufacturing population	Mean	264 637	226 752	318 594	307 672	150 383	165 449
	Standard deviation	38 646	53 493	62 034	36 278	72 291	30 873

Note: the unit of measurement for GDP, GDP-manufacturing and GFCF is millions of pesos. The employed population was measured as the number of people
Source: Prepared by the authors with data from Inegi

Results

The ISC results are provided in Table 2. In the first five years from 1999 to 2004, the national-level ISC was 3.2%, and the growth rate Δp_{it} was negative (-18.3%), a finding consistent with that reported by authors such as Rodrik (2016), Calderón-Villarreal & Hernández-Bielma (2016) and Sobrino (2012) and indicative of a process of deindustrialization for the Mexican economy. However, in the five-year periods from 2004 to 2009 and 2009 to 2014, the ISC decreased to 0.2% and 0.6%, respectively, inconclusive results with regard to determining the presence of a process of deindustrialization and structural change in the Mexican economy. For the five-year period from 2014 to 2019, the ISC increased to 1.5%, and Δp_{it} also increased to 10.3%. Under this scenario, the presence of a favourable structural change can be confirmed.

For the northern border of Mexico during the five-year period from 2004 to 2009, the ISC results did not confirm a structural change in which the manufacturing industry loses importance with regard to its contribution to the regional GDP because the values indicate a downwards trend. In contrast, from 2009 to 2014, the ISC results suggest the presence of a favourable structural change towards border industrialization, as evidenced by the ISC and the growth rate of Δp_{it}. However, for the five-year period from 2014 to 2019, the ISC value decreased compared with that in 2014, and Δp_{it} also decreased; therefore, the presence of an unfavourable structural change cannot be established.

Table 2. Manufacturing structural change index and growth rate of p_{it} for 2004, 2009, 2014 and 2019

Location	Growth rate of P_{it} (%)				Structural change index (%)			
	2004	2009	2014	2019	2004	2009	2014	2019
National	**-18.3**	**-1.7**	**4.1**	**10.3**	**3.2**	**0.2**	**0.6**	**1.5**
Northern border	**-5.3**	**1.4**	**5.0**	**2.2**	**1.3**	**0.3**	**1.1**	**0.5**
Baja California	5.1	4.6	11.4	-1.4	1.1	1.0	2.6	0.4
Coahuila	-1.9	7.6	11.2	-0.2	0.5	2.2	3.4	0.1
Chihuahua	22.8	-14.6	3.2	-2.3	5.6	4.4	0.8	0.6
Nuevo León	-18.1	6.6	-8.3	12.0	4.2	1.2	1.7	2.2
Sonora	-16.9	10.5	16.1	-17.2	3.8	2.0	3.3	4.2
Tamaulipas	-9.7	1.8	16.4	1.1	1.9	0.3	3.0	0.2

Source: prepared by the authors based on the 1999, 2004, 2009, 2014 and 2019 economic censuses by Inegi

In a vertical analysis of Table 2, by border state, the rate for the first five-year period (2004-2009) are negative (p_{it}) for most of the states analysed, with the exception of Baja California and Chihuahua; only in Baja California does industry maintain a very solid position with respect to GDP. For Baja California, for the five-year period from 2004 to 2019, there is a loss in the contribution of manufacturing to the state GDP and a reduction in the ISC in relation to 2014.

Nuevo León, whose manufacturing tradition since the beginning of the 20th century has not comparable with the rest of the country due to its extensive participation in the industrialization of Mexico, has shown recent indications of deindustrialization,

similar to the Mexican economy, as seen with its ISC, particularly due to its Δp_{it}, which is negative for the 1999-2004 period. After exhausting the growth of its basic manufacturing industries (Vazquéz Galán & Corrales Corrales, 2021), Nuevo León began to develop industrial and financial services for the national and foreign economies, resulting in a process of intense deindustrialization. However, for the five-year period of 2014-2019, there was a favourable rebound in the contribution of manufacturing in Nuevo León, as evidenced by the increase in ISC and Δp_{it}, indicating that favourable structural change occurred.

For the five-year periods of 2004-2009, 2009-2014 and 2014-2019, vertical and horizontal analyses of the results of Table 2 confirm the recovery of the industrial sector along the northern border of Mexico. However, competition from China, with its entry into the World Trade Organization (WTO) in 2001, together with the relocation of the maquiladora industry to that country during the same period, generated negative effects for the border economy in terms of plant and job creation. The recovery of the United States economy beginning in 2004 had positive impacts on exports (Pérez Llanas, 2006) by the border maquiladora industry.

The data analysed show structural change in favour of manufacturing along the entire Mexico-United States border; however, Nuevo León can be given the prefix *de-* for the five-year period from 2009 to 2014, during which industrial development favoured trade and services. The p_{it} for Chihuahua contracted significantly in the five-year period from 2009 to 2014 but was lower than the growth experienced in the five-year periods of 2004-2009 and 2014-2019. In general, the indicators confirm the recovery of the manufacturing industry in the last two five-year periods analysed, after a sharp decrease between 1999 and 2004, a time coinciding with national deindustrialization, for which both academics and industrialists have provided scientific and academic evidence and stylized facts (Kaldor, 1967).

Likewise, for Sonora, the ISC increases, and Δp_{it} decreases; therefore, an unfavourable structural change can be established, at least for the five-year period from 2014 to 2019. Analysing the commerce and services sectors using the same methodology allows the determination of whether the loss in the manufacturing sector was gained by these sectors; Table 3 provides the calculation results.

The ISC for trade at the national level suggests the presence of favourable structural change, at least for the five-year period from 2014 to 2019, given that the growth rate of trade participation in total production was positive and the ISC increased. For this period, the results suggest the same for the northern border. At the state level and for the same period, only Nuevo León and Tamaulipas showed favourable structural change in the commerce sector.

Table 3. Structural change index in services and trade and growth rates of P_{it} for 2004, 2009, 2014 and 2019

Location	Growth rate of P_{it} (%)				Structural change index (%)			
	2004	2009	2014	2019	2004	2009	2014	2019
Trade								
National	**-20.5**	**-30.8**	**31.5**	**37.6**	**2.2**	**2.6**	**1.9**	**2.9**
Northern border	**-17.1**	**-29.7**	**21.3**	**27.7**	**1.9**	**2.7**	**1.4**	**2.1**
Baja California	-23.9	-28.5	49.5	12.4	3.3	3.0	3.7	1.4
Coahuila	22.6	-42.3	21.8	17.7	1.6	3.6	1.1	1.0
Chihuahua	-33.4	-20.9	56.2	26.2	4.1	1.7	3.7	2.7
Nuevo León	-14.9	-24.0	1.0	37.1	1.5	2.1	0.1	2.5
Sonora	-14.3	-44.9	19.5	18.6	2.0	5.5	1.3	1.5
Tamaulipas	-15.7	-28.6	33.8	39.3	1.6	2.5	2.1	3.3
Services								
National	**27.4**	**-3.0**	**-2.8**	**33.0**	**2.5**	**0.4**	**0.3**	**3.6**
Northern border	**19.8**	**-10.6**	**26.0**	**3.9**	**1.4**	**0.9**	**2.0**	**0.3**
Baja California	0.6	0.5	32.8	2.9	0.0	0.0	2.3	0.3
Coahuila	8.4	-11.0	-2.0	9.4	0.5	0.7	0.1	0.5
Chihuahua	-25.7	-0.2	19.8	10.9	1.8	0.0	1.0	0.7
Nuevo León	51.1	-13.2	4.6	29.4	4.4	1.7	0.5	3.5
Sonora	38.7	-23.4	-5.8	16.8	2.0	1.7	0.3	0.9
Tamaulipas	-21.7	0.3	207.6	-57.3	1.4	0.0	10.2	8.7

Source: prepared by the authors with data from the 1999, 2004, 2009, 2014 and 2019 economic censuses by Inegi

For services at the national level, it is not possible to confirm the presence of structural change during the five-year period from 2004 to 2009. However, in the five-year period from 2009 to 2014, there is a slight increase in the ISC and a decrease in the contribution of this sector to total production; given that the changes in values are marginal, the conclusion should be interpreted with caution. However, for the five-year period from 2014 to 2019, there is an increase in the ISC and an increase in Δp_{it}; therefore, for this period, favourable structural change can be confirmed. Along the northern border, the presence of structural change is present in the five-year period from 2009 to 2014, and given that the contribution of this sector to total production has increased, positive structural change can be confirmed. For the five-year period from 2014 to 2019, the result is not conclusive for the service sector.

In general and when comparing the ISC for the manufacturing, commerce and service sectors, only the commerce sector presents favourable structural change. A vertical analysis of the table illustrates the recovery of trade and services in production in 2014 and 2019 but without sufficient robustness to affirm the existence of a rapacious deindustrialization process, which inhibits the propensity to invest.

As argued in the methodology, an SC was calculated to strengthen the ISC results for the northern border. The results are shown in Table 4. For each year since 2007, in all

cases, the result is greater than one, and the average is very similar, except for Coahuila, whose value exceeded two. The trend in each case has little variation, as shown by the standard deviation.

Table 4. Specialization coefficients for the states of the northern border of Mexico, 2007-2019

Year/state	Baja California	Coahuila	Chihuahua	Nuevo León	Sonora	Tamaulipas
2007	1.47	2.37	1.45	1.42	1.47	1.40
2008	1.43	2.32	1.47	1.43	1.55	1.51
2009	1.39	2.04	1.44	1.52	1.52	1.55
2010	1.36	2.32	1.42	1.52	1.49	1.41
2011	1.30	2.37	1.43	1.48	1.51	1.36
2012	1.32	2.43	1.53	1.46	1.47	1.36
2013	1.31	2.42	1.56	1.44	1.54	1.36
2014	1.37	2.46	1.55	1.41	1.52	1.33
2015	1.42	2.42	1.58	1.40	1.52	1.33
2016	1.46	2.31	1.60	1.39	1.46	1.34
2017	1.44	2.27	1.61	1.41	1.36	1.31
2018	1.50	2.33	1.60	1.42	1.31	1.27
2019	1.53	2.34	1.60	1.43	1.35	1.31
Average	1.43	2.36	1.51	1.45	1.45	1.37
Standard deviation	0.07	0.10	0.07	0.04	0.09	0.07

Source: prepared by the authors with data from the Inegi Economic Information Bank (Información Económica)

The SC results indicate strong manufacturing sector roots along the northern border of Mexico. Therefore, the panel model reveals the determinants of the SC. The results are shown in Table 5. According to the specification tests, the structure of the model resulted in random effects; that is, the intercept is completely random, and therefore, it is decomposed into its stochastic part, corresponding to the individual ($\varepsilon_{i,}$), and its constant part (α), i.e., $\alpha_{it} = \alpha + \varepsilon_{i,}$, $\varepsilon_{i,} \sim N(0, \sigma^2)$, which results in the following panel structure: $Y_{it} = \alpha + \beta x_{i,t} + v_{i,t}$, where $v_{i,t} = u_{i,t} + \varepsilon_i v_{i,t} \sim N(0, \sigma^2)$.

Table 5. Model results

Endogenous variable: SC		
Exogenous variables	Coefficients	
Intercepto	2.9128 (1.1156)	**
GFCF	0.0771 (0.0046)	**
RERI	0.0022 (0.0007)	***
TTI	0.0093 (0.0136)	
GDPUSA	1.1853 (0.0653)	***
PEm	0.5651 (0.1588)	***
Dummy (crisis 2008)	-0.0231 (0.0103)	**
No. of observations	78	
Standard deviation of the model	0.0304	
Model specification tests: F Test H0 = the groups have a common intercept. F (5.66) = 127,135; *p*-value of statistic $F = 0.0000$ Breusch–Pagan test H0 = error variance equal to zero, $Var(u_i)=0$ chi-square (1) = 28.6291; *p*-value of the chi-square X^2 statistic = 0.0090 Hausman test H0 (random effects) = estimators of GLS are consistent, $[\mathrm{Cov}(X_{i,t}, u_{it})] = 0$ chi-square (2) = 3.0943; *p*-value of the chi-square X^2 statistic = 0.2128		

Notes: *, ** and *** denote significance at the 10, 5 and 1% levels, respectively. Values in parentheses denote the standard error
Source: prepared by the authors

According to the results of the model, the best specification resulted in random effects, which are shown in Table 5. Only the variable TTI was not statistically significant; however, the sign was as expected. The variable GFCF acquired the expected sign and was statistically significant; the coefficient implies that an increase of one percentage unit of GFCF increases SC by 0.0771 percentage points.

RERI obtained the expected sign because an increase in the index implies that there is a depreciation of Mexican currency and, therefore, that there are greater incentives for production due to a greater benefit from exports. In quantitative terms, an increase of one percentage unit in RERI increases the SC by 0.0022 percentage points.

In relation to GDPUSA, the results indicate that it is statistically significant, with the expected sign. The value implies that the SC increases by 1.18 percentage points due

to an increase in the GDP of the United States. In this sense, it was the variable with the greatest quantitative impact on the SC. This finding suggests that manufacturing activity has a strong dependence on external sectors, a result that is explained by the geographical proximity of Mexico to the United States. The *employed personnel* variable was statistically significant, with the expected sign. Quantitatively, the coefficient implies that an increase in the employed population of the manufacturing sector increases the SC by 0.56 percentage points. Finally, the crisis *dummy* variable had the expected sign, and the coefficient indicates a reduction of 0.023 percentage points in the SC.

The econometric model shows the strong dependence of manufacturing on external sectors as well as investment and employed personnel. These variables together help to reveal the factors that contribute to continuous high impact that manufacturing has on the northern border of Mexico.

Conclusions

The phenomenon of deindustrialization recently acquired special importance because trade and services became the main components of GDP, leading to the relative decline in the manufacturing industry. In industrialized countries, that is already a consolidated fact. In Mexico, this phenomenon is premature because of its low level of development; however, the northern border states created deep foundations through manufacturing activity, i.e., the maquiladora industry, which continues to be the axis of economic growth.

The border states of northern Mexico, such as Baja California, Chihuahua, Sonora and Tamaulipas, maintain very similar gaps due to their contributions to regional GDP. Coahuila and Nuevo León are leaders in industrial activity, despite their relative stagnation as trade and services increase over manufacturing. In general, the growth trend for the industrial sector in border states is positive; however, in some states such as Chihuahua, industry has a lower specific weight due to the value of production, and in Nuevo León, which exhibits indications of deindustrialization, maintains manufacturing specialization in the region.

Unlike the findings of research on deindustrialization in different countries and regions of the world, along the northern border of Mexico, there is strong specialization by the manufacturing sector, under a process that cannot be described with the prefix *de-*; this is demonstrated by the general statistics analysed, the indices of structural change for different periods and the results of the model.

The persistence of the border industry, despite external pressure that has led to the relocation of many maquiladora plants and the automotive industry, is a result of the competitive advantages due to its proximity to the United States, a factor that keeps the manufacturing industry stable. It is an industry that, as seen, reflects strong dependence on variables associated with foreign trade.

Therefore, to speak of deindustrialization in the northern Border states is premature. The results of this research serve to draw attention and redirect potential factors that lead to mitigating a possible loss of importance of the industry sector. For example, in the analysis by states, in Nuevo León, there was a decrease in the contribution of the industry sector and an increase in the ISC, which can be interpreted as a process of unfavourable structural change, at least for the quinquennium of 2014-2019.

The above sets the standard for establishing that in some states, the tertiary sector has gained weight in the economic structure to the detriment of the industry sector. Further research is required to determine the continued importance of the tertiary sector in the generation of economic benefits, for which the manufacturing sector is irrelevant as a source of economic growth. It is necessary to analyse the information at a more disaggregated level, that is, by branch of the economy, and identify the industry sectors and subsectors that have lost weight in the regional economy to confirm or dismiss deindustrialization.

In short, the manufacturing sector, constituted by the export maquiladora industry, continues to support growth and economic development along the northern border of Mexico. When studying deindustrialization, it is important to obtain conclusions about its real causes and to address those cause because industry is the main engine of growth of economies. Increasing investment in the industry sector, investing in research and development (R&D), strengthening the export industry, moving towards a more diversified industry and reducing assembly as a priority in the industrialization process are some strategic activities that will strengthen the manufacturing industry, both along the northern border and in Mexico as a whole.

The results and findings of this research should be interpreted with caution because the investigation was conducted at an aggregate level, i.e., the entire northern border region. Therefore, future research should conduct more specific analyses, that is, at the subsector level or for a branch of economic activity that is representative of each state and its main sector of industrial activity.

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