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Localization of manufacturing industries and specialization in Mexican states: 1993–2013*

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Abstract. We document how the localization of production in Mexico's range of manufacturing subsectors and the specialization of its states have evolved as a result of the process of trade opening. We use the global estimate methodology to calculate the extent to which all industries are localized or all regions specialized. The results show that: (*i*) since 1993, there has been an increase in global localization and specialization in manufacturing production; (*ii*) transportation equipment, chemicals, and food products account for the greatest share of the overall increase in localization during this period; and (*iii*) those states closest to the US contributed most to the overall increase in specialization.

JEL classification: F15, R11, R12

Key words: Industrial localization, regional specialization, economic integration

1 Introduction

The processes of economic integration in various parts of the world have given rise to a series of studies into the impact these have on the degree of industrial localization and level of specialization in an economy.[1] These not only document the changes brought about by the processes of economic liberalization, but also investigate whether these changes are consistent with the predictions of traditional models of trade, new trade theories or new economic geography. All these models make similar predictions about the consequences of integration (i.e., more integration or trade leads to greater concentration), while only differing in their explanation of the factors that

* The views and conclusions presented in this paper are the authors' own and do not necessarily reflect those of Banco de México.

[1] Classical theoretical models such as Ricardo's predict that trade will lead to regional specialization and to a higher level of concentration of production due to productivity differences among economies, whereas in the Heckscher-Ohlin model, economies specialize in economic activities that are intensive in factors of production in which they are relatively abundant. Similarly, models from the literature known as 'new economic geography' explain that trade costs, increasing returns to scale, input–output linkages (among companies in the same or different industrial sectors), and so on can lead to increased agglomeration of economic activity (see Krugman 1991a, 1991b; Krugman and Venables 1995, 1996, among others).

cause these. The vast majority of these studies have examined the changes in the patterns of localization and specialization in EU countries (see, Amiti 1999; Storper et al. 2002; Ezcurra et al. 2006; and Krenz and Rübel 2010, among others). At a regional level, they primarily discuss the experience of developed economies, for example, the US (see Kim 1995, 1999; and Mulligan and Schmidt 2005, among others); France (Maurel and Sédillot 1999) or Spain (Paluzie et al. 2001), to mention just a few.

A developing country such as Mexico – and particularly in the period under analysis, 1993–2013 – represents an interesting case for study due to the rapid and significant decrease in trade barriers and costs that the country experienced from the mid-1980s onwards. These events provide us with an opportunity to compare our results with those of other empirical studies that analyse the effects of economic liberalization on a country's economic structure. The period under analysis saw at least two major events in Mexico's integration with North America (in particular the US): the entry into effect of the North American Free Trade Agreement (NAFTA) in early 1994 and China's joining the World Trade Organization (WTO) at the end of 2001. We believe that in our case study, the effects of economic integration are reflected more intensely, first because Mexico was a relatively closed economy[2] until the mid-1980s, and second because, in regional-level studies, the forces that tend to concentrate production or to encourage specialization are stronger due to the high mobility of the factors of production.[3]

Previous studies on Mexico have looked at the effects of liberalization reforms on the development of its range of manufacturing activities. Hanson (1998) analyses employment data from the manufacturing sector and makes two main assertions: first, manufacturing companies sought to reduce their transport costs by relocating to states closer to the US (now the most important market), thereby breaking up the manufacturing belt around Mexico City (until then the most important market)[4]; and second, due to important linkage effects, companies were motivated to relocate, that is, closer to their suppliers or the buyers of their products. Chiquiar et al. (2016) analyse the impact of international trade on the labour market in different metro areas and assert that, as a result of NAFTA, employment and wages in the manufacturing sector increased. In contrast, they document that the increase in US imports from China following the latter's incorporation into the World Trade Organization (WTO) negatively impacted employment and wages in Mexico. Furthermore, they find evidence that the effects described above were not uniform across the country but rather more marked in those labour markets that were more vulnerable to international markets and foreign competition. Hernández-González (2007) uses local Gini coefficients to describe the evolution of the localization of industries and the specialization of particular regions. Not using a global coefficient to describe the entire spatial industry-state matrix leads her to analyse each state or subsector individually over a given period of time to see what happened to its level of specialization or localization. Consequently, she does not describe what happens to the country as a whole, whereas our study does show how the overall concentration of all manufacturing industries changes (this is presented in

[2] The accession to the General Agreement on Tariff and Trade (GATT) in 1986 is generally considered to be the first major step in the economic liberalization reforms that put an end to four decades of the model known as 'import substitution industrialization'.

[3] During the period considered in this study, Mexico signed various other trade agreements with countries on different continents, in addition to NAFTA with the US and Canada. It is also a member of a number of organizations that promote free trade [the Organization for Economic Cooperation and Development (OECD), Asia-Pacific Economic Cooperation (APEC), and the Latin American Integration Association (ALADI), among others]. Nevertheless, throughout this paper we cite NAFTA as the main driving force behind the changes observed in the specialization of states and localization of economic activities due to the fact that from 1990 to 1994, Mexico's average annual exports to the US and Canada accounted for 79.7 per cent of its total exports, and 85.9 per cent in the post-NAFTA period, 1995–2015.

[4] This evidence is consistent with that reported by Rodríguez-Pose and Sánchez Reaza (2003) and Garduño (2014), who assert that liberalization has led to an increase in regional disparities, to the benefit of those regions located closer to the US and to the detriment of those located farther away, which have not been able to reap the benefits of access to world markets. In addition to being disadvantaged by their geographical location, they are also limited, to a significant degree, in terms of transport and communications infrastructure and by a low level of schooling.

the first subsection of the results). In general, her findings on the change in specialization of states and the change in localization of industries are similar to ours for the period where both studies coincide (1993–2003). It is for this reason that in this paper we choose to use the methodology proposed by Mulligan and Schmidt (2005) of a global coefficient constructed from local indexes. Moreover, a particular characteristic of this global measure is that it is identical regardless of whether it is calculated using a local index of localization or of specialization, unlike other measures commonly used in the literature (e.g., Gini coefficients, Hirschman-Herfindhal index, etc.).[5]

The aim of this study is to provide a clear description of the changing pattern of manufacturing production within the country and to determine whether or not the predictions of theoretical trade models are accurate. We document the extent to which the process of economic integration affected the specialization of the different states and the localization of all manufacturing activities.[6] While various studies have described the changes experienced by the country in the post-NAFTA period, our findings help to better understand which manufacturing subsectors and states have been most impacted by the opening-up of trade. Our results show that, in general, the states that contributed most to the increase in the level of specialization within the country – and as a consequence of economic integration – tend to be located closer to the US Moreover, in terms of their increase in specialization, the states are not randomly spatially distributed but instead show positive spatial dependence. Three manufacturing subsectors account for the greatest share of the overall increase in localization during this period: transportation equipment (one of the subsectors most closely linked to the external market), and chemicals and food products, two subsectors closely linked to the domestic market.

The rest of the article is organized as follows. In Section 2, we describe the methodology proposed by Mulligan and Schmidt (2005) for obtaining a global measure of localization and specialization. Section 3 presents the results, first from a global point of view and then at a sectoral and regional level. Lastly, Section 4 concludes.

2 Data and methodology for determining the indexes of industrial localization and state specialization

Localization and specialization indexes are calculated using data on the value added (VA) of 21 manufacturing subsectors (at a 3-digit level of disaggregation), for each of the 32 states.[7] These were obtained from the 1994, 1999, 2004, 2009, and 2014 Economic Censuses published by Mexico's National Institute of Statistics and Geography (INEGI).[8]

Let us consider a matrix comprised of 32 rows and 21 columns, with states denoted by the letter i and subsectors by the letter j. Thus, element $x_{i,j}$ of the matrix indicates the VA produced in state i by subsector j; the total VA produced in state i is obtained by adding the elements of the corresponding row and denoted by $X_{i,\cdot}$; the total VA of subsector j in the country is obtained by adding the elements of the corresponding column and denoted by $X_{\cdot,j}$; and finally, the total VA of the country's manufacturing firms is obtained by adding all of the elements of the matrix and denoted by X.

Following Mulligan and Schimidt (2005), local geographic concentration indicators for each subsector are measured by the localization coefficient (COL_j), which compares the share of

[5] For a more in-depth explanation of the advantages of this methodology, see Mulligan and Schmidt (2005).
[6] Previous studies have documented the relocation of manufacturing activity but have not specifically identified the subsectors most affected by greater openness.
[7] The 1994 census classifies economic activities according to the Mexican Classification of Activities and Products (CMAP) system. From 1999 onward, the censuses use the North American Industry Classification System (NAICS). The 1994 data were adapted to make them consistent with the NAICS system.
[8] Each year's census contains information for the immediately preceding year.

industry j in the manufacturing production of each of the states with respect to the share that each state represents of all domestic manufacturing activity:

$$COL_j = 0.5 \cdot \sum_{i=1}^{32} \left| \frac{x_{i,j}}{X_{\cdot,j}} - \frac{X_{i,\cdot}}{X} \right|. \tag{1}$$

Thus, the greater the difference between the relative importance of manufacturing activity j in state i and the importance of state i nationally, the greater the level of geographic concentration of that activity.

Meanwhile, to measure the degree of diversification of state i, a specialization coefficient (COS_i) is used, which compares the share of the various manufacturing industries in that state to their share at the national level:

$$COS_i = 0.5 \cdot \sum_{j=1}^{21} \left| \frac{x_{i,j}}{X_{i,\cdot}} - \frac{X_{\cdot,j}}{X} \right|. \tag{2}$$

This definition implies that the more the economic structure of the state differs from that of the country as a whole, the greater its level of specialization.

The localization and specialization coefficients described above are specific to each manufacturing industry and state analysed. To obtain the global localization coefficient $G(L)$ of all of the manufacturing industries combined or the global specialization coefficient $G(S)$ of all the states, we first obtain the weighted sum of the local indicators. In particular, the global localization coefficient $G(L)$ weights the localization coefficients by industry, COL_j, according to the share of each industry in the VA in domestic manufacturing, ($u_j = X_{\cdot,j}/X$). Hence:

$$G(L) = \sum_{j=1}^{21} u_j \cdot COL_j. \tag{3}$$

Similarly, the global specialization coefficient, $G(S)$, weights the specialization coefficients of the states, COS_i, according to the share of each state in the VA in domestic manufacturing, ($v_j = X_{i,\cdot}/X$)[9]:

$$G(S) = \sum_{i=1}^{32} v_i \cdot COS_i. \tag{4}$$

Mulligan and Schmidt stress the need to employ global indexes in the literature in order to evaluate the general characteristics of the spatial economy-industry matrix, and thus examine the extent to which all industries are localized or all regions specialized. They therefore stress the fact that, in their proposal for how to measure localization and global specialization, both indicators are identical, $G(L) = G(S)$.[10]

[9] Appendix 1 illustrates how these measures are calculated, using hypothetical data for four economies and four economic activities.

[10] The local indicators (COL_j and COS_i) that are computed in order to calculate their global equivalents ($G(L)$ *or* $G(S)$) are similar to other commonly used local indicators (the Gini and Hirschman–Herfindahl index, among others) in that they describe what happens to a *specific* industry or state at a given time and not the economy as a whole.

3 Results

3.1 Evolution of global localization and specialization of manufacturing firms

Figure 1 shows the evolution of global localization, $G(L)$, and global specialization, $G(S)$. The indicator shows an upward trend during the subperiod 1993–2003, which coincides with the implementation of NAFTA. This trade treaty significantly increased Mexican exports to the US, though to differing degrees depending on the subsector and the state. However, nationally, figures indicate an increase in the geographical concentration of manufacturing production and in state specialization.[11]

Subsequently, we see a decrease in the levels of localization and specialization in the manufacturing sector nationally in the subperiod 2003–2013. This is explained by China's entry to the WTO and the consequent increase in its exports to the US, which led to a decrease in Mexico's share of imports to that country (Chiquiar et al. 2016).[12] This implies that China tempered the impact that NAFTA had had on levels of localization and specialization by displacing some of the market share of Mexico's exporting subsectors and of the states in the country's north, which was where the focus of manufacturing activity had shifted from 1994 on. We will elaborate upon these explanations in our description of the evolution of localization by subsector and of specialization by state.[13,14]

3.2 Evolution of states' specialization

Table 1 shows the estimates of the state specialization coefficient (COS_i), their percentage share (v_i) of domestic manufacturing production, and the level of specialization adjusted according to share ($COS_i \cdot v_i$) for three of the five years of the sample. Starting in 1993, states that share a border with the US (Baja California, Coahuila, Chihuahua, Nuevo León, Sonora and Tamaulipas) increased their level of specialization and, in the final year of the sample, all six were among the 12 states that made the greatest contribution to the global specialization of the country as a whole. This is in line with the findings of Garduño (2014), who asserts that NAFTA has primarily benefited those Mexican municipalities located closest to the US, since they have better integrated into world markets. In contrast, those located further from the country's northern neighbour have lost out as a result of NAFTA.

With the entry into force of NAFTA, the US market became the most important market for domestic manufacturing. This caused a shift in manufacturing activity away from the country's centre (Mexico City and Mexico State) mainly to the states along the northern border. This can be seen in Figure 2, which shows the change in manufacturing share by state in the period

[11] The evolution of the coefficients $G(L) = G(S)$ in Graph (1) remains quite similar when these are calculated using a different variable, persons employed (PE). Likewise, the results are similar if we use different levels of disaggregation of the variables VA and PE (4, 5, and 6 digits). The robustness of the results makes them comparable to those of other studies that describe, using the PE variable, the changes in the regional economic structure since economic liberalization (e.g., Hanson 1998 and Chiquiar et al. 2016).

[12] According to World Bank statistics (http://wits.worldbank.org; trade statistics for China are available for the period from 1992 onwards), during the nine years prior to its entry to the WTO (i.e., from 1992 to 2001), China's exports to the US increased by only US$45 billion. Over the following nine years (2002–2011), China's exports rose by 254 billion, a remarkable increase given the global economic crisis of 2008 (from 2008 to 2009, China's exports to the US actually decreased by 31 billion). By 2015, China's exports to the US had reached $410 billion. Prior to China's entry into the WTO (1990–2001), the average annual growth rate of Mexican exports to the US was 17.54 per cent; following China's entry into the WTO (2002–2015), this figure fell to just 5.8 per cent.

[13] It is important to mention that other important events may explain the reduction in industry concentration seen after 2003; for example, the global crisis of 2008, which caused a decline in Mexican exports, particularly of transportation equipment.

[14] Appendix 2 presents the results by regions. In general, these allow us to draw the same conclusions as those from the analysis by states.

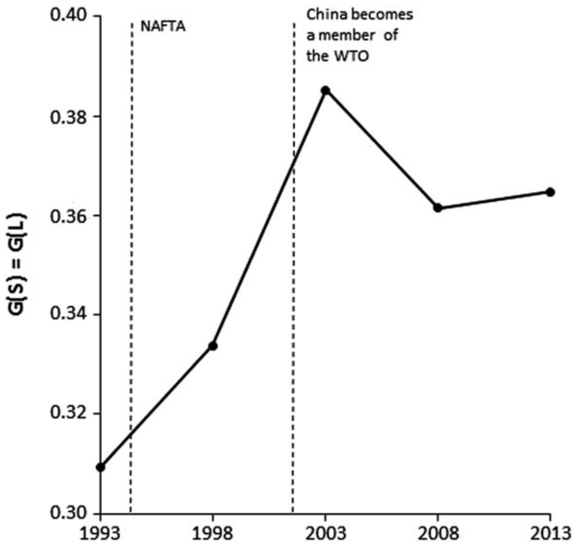

Fig. 1. Evolution of global localization and specialization
Note: Own estimates based on information from the Economic Censuses published by INEGI.

1993–2003. During this time, the share of domestic manufacturing production of the six states in the North rose from 23.8 per cent to 33.4 per cent. The share of domestic manufacturing production of Aguascalientes, Durango, Guanajuato, Querétaro, San Luis Potosí, and Zacatecas rose from 8.7 per cent to 14.8. Of the states in the south of the country, Chiapas and Tabasco saw the most significant increase, their share rising by 1 per cent during this period. In contrast, Mexico City and Mexico State's share decreased from 37.3 to 18.3 per cent in the same period.

This relocation of manufacturing production was the result of companies seeking to reduce transportation costs by moving production closer to their export market (see Hanson 1998) or their deciding to increase their production levels in states better endowed in terms of the communications and transport infrastructure and human capital required to export goods (see Chiquiar 2005).

However, the process of state specialization was not uniform throughout the period 1993–2013. From 1993 to 2003, the specialization coefficient increased in 75 per cent of the states, whereas from 2003 to 2013 this was true for only 46 per cent. The increase in the level of state specialization following the introduction of NAFTA slowed down after 2001 due to the effect of increased competition from China on the country's exporting states (see Chiquiar et al. 2016).

The increase in concentration during the first subperiod was primarily due to the increase in concentration in border states. Nevertheless, as reflected in Figure 3, during the period 2003–2013 only three of the six states on the northern border increased their share of manufacturing. Something similar occurred in a number of the states in the North-Central region (Aguascalientes and Durango). All this suggests that during the period 2003–2013 the shift in manufacturing activity away from the centre (Mexico City and Mexico State) towards the north continued at a more moderate rate and in a more heterogeneous fashion.

3.2.1 Spatial distribution of the change in the contribution of individual states to the concentration of production

In this subsection, we analyse the spatial distribution of the change in the contribution of individual states to the concentration of manufacturing production. Following Anselin (1993), we construct a Moran scatterplot that plots the change in the contribution of each state to the level of concentration of the country's manufacturing production from 1993 to 2003

Table 1. Evolution of state contribution[a]

State	1993			2003			2013		
	COS_i	v_i	$COS_i \cdot v_i$	COS_i	v_i	$COS_i \cdot v_i$	COS_i	v_i	$COS_i \cdot v_i$
Coahuila	0.342	0.039	0.013	0.367	0.055	0.020	0.437	0.081	0.035
Veracruz	0.482	0.061	0.029	0.429	0.041	0.018	0.457	0.065	0.030
Mexico City	0.231	0.194	0.045	0.529	0.079	0.042	0.397	0.066	0.026
Nuevo León	0.301	0.088	0.026	0.274	0.098	0.027	0.248	0.103	0.026
Jalisco	0.254	0.081	0.021	0.299	0.069	0.021	0.346	0.074	0.026
Puebla	0.251	0.029		0.398	0.056	0.022	0.451	0.054	0.024
Mexico State	0.180	0.178	0.032	0.192	0.134	0.026	0.183	0.117	0.021
Sonora	0.307	0.024	0.007	0.303	0.025	0.008	0.357	0.051	0.018
Tamaulipas	0.298	0.030	0.009	0.293	0.040	0.012	0.443	0.040	0.018
Chihuahua	0.468	0.033	0.016	0.477	0.074	0.035	0.392	0.042	0.017
Tabasco	0.550	0.007	0.004	0.634	0.018	0.011	0.712	0.023	0.016
Baja California	0.336	0.024	0.008	0.433	0.041	0.018	0.368	0.039	0.014
Guanajuato	0.339	0.035	0.012	0.377	0.058	0.022	0.208	0.058	0.012
Hidalgo	0.456	0.017	0.008	0.604	0.024	0.015	0.605	0.017	0.010
Chiapas	0.504	0.004	0.002	0.614	0.014	0.009	0.601	0.016	0.010
Oaxaca	0.677	0.022	0.015	0.736	0.022	0.016	0.717	0.012	0.009
San Luis Potosí	0.338	0.022	0.007	0.311	0.022	0.007	0.276	0.029	0.008
Querétaro	0.274	0.021	0.006	0.315	0.026	0.008	0.245	0.030	0.007
Aguascalientes	0.460	0.011	0.005	0.430	0.018	0.008	0.439	0.015	0.007
Michoacán	0.423	0.015	0.006	0.508	0.011	0.006	0.550	0.009	0.005
Morelos	0.514	0.023	0.012	0.458	0.020	0.009	0.352	0.012	0.004
Yucatán	0.423	0.008	0.003	0.494	0.009	0.004	0.540	0.008	0.004
Zacatecas	0.483	0.002	0.001	0.626	0.006	0.004	0.567	0.007	0.004
Sinaloa	0.455	0.008	0.004	0.523	0.007	0.004	0.485	0.007	0.003
Durango	0.383	0.008	0.003	0.467	0.010	0.004	0.405	0.008	0.003
Tlaxcala	0.391	0.007	0.003	0.370	0.011	0.004	0.267	0.008	0.002
Nayarit	0.634	0.003	0.002	0.642	0.002	0.001	0.512	0.002	0.001
Guerrero	0.546	0.003	0.002	0.589	0.003	0.002	0.642	0.002	0.001
Colima	0.422	0.001	0.001	0.646	0.003	0.002	0.553	0.001	0.001
Campeche	0.511	0.001	0.000	0.550	0.001	0.001	0.567	0.001	0.001
Baja California Sur	0.528	0.001	0.001	0.603	0.001	0.001	0.623	0.001	0.001
Quintana Roo	0.552	0.002	0.001	0.571	0.001	0.001	0.607	0.001	0.001
***G*(*S*)**			0.309			0.385			0.365

Notes: [a]States are ranked highest to lowest according to their weighted specialization coefficient ($COS_i \cdot v_i$) in 2013.

$\left[\left(COS_i^{2013} \cdot v_i^{2013}\right) - \left(COS_i^{1993} \cdot v_i^{1993}\right)\right]$ against its spatial lag; both variables are standardized. As usual, the spatial lag of each state is the average of the change in the contribution of its neighbouring states.[15]

Figure 4 shows that there is positive spatial autocorrelation in the contribution of states to the concentration of production, given that those states that contributed most to the increased concentration observed are located close to others whose contribution was also significant; furthermore, those states that contributed least to the concentration of production are located close to others whose contribution was also insignificant. The states in quadrant I (containing the HH values) are those that contributed most to the increase in the concentration of manufacturing production in Mexico from 1993 to 2003; in general, these states are surrounded by states which, on average, also saw an increase in their contribution to the concentration of manufacturing production. The states in quadrant III (containing the LL values) are those that contributed least to the increase in the concentration of manufacturing production in the country;

[15] To calculate the spatial lag variable, we use a simple queen's contiguity matrix.

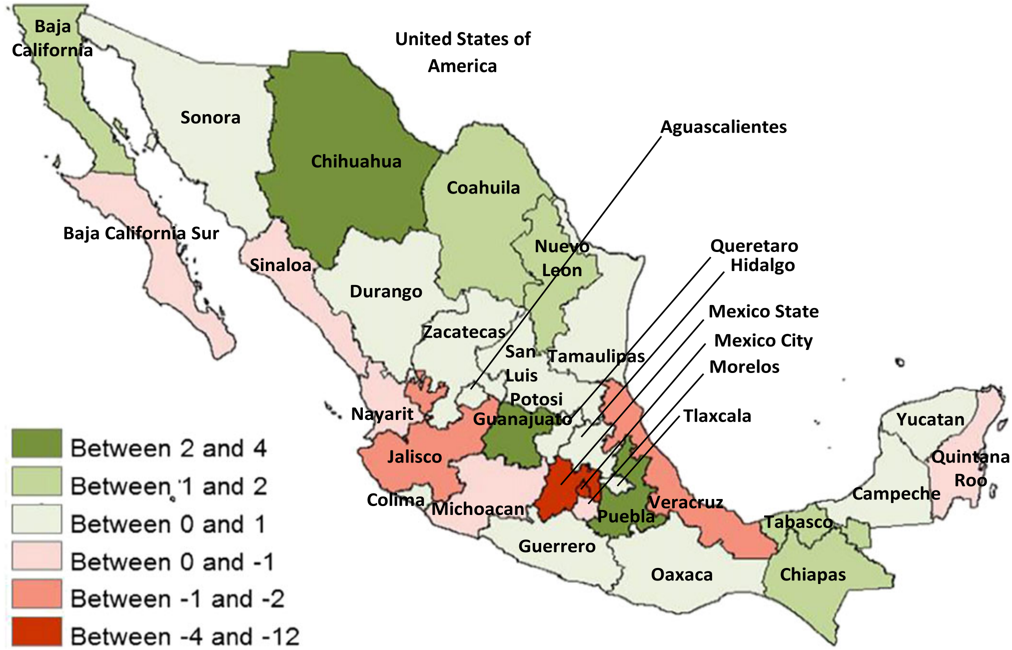

Fig. 2. Change in share of domestic manufacturing GDP, 1993–2003 percentage points
Note: Own estimates based on information from the economic censuses published by INEGI.

Fig. 3. Change in share of domestic manufacturing GDP, 2003–2013 percentage points
Note: Own estimates based on information from the Economic Censuses published by INEGI.

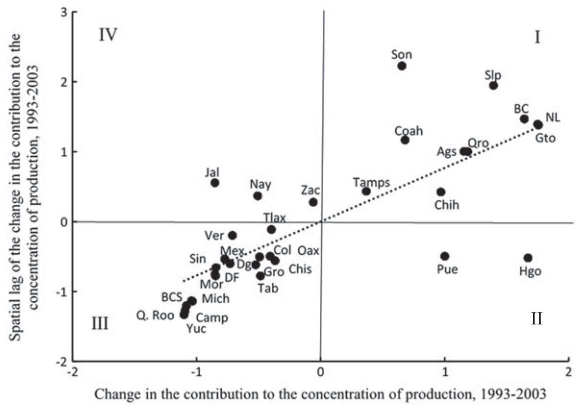

Fig. 4. Moran scatterplot, change in the contribution of each state to the level of concentration of the country's manufacturing production from 1993 to 2003

Note: Own estimates based on information from the Economic Censuses published by INEGI.

in general, the contribution of the neighbouring states of those in this quadrant to the increase in the concentration of production was also low. Most states (i.e., 27 out of 32) are located in quadrants I and III, which shows that there is positive spatial dependence. The states in quadrant I include those that share a border with the United States, along with the states of Aguascalientes (Ags), Guanajuato (Gto), Querétaro (Qro), and San Luis Potosí (Slp). The states in quadrant III are, in general, states in the south of the country, plus others whose contribution to the increase in concentration was relatively low.[16]

3.3 Evolution of industrial localization

Table 2 shows the estimates of the localization coefficient of manufacturing subsectors (COL_j), their percentage share (u_j) of domestic manufacturing production, and the level of localization adjusted according to share ($COL_j \cdot u_j$) for three of the five years of the sample. In 1993, the four most important industries in terms of localization were (from highest to lowest): petroleum and coal byproducts, transportation equipment, chemicals, and food products. By 2013, petroleum and coal byproducts ranked fifth due to both a decrease in its localization coefficient and, more importantly, a decrease in the sector's share of manufacturing output, which fell by more than half from 7.7 per cent to 3.7 per cent. That year, transportation equipment ranked top, partly due to the increase in its level of localization, though primarily to the increase in its share of manufacturing industry, which rose from 9.5 per cent to 21.7 per cent. The increase in the importance of the chemicals, food products, and primary metal industries, which occupied second, third, and fourth place respectively in 2013, was the result of both an increase in their level of localization and in their share of manufacturing overall.

Figure 5 shows the change in the contribution of the most important subsectors to the global localization of manufacturing industry during the period studied.[17] The industries that showed the greatest increase in terms of their contribution to global localization were: transportation equipment, chemicals, and food products. Furthermore, this growth was more significant in the period 1993–2003 than in the subperiod 2003–2013. Transportation equipment is a

[16] A similar analysis for the period 2003–2013 shows much weaker evidence of spatial dependence, since the change in the contribution of states was less regionally uniform. For example, during this period half of the states that share a border with the US decreased their manufacturing share; similarly, states such as Aguascalientes and Durango in the North-Central region also decreased their share, while in others in the same region it increased, as shown in Figure 3.

[17] The six subsectors shown account for almost 65 per cent of the VA in manufacturing output in 2013.

Table 2. Evolution of industrial localization[a]

Industries	1993			2003			2013		
	COL_j	u_j	$COL_j \cdot u_j$	COL_j	u_j	$COL_j \cdot u_j$	COL_j	u_j	$COL_j \cdot u_j$
Transportation equipment	0.326	0.095	0.031	0.405	0.171	0.069	0.329	0.217	0.071
Chemicals	0.251	0.115	0.029	0.465	0.143	0.067	0.436	0.133	0.058
Food products	0.140	0.156	0.022	0.267	0.132	0.035	0.266	0.187	0.050
Primary metal industries	0.504	0.033	0.017	0.437	0.029	0.013	0.492	0.072	0.036
Petroleum and coal	0.714	0.077	0.055	0.794	0.044	0.035	0.668	0.037	0.025
Tobacco and beverages	0.220	0.097	0.021	0.317	0.079	0.025	0.354	0.070	0.025
Electronics	0.464	0.033	0.015	0.605	0.049	0.030	0.567	0.028	0.016
Electrical appliances	0.365	0.048	0.017	0.370	0.034	0.012	0.377	0.031	0.012
Plant and machinery	0.213	0.019	0.004	0.362	0.023	0.008	0.368	0.024	0.009
Paper	0.304	0.021	0.006	0.389	0.026	0.010	0.367	0.023	0.008
Plastics and rubber	0.208	0.038	0.008	0.218	0.042	0.009	0.263	0.031	0.008
Other industries	0.323	0.008	0.003	0.365	0.020	0.007	0.412	0.019	0.008
Leather and hides	0.602	0.014	0.009	0.655	0.010	0.006	0.690	0.011	0.007
Metal products	0.188	0.059	0.011	0.276	0.041	0.011	0.184	0.040	0.007
Apparel	0.272	0.031	0.008	0.338	0.037	0.012	0.368	0.017	0.006
Non-metal products	0.267	0.065	0.017	0.230	0.067	0.015	0.225	0.027	0.006
Textile mill products	0.366	0.024	0.009	0.400	0.015	0.006	0.472	0.008	0.004
Printing and publishing	0.373	0.034	0.013	0.380	0.013	0.005	0.376	0.009	0.003
Furniture	0.244	0.012	0.003	0.302	0.013	0.004	0.310	0.010	0.003
Lumber/wood	0.503	0.007	0.004	0.332	0.005	0.002	0.375	0.003	0.001
Textile products	0.517	0.014	0.007	0.294	0.006	0.002	0.336	0.003	0.001
***G*(*L*)**			0.309			0.385			0.365

Note: [a]The industries are ranked according to their weighted localization coefficient ($COL_j \cdot u_j$) in 2013, from highest to lowest.

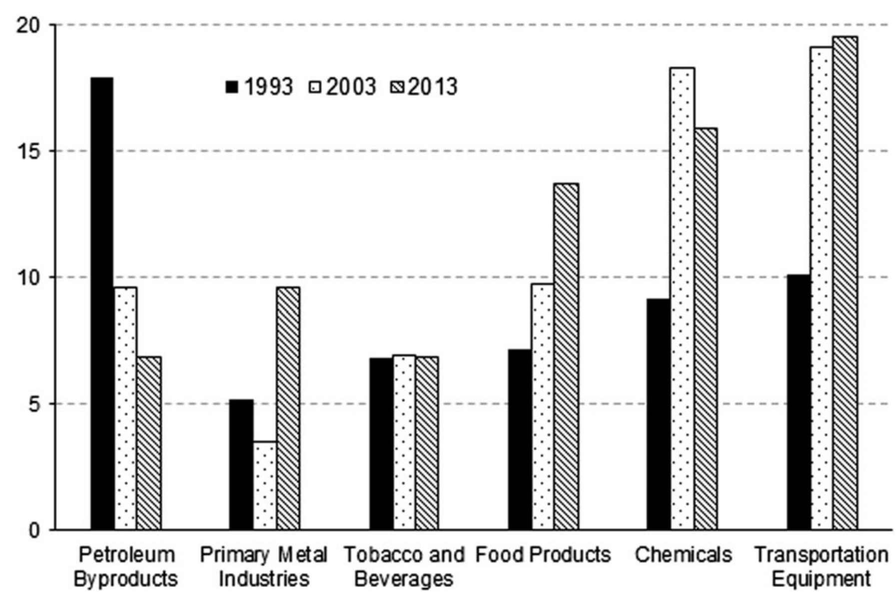

Fig. 5. Contribution of major industries to global localization[a]
Source: Own estimates based on INEGI data.
Note: [a]The contribution of each subsector is calculated as $(COL_j \cdot W_j \cdot 100)/G(L)$.

manufacturing subsector that comprises three different industrial groups: motor vehicle manufacturing, motor vehicle parts manufacturing, and motor vehicle body and trailer manufacturing. Of these, the first two are the most important, each representing around 49 per cent of the VA at the national level, whereas the last represents the remainder, just 2 per cent. In the chemical manufacturing subsector, the main industrial groups are petrochemical manufacturing and industrial gas manufacturing. Finally, the food manufacturing subsector has a more homogeneous distribution of its VA among its various components, these being: animal food, grain and oilseed milling, sugar and confectionary products, fruit and vegetable preserving and specialty food, dairy products, animal slaughtering and processing, seafood product preparation and packing, and bakeries and tortilla and other food manufacturing.

The effect of more open trade was reflected in an increase in the relative importance of more export-oriented activities. In particular, the contribution of transportation equipment production increased significantly relative to the global localization of manufacturing firms during the period 1993–2003. This increase is explained by both the increase in its share of manufacturing VA (u_j), which rose from 9.5 per cent to 17 per cent, and by the increase in its localization coefficient (COL_j), which went from 0.33 to 0.41 in the same period. From 2003 to 2013, its share continued to increase, although at a lower rate, eventually reaching 21.7 per cent; however, the decrease in its localization coefficient resulted in the increase in its share being marginal during this period.[18]

Similarly, other subsectors more closely linked to the domestic market also increased their contribution to the global localization of manufacturing during the period studied. In particular, the increase in the contribution of the food industry in the period 1993–2003 is due entirely to the increase in its level of localization, whereas its growth in the period 2003–2013 is due solely to the increase in its share of VA. The marked growth in the contribution of the chemical industry during the period 1993–2003 was due both to the growth of its share of VA and to an increase in its level of localization, while the decrease seen in the period 2003–2013 was due to a fall in both its share of manufacturing VA and the level of localization of the economic activity.

In contrast, the contribution of other activities to global localization fell. In particular, the production of coal and petroleum byproducts showed the greatest fall in terms of its contribution to the $G(L) = G(S)$. The significant decrease registered between 1993 and 2003 was entirely due to the fall in their share of VA, since their level of localization actually increased. Meanwhile, the decrease from 2003 to 2013 is explained by a reduction in both the share of VA and the level of localization.

4 Final comments

This paper provides new elements with which to describe the processes of reallocation of resources between states and subsectors that began with NAFTA, processes that are not only consistent with the predictions of traditional and new trade theories but ones which continue some 20 years later, heterogeneously affecting the development of the country's various regions.

Trade liberalization and the environment of increased competition faced by Mexican manufacturing production have had a varying effect on the development of its industries and, therefore, its regional economic structure. This has been reflected in changes in the levels of

[18] Electronics, another sector closely linked to the external market, also increased its measure of localization from 1993 to 2013. However, its relative weight in the manufacturing sector declined, hence its contribution to global localization increased only marginally.

industrial localization and the specialization in the country's states. Our results allow us to affirm that the process of economic liberalization has had a mixed impact on Mexico's various manufacturing subsectors and individual states, though contributed to an overall increase in the country's levels of localization and specialization.

The results presented here are in line with the predictions of theoretical trade models, since an increase in regional specialization or industrial localization took place after the gradual removal of trade barriers. Furthermore, they indicate that there is a positive spatial autocorrelation between the value of the change in the contribution of each state and the general concentration of manufacturing activity, which suggests a spatial pattern or structure among states in terms of the change in their contribution to global concentration.

NAFTA has not contributed to a decrease in regional disparities, which actually appear to have increased due to the shift in manufacturing activity in general away from the south towards the north of the country. Therefore, regional development policies need to be implemented to stimulate economic growth in those states or regions that have not been able to reap the benefits of free trade. The creation of so-called special economic areas (SEZ) is a policy aimed at triggering economic growth by stimulating specific economic activities in those regions of Mexico that have lagged behind (Chiapas, Oaxaca and Michoacán), by taking advantage of the particular strengths or comparative advantages of each. Nevertheless, it will take several years to see if this policy is successful.

Appendix 1

We present a hypothetical example comprised of four economies (A, B, C, and D) and four manufacturing activities (1, 2, 3, and 4), for which we assume the following values of VA:

$$
\begin{array}{ccc}
 & & \textit{Economic Activities} \\
 & & \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\
\textit{States} & \begin{array}{c} A \\ B \\ C \\ D \end{array} & \begin{bmatrix} 100 & 250 & 1000 & 1000 \\ 1500 & 500 & 350 & 150 \\ 400 & 600 & 1200 & 470 \\ 850 & 400 & 700 & 2000 \end{bmatrix} \begin{array}{c} 2350 \\ 2500 \\ 2670 \\ 3950 \end{array} \\
 & & \begin{array}{ccccc} 2850 & 1750 & 3250 & 3620 & 11470 \end{array}
\end{array}
$$

According to Equation 1, the localization coefficient for each sector is:

$$COL_1 = 0.5^*[|0.03 - 0.20| + |0.52 - 0.21| + |0.14 - 0.23| + |0.29 - 0.34|] = 0.31,$$
$$COL_2 = 0.5^*[|0.14 - 0.20| + |0.28 - 0.21| + |0.34 - 0.23| + |0.22 - 0.34|] = 0.18,$$
$$COL_3 = 0.5^*[|0.30 - 0.20| + |0.10 - 0.21| + |0.36 - 0.23| + |0.21 - 0.34|] = 0.24,$$
$$COL_4 = 0.5^*[|0.27 - 0.20| + |0.04 - 0.21| + |0.12 - 0.23| + |0.55 - 0.34|] = 0.28.$$

Activity 1 is the most localized, since 82 per cent of it is concentrated in states B and D. Activity 2 is the least localized, since it is distributed more homogeneously among states.

According to Equation 3, the global index based on the weighted industry localization is:

$$G(L) = 0.248(0.31) + 0.152(0.18) + 0.283(0.24) + 0.315(0.28) = 0.2597$$

According to Equation 2, the specialization coefficient for each state is:

$$COS_A = 0.5^*[|0.04 - 0.25| + |0.11 - 0.15| + |0.43 - 0.28| + |0.43 - 0.32|] = 0.25$$
$$COS_B = 0.5^*[|0.60 - 0.25| + |0.20 - 0.15| + |0.14 - 0.28| + |0.06 - 0.32|] = 0.40$$
$$COS_C = 0.5^*[|0.15 - 0.25| + |0.22 - 0.15| + |0.45 - 0.28| + |0.18 - 0.32|] = 0.24,$$
$$COS_D = 0.5^*[|0.22 - 0.25| + |0.10 - 0.15| + |0.18 - 0.28| + |0.51 - 0.32|] = 0.19.$$

State B is the most specialized, focusing primarily on activity 1. State D is the most diversified.

According to Equation 4, the global index based on the weighted regional specialization is:

$$G(S) = 0.204(0.25) + 0.217(0.40) + 0.232(0.24) + 0.344(0.19) = 0.2597.$$

Both $G(L)$ and $G(S)$ are calculated as having the same magnitude.

Appendix 2

We also present the results obtained when the analysis is based on regions.[19] Figure A1 shows that the global concentration of manufacturing production rises throughout the sample period. Nevertheless, it follows a slightly different pattern to that calculated using states, decreasing immediately after the enactment of NAFTA, before starting to increase after 1998. In general, with this different level of aggregation we can observe that all regions increase their level of specialization.

Table A1 shows the evolution of the coefficient of specialization by region (COS_i), the share of manufacturing production of each region (v_i), and the weighted specialization coefficient ($COS_i \cdot v_i$). The v_i columns show that the Central region's share decreased after the liberalization of trade, falling from 50.4 per cent of national manufacturing production in 1993 to 36.2 per cent by 2013. In the same period, the North region increased its share from 23.7 to 35.5 per cent, whereas the North-Central region maintained practically the same level. Meanwhile, the COS columns show that the Central and South regions became more diversified throughout the period, their COS decreasing from 0.138 and 0.454 to 0.114 and 0.416, respectively. The North region became more specialized, its coefficient rising from 0.218 to 0.235, whilst the North-Central region maintained practically the same level of diversification/specialization.

The results here confirm the findings from our analysis of the results calculated by states. Manufacturing production shifted from south to north, and, in general, states that share a border with the US specialized in specific economic activities, particularly those related to the automotive and electronics industries.

These new results allow us to affirm that, as a whole, the contribution of states in the Central region to global concentration decreased (while that of states in the north increased, for precisely

[19] We follow the regionalization classification used by Banco de México. North: Baja California, Chihuahua, Coahuila, Nuevo León, Sonora, and Tamaulipas; North-Central: Aguascalientes, Baja California Sur, Colima, Durango, Jalisco, Michoacán, Nayarit, San Luis Potosí, Sinaloa, and Zacatecas; Central: Mexico City, Mexico State, Guanajuato, Hidalgo, Morelos, Puebla, Querétaro, and Tlaxcala; South: Campeche, Chiapas, Guerrero, Oaxaca, Quintana Roo, Tabasco, Veracruz, and Yucatán.

Fig. A1. Evolution of global localization and specialization by region
Note: Own estimates based on information from the Economic Censuses published by INEGI.

Table A1. Evolution of regions' contribution

State	1993			2003			2013		
	COS_i	v_i	$COS_i \cdot v_i$	COS_i	v_i	$COS_i \cdot v_i$	COS_i	v_i	$COS_i \cdot v_i$
Central	0.138	0.504	0.069	0.121	0.408	0.049	0.114	0.362	0.041
North	0.218	0.237	0.051	0.219	0.333	0.073	0.235	0.355	0.083
North-Central	0.215	0.150	0.032	0.235	0.148	0.034	0.218	0.154	0.033
South	0.454	0.106	0.048	0.410	0.109	0.045	0.416	0.127	0.052
$\boldsymbol{G(S)}$			0.202			0.213			0.211

Note: Own estimates based on information from the Economic Censuses published by INEGI.

the opposite reason): (*i*) their share of national manufacturing production decreased from 1993 to 2013 and (*ii*) their levels of diversification rose (i.e., they became less specialized) The contribution of the other two regions – North-Central and South – to global concentration stayed the same, though for different reasons. The first region maintained virtually the same share of manufacturing production and coefficient of specialization, at 0.150 and 0.215, respectively, whereas the second increased its share of national production from 10.6 per cent to 12.7 per cent, though also increased its level of diversification, with its COS falling from 0.454 to 0.416.

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Resumen. Este artículo documenta cómo la localización de la producción en la gama de subsectores manufactureros de México y la especialización de sus estados han evolucionado como resultado del proceso de apertura comercial. Se utilizó la metodología de estimación global para calcular qué tan localizadas están las industrias o qué tan especializadas están las regiones. Los resultados muestran que: *(i)* desde 1993, ha habido un aumento en la localización global y la especialización en la producción manufacturera; *(ii) el* equipo de transporte, los productos químicos y los productos alimenticios representan la mayor parte del aumento en general de la localización durante este período; y *(iii)* los estados más cercanos a los Estados Unidos contribuyeron más al aumento en general de la especialización.

抄録: 本稿では、メキシコの工業サブセクター領域における生産の地域化および各州の生産の特殊化が、貿易自由化のプロセスの結果として、どのように展開されてきたかを述べる。世界推計の方法を用いて、すべての産業の地域化の程度およびすべての地域の特殊化の程度を測定する。結果から以下の事項が示唆される。1)1993年以降、工業生産におけるグローバルな地域化と特殊化が増加している。2)この期間での地域化全体の増加のほとんどが輸送用機械器具、化学製品、食品で占められている。3)より米国に近い州が特殊化全体の増加に最も貢献している。