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

Gómez-Zaldívar, Manuel and Mosqueda, Marco T. and Duran, Jazmin A.

Universidad de Guanajuato, Banco de México, Universidad de Guanajuato

30 January 2017

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

Manuel Gómez-Zaldívar[♣] Marco T. Mosqueda[‡] J. Alejandra Duran[§]

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; (iii) those states closest to the US contributed most to the overall increase in specialization.

Keywords: Industrial Localization; Regional Specialization; Economic Integration

JEL Classifications: F15; R11; R12

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

♣ Contact Author: Department of Economics and Finance, University of Guanajuato, México. Email: manuel.gomez@ugto.org.

‡ Directorate General of Economic Research, Banco de México. Email: m.mosqueda@banxico.org.mx

§ Graduate of the University of Guanajuato's Bachelor of Economics program. Email: jazminalejandraduran@gmail.com.

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. They make generally similar predictions about the consequences of integration, while only differing in their explanation of the factors that 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), Kim (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 analyze 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, firstly because Mexico was a relatively closed economy[2] until the mid-1980s, and secondly because, in regional-level studies, the forces

[1] Based on theoretical models from the literature known as "new economic geography," which 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 (1991), Krugman and Venables (1995), and Venables, (1996), among others].

[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."

that tend to concentrate production or to encourage specialization are stronger due to the high mobility of the factors of production.

Previous studies on Mexico have looked at the effects of liberalization reforms on the development of its range of manufacturing activities. Hanson (1998) analyzes 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)[3]; and second, due to important linkage effects, companies were motivated to relocate, i.e., closer to their suppliers or the buyers of their products. Chiquiar *et al*. (2016) analyze the impact of international trade on the labor market 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 labor 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 assert that manufacturing specialization in Mexico decreased from 1980 to 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.).[4]

[3] 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.

[4] For a more in-depth explanation of the advantages of this methodology, see Mulligan and Schmidt (2005).

In addition to being consistent with those of previous studies, our results also provide further support for the description of diverse aspects of the effects of trade liberalization on the manufacturing structure of various regions of the country: i) we identify the manufacturing subsectors and states that have been most impacted by the opening-up of trade;[5] ii) transportation equipment, one of the subsectors most closely linked to the external market, along with chemicals and food products, two subsectors closely linked to the domestic market, account for the greatest share of the overall increase in localization during this period; (iii) those states closest to the United States contributed most to the overall increase in specialization.

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

[5] Previous studies have documented the relocation of manufacturing activity but have not specifically identified the subsectors most affected by greater openness.

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.[6] These were obtained from the 1994, 1999, 2004, 2009, and 2014 Economic Censuses published by Mexico's National Institute of Statistics and Geography (INEGI).[7]

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 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.

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

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.

[6] 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.
[7] Each year's census contains information for the immediately preceding year.

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

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 analyzed. 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,

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

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, ($v_j = X_{i,\cdot}/X$).

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

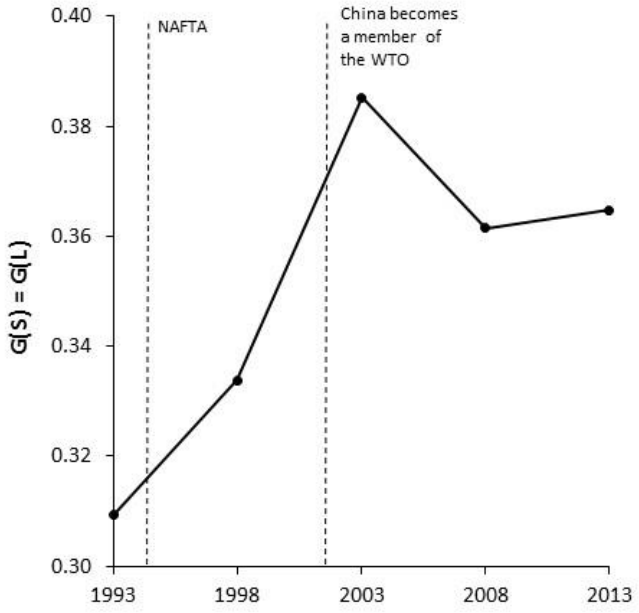
Mulligan and Schmidt stress the need to employ global indexes in the literature in order to evaluate the general characteristics of the spatial economy-industry matrix, and thus examine the extent to which *all* industries are localized or *all* regions specialized. They therefore stress the fact that,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

3. Results

3.1 Evolution of global localization and specialization of manufacturing firms

Graph (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.[8]

Graph 1. Evolution of Global Localization and Specialization



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

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). This implies that China tempered the impact that NAFTA had had on levels of localization and specialization by

[8] 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)].

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.

3.2 Evolution of state 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 neighbor have lost out as a result of NAFTA.

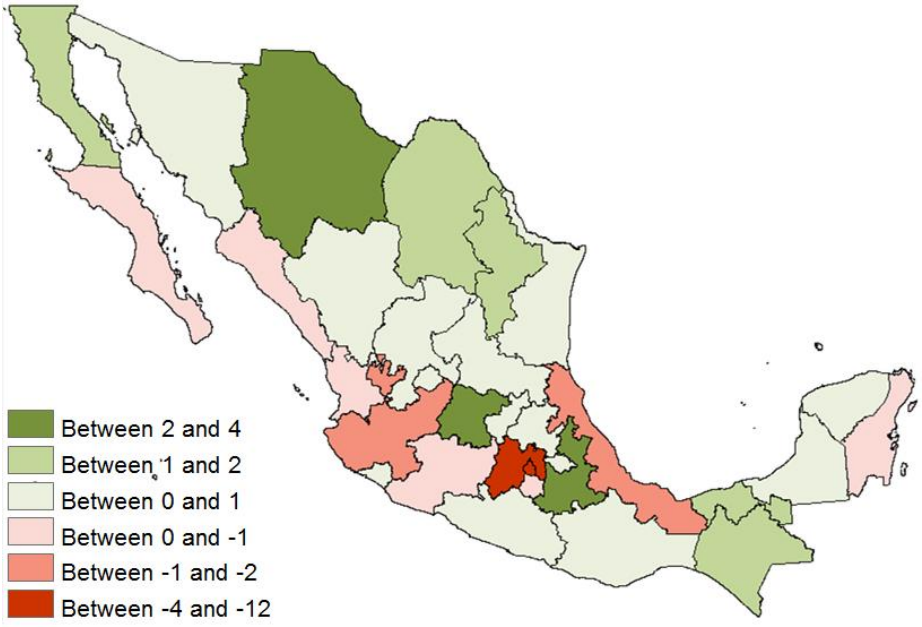
Table 1. Evolution of State Contribution [1/]

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	0.007	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

1/ States are ranked highest to lowest according to their weighted specialization coefficient ($COS_i \cdot v_i$) in 2013.

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 center (Mexico City and Mexico State) mainly to the states along the northern border. This can be seen in Figure (1), which shows the change in manufacturing share by state in the period 1993–2003. During this time, the share of domestic manufacturing production of the six states in the North rose from 23.8 percent to 33.4 percent. The share of domestic manufacturing production of Aguascalientes, Durango, Guanajuato, Querétaro, San Luis Potosí, and Zacatecas rose from 8.7 percent to 14.8. In contrast, Mexico City and Mexico State's share decreased from 37.3 to 18.3 percent in the same period.

Figure 1. Change in Share of Domestic Manufacturing GDP, 1993–2003
Percentage points



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

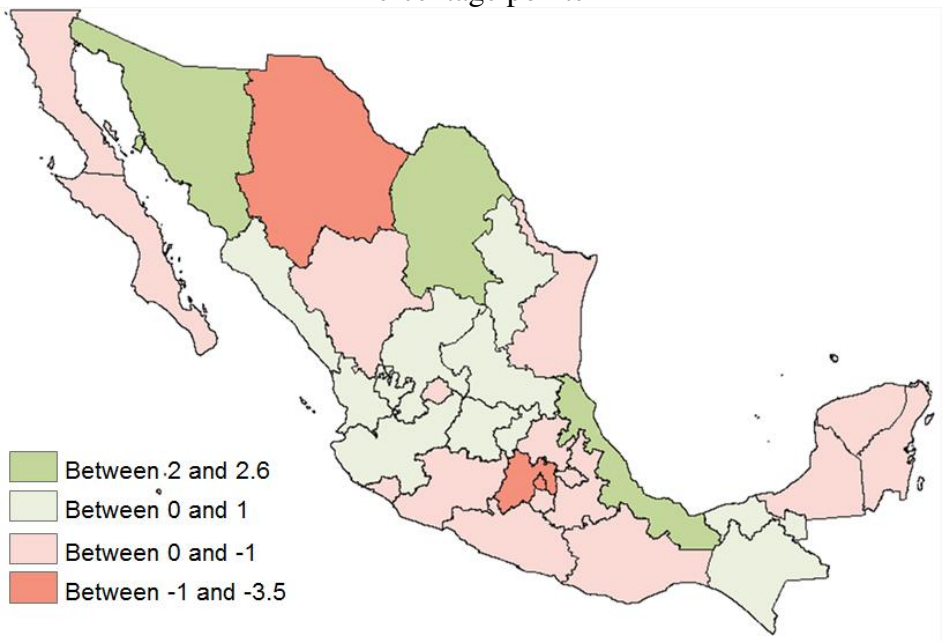
This relocation of manufacturing production was the result of companies seeking to reduce transportation costs by moving production closer to their export market (see Hanson, 1998) or their deciding to increase their production levels in states better endowed in terms of the communications and transport 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% of the states,

whereas from 2003 to 2013 this was true for only 46%. 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). This fact is reflected in Figure (2), which suggests that during the period 2003–2013 the shift in manufacturing activity away from the center towards the north continued at a more moderate rate and in a more uniform fashion.

Figure 2. Change in Share of Domestic Manufacturing GDP, 2003–2013

Percentage points



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

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% to 3.7%. 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 percent to 21.7 percent. 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.

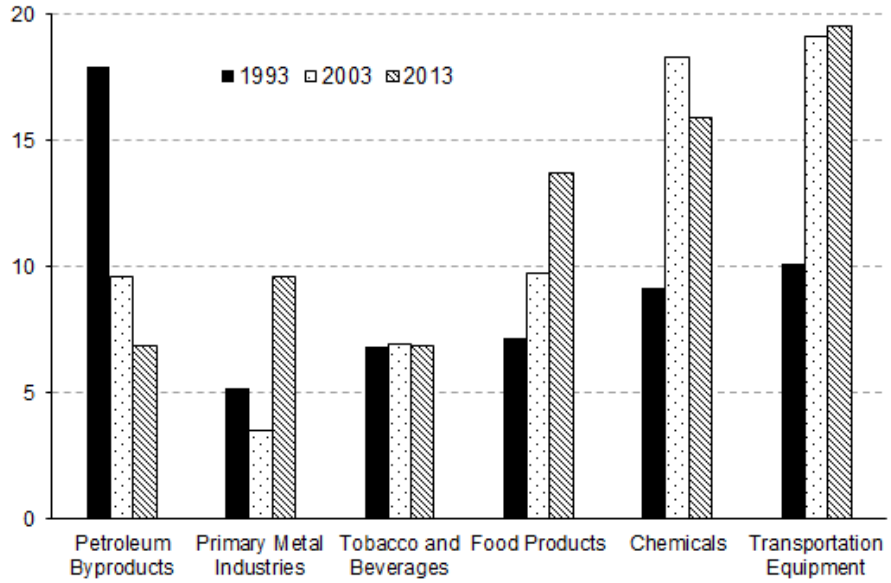
Table 2. Evolution of Industrial Localization[1/]

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
$\boldsymbol{G(L)}$			0.309				0.385				0.365

1/ The industries are ranked according to their weighted localization coefficient $(COL_j \cdot u_j)$ in 2013, from highest to lowest.

Graph (2) shows the change in the contribution of the most important subsectors to the global localization of manufacturing industry during the period studied.[9] 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.

Graph 2. Contribution of Major Industries to Global Localization[1/]



1/ The contribution of each subsector is calculated as $(COL_j \cdot W_j \cdot 100)/G(L)$.
Own estimates based on INEGI data

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 percent to 17 percent, 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

[9] The six subsectors shown account for almost 65% of the VA in manufacturing output in 2013.

percent; however, the decrease in its localization coefficient resulted in the increase in its share being marginal during this period.[10]

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.

[10] 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.

4. Final comments

This paper provides new elements with which to describe the processes of reallocation of resources between regions and subsectors that began with NAFTA and which still continue some twenty years later, affecting the development of the various regions of the country.

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 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.

We believe this paper opens up new avenues for future research; for example, the methodology we employ here examines the spatial distribution of production, but not its geographical arrangement within the country. Therefore, one possible extension to this research would be to analyze the changes in the spatial distribution of the country's manufacturing subsectors.

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