Technical efficiency in the Mexican automotive industry, 1988-2008

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Abstract

This work evaluates the impact of productive specialization on the technical efficiency of the automotive industry in Mexico (1988-2008), using the production-possibility frontier method on a regional scale and considering its regional localization. To this end, an index of regional specialization in said sector was calculated, in addition to a technical efficiency index for the automotive industry using the stochastic frontier model (Battese and Coelli, 1995). The findings that were obtained suggest that specialization has a positive impact on productive efficiency in the units of analysis, and further, demonstrate that education levels and the localization of automotive plants in the northern and central regions of the country contribute to decreasing levels of productive inefficiency.

Keywords: automotive industry; productive specialization; technical efficiency; automotive clusters; stochastic frontier.

1. INTRODUCTION

The installation of the first Ford production lines during the 1920s marks the start of Mexico's automotive industry, which came to be one of the main manufacturing industries in the country (Covarrubias, 2014). During the 1980s, the industry began to supply the foreign as well as the domestic market. This is a result of economic liberalization, capital accounts, and the increase in the amount of property owned by foreigners. This process was consolidated by the entry into force of the North American Free Trade Agreement (NAFTA) in 1994. This treaty imposed new rules and a progressive reduction of both customs tariffs and of the percentage of exports produced nationally. Understood in this way, the expansion and consolidation of the Mexican auto-motive industry is the result of domestic industrial policies and the process of economic globalization (Miranda, 2007), as these caused the Mexican economy to open up. Currently, the automotive industry is one of the main manufacturing industries in Mexico.

The auto-motive sector has been studied from various perspectives, such as historical (Mirando, 2007); labor (Dombois, 1985; Arteaga, 2003; Covarrubias, 2014) and regional (Unger and Chico, 2004; Chavez-Martin del Campo and Fonseca, 2013), to name just a few. In terms of technical efficiency, however, these studies are predominately focused on the manufacturing sector in federal entities. The present study is based on a micro-economic approach with a higher level of geographical breakdown, in accordance with the stochastic frontier analysis (SFA) methodology. Technical efficiency is estimated using a parametric methodology, specifically a Cobb-Douglas production function with two and three productive factors, as well as control variables such as education level, productive specialization, geographic regions, and economic treaties, allowing their impact on technical efficiency to be measured. By doing so, it is hoped the analysis will explain the automotive sector's technical efficiency, factoring in productive specialization and economic liberalization.

A second model is used to measure the determinants of technical efficiency. There seem to be six variables which account for the inefficiency indicator. Some of these variables, such as the specialization index, are also included in the deterministic factor of the equation. The cross-sections in the panel-data model are: regions -metropolitan zones or municipalities in the country- with temporal variables such as units of time, in addition to production variables in the auto-motive industry, such as employment, etc. All data has been obtained from national economic censuses.

This paper works from the hypothesis that recent developments in the automotive industry have created a certain productive specialization in regions focused on the exportation of automotive goods and that, additionally, these regions constitute the production possibility frontier for the Mexican automotive industry. Following on from this, the paper seeks to answer questions which rise from this hypothesis; which units of analysis in the automotive industry are the most specialized; what is the effect of specialization on technical efficiency in the automotive industry; is there a significant difference in the technical efficiency between regions of automotive production and, finally, to establish what are the determinants of automotive technical efficiency in the regions studied.

This paper is structured in six sections, including this introduction; the second section gives an overview of the development of the automotive industry in Mexico by briefly describing the stages of its development up to the present day. The third section contains a review of relevant theoretical approaches and describes the methodology employed for the analysis, including a review of specialization and localization theories (Krugman, 1991; Goldstien and Gronberg, 1984; Eberts and McMillen, 1999; Venables, 1996; Fujita *et al.* 1999). The fourth section describes the microeconomic theory related to technical efficiency and the main estimation models (data envelopment analysis and SFA), as well as the main production functions for the parametric estimation (SFA). Studies on technical efficiency in Mexico are also reviewed, followed by the estimated empirical model and the data and descriptive statistics of the variables employed in the empirical model. In the fifth section, the findings obtained from the technical efficiency model are presented. The final section contains some conclusions.

2. THE AUTOMOTIVE INDUSTRY IN MEXICO

The automotive sector is the main generator of foreign currency, with a surplus of $71 billion in 2017 (INEGO, 2018). Exports from this sector constituted 31% of the country's total manufacturing exports, with a value of $126.7 billion. Additionally, the sector was one of the largest recipients of foreign direct investment (FDI) between 2000 and 2017, receiving roughly $60.6 billion, more than the full-service banks ($56.1 billion), and the beverage industry ($39.9 billion) (AMIA, 2018). Mexico is the fourth largest producer of vehicles, with a 7.6% share of total automobile exports, after Germany, Japan, and the U.S., with shares of 17.8%, 9.9%, and 9.4 %, respectively.

The installation of assembly plants throughout the country in different periods of time, diverse international economic contexts and under specific industrial policies have all contributed to the development of the industry. The industry dates back to the opening of the first Ford plant in 1925, and has passed through various stages of development until its consolidation in the period of Mexican economic liberalization (Miranda, 2007). The first automotive decree was issued for the period

1962–1976, and restricted imports of vehicles and auto parts, as well as establishing that 60% of finished vehicles must be domestically produced and limiting FDI to a 40% share in assembly plants. Additionally, price controls were established. In this context, important automotive brands arrived in Mexico, such as Volkswagen in Puebla, General Motors and Chrysler in the State of Mexico, and Nissan in Morelos.

Faced with a rising deficit in the balance of payments arising from the oil crisis in the 1970s, regulation was more relaxed during the period 1979–1989. A 1977 decree declared that Mexico would become a competitive exporter country, reducing the domestic content of local production destined for the export market to 50% while maintaining a protectionist stance towards investment.

The competition from Japanese vehicles in the American market motivated the North American industry to invest in Mexico, in an attempt to decrease production costs and to take on the new competition. To do so, they constructed assembly plants and motor production plants for North American companies in the north of the country: General Motors and Chrysler in Ramos Arizpe (1981) and Ford in Chihuahua and Sonora in 1983 and 1986, respectively. In 1989, an economic liberalization decree was issued, intended to modernize the industry, as well as increase its efficiency and productivity. The new regulation allowed new vehicles to be imported, offered tax concessions equal to 30% of investment, and reduced domestic content for exported vehicles from 50 to 36%.

The implementation of NAFTA in 1994, together with other complimentary measures, resulted in the consolidation of economic liberalization in 2004, eliminating the last traces of protectionism. The new trade regulations included progressive tariff reductions, as well as progressive reductions in the domestic content of exported automobiles until their complete elimination in 2004.[1] This brought with it new investment in the northern and central regions of the country. Merecedes-Benz set up in Nuevo Leon (1994), General Motors relocated to Guanajuato from Mexico City in (1995); Chrysler set up in Coahuila (1995), with BMW and VOLVO setting up in Mexico City in 1995 and 2000, respectively. Essentially, this was the birth of the automotive industrial plant as we know it today, one that obtains record investment figures and export values and, as previously mentioned, made Mexico an important vehicle exporter.

3. LOCALIZATION & PRODUCTIVE SPECIALIZATION

The automotive industry in Mexico is concentrated in specific regions of the country (Mendoza, 2003). The concept of agglomeration refers to new approaches in economic geography which privilege the competitive potential associated with the close relation between the supply and demand sides of regional groups and allied industries. Some authors have tried to explain the factors which determine industrial development in a given geographic area (Porter, 1982; Krugman and Venables, 1995). For other authors, local markets specializing in labor or intermediate products are factors which generally trigger productive proximity (Driffield and Munday, 2001). Industrial concentration produces positive externalities related to an alternating effects process, which, in some cases, are derived from technological innovation or even industrial organization (Arrow, 1962; Romer, 1986; Marshall, 1920; Jacobs, 1969).

The main economic advantages that businesses or industries can exploit, depending on their location, arise from economies of scale within the company itself; localization economies related to concentration of one industry in a geographic region, and urbanization economies, related to uncommon traits of productive activity and public infrastructure.

Industrial concentration is the result of the interaction between the industrial demand of companies and businesses that decided to set up in close proximity to each other in order to minimize fixed costs and transport costs (Krugman, 1981). This basic model for economies of scale within a company follows Krugman's (1980) international trade model, with the exception that geographical regions are no longer the unit of analysis. In yet another model, concentration derives from intermediary goods specialization and results from cost minimization and interaction between companies on the demand side (Venables, 1996).

Knowledge spillovers have unmeasurable geographical limitations, as they leave no tangible, quantifiable trace (Krugman, 1991). Other studies have tried to propose solutions to the knowledge quantification problem in economic geography (Jaffe, 1989; Feldman, 1994; Audretsch and Feldman, 1996).

This kind of economy provides specialized services – public infrastructure such as roads, industrial parks, energy installations, security – to large urban areas, therefore not developing in smaller zones (Goldstein and Gronberg, 1984). The most highly developed methodologies for incorporating heterogeneity between companies are those which are based on production frontier estimates (e.g. Christensen *et al*., 1973; Aigner *et al*., 1977; Battese and Coelli, 1995; Cullinane *et al*., 2006; Driffield and Munday, 2001; Kirkley *et al*., 1995; Reinhard *et al*., 1999; Seyoum *et al*., 1998; Tovar and Martín-Cejas, 2010). However, there are few empirical studies on production frontiers which focus on the link between specialization and production efficiency (*e.g.* Álvarez-P. *et al*., 2017; Bannister and Stolp, 1995; Acevedo and Ramírez, 2005).

4. TECHNICAL EFFICIENCY AND ESTIMATION METHODS

One definition of technical efficiency claims that, faced with a set of production possibilities, an input vector and an output vector can technically be described as efficient if no other input vector exists which uses few inputs to produce the same level of output (Koopmans, 1951).

There are two categories of efficiency: technical and assignative (Álvarez-P.,2013). Technical efficiency refers to the exploitation of resources in terms of inputs. In other words, the existing relation between the productive inputs used and the finished product. Technical efficiency, therefore, is the capacity to produce goods with the fewest available inputs (Farrell, 1957). Assignative efficiency refers to cost minimization and profit maximization, obeying prices set by supply and demand. The present paper is concerned with technical efficiency, focusing on the appropriate exploitation of productive inputs.

There are various ways of estimating technical efficiency, each one with technical and methodological arguments with their own strengths and weaknesses (Álvarez-P., 2013). The present paper uses SFA as its estimating methodology, as this methodology is the one best suited to investigating the research question. SFA analysis is a parametric estimation technique involving a production function which may have distinct variants if a random error is incorporated into it. This is known as a stochastic frontier. The error term has two components, one which measures the random effect and another which measures inefficiency. The original basic model (Aigner *et al.,* 1977) proposes the following structure:

$$y_i = f(x_i;\beta) + \varepsilon_i, i = 1, \ldots, N \qquad (1)$$

Y_i is the maximum possible production of the *i* unit given an input vector x_i, β is an estimated parameter and $\varepsilon_i \leq 0$ is the error term, which contains the random factor and the inefficiency factor, expressed as follows:

$$\varepsilon_i = v_i + u_i, i = 1, ..., N \quad (2)$$

On the one hand, v_i is the idiosyncratic error which is assumed to be independent and identically distributed with $N(0,\sigma 2)$, while on the other hand u_i is the error that measures inefficiency. It is assumed to be independently distributed from v_i, and presents a normal truncated positive distribution, which confirms that $u_i \leq 0$. In other words, values in u_i which are higher than zero suggest inefficient units of observation, while values equal to zero suggest units above the efficient frontier.

This model does not specify the inefficiency term's explicative variables and could only be estimated for cross-sectional data (Aigner *et al.,* 1977). More recent studies have developed efficiency models that incorporate explicative variables, modelling the technical efficiency of textile mills in Indonesia using types of ownership, age, and units of analysis. However, temporality in efficiency was omitted, meaning variations over time for the random term could not be factored in (Pitt and Lee, 1981).

Empirical Model

This study adopts the estimation technique suggested by authors such as Battese and Coelli (1995), as such studies are based on panel data and use the production function specified in another study from the 1970s (Aigner *et al.,* 1977), shown as follows:

Cobb-Douglas stochastic production function (1928):

$$y_{it} = (x_{it}\beta) + \varepsilon;\ \varepsilon = V_{it} - U_{it} \quad (3)$$

Random error associated with efficiency:

$$U_{it} = z_{it}\delta \quad (4)$$

$$U_{it} \sim N + (z_{it}\delta, \sigma^2_u) \quad (5)$$

The general equation for the determining factor is the modeling of the production possibility frontier and follows a Cobb-Douglas function, as follows:

$$\ln Y_{it} = \beta_0 + \ln\beta_1 K + \ln\beta_2 L + \sum_{j=3} \beta_j x_{jit} + \varepsilon; \quad \varepsilon = V_{it} - U_{it} \quad (6)$$

i denotes the geographic area of analysis (municipalities and metropolitan zones); *Y*, *K*, and *L* are variables that represent automotive production, capital, and labor, respectively, and which will be explained in further detail later on; x is a control group for estimating the stochastic production frontier, *j* denotes the number of control variables used, which is three in this case, meaning *j*=3. These are: productive specialization, population, and electrical energy. All variables which contain this functional form are presented in a natural logarithm, with the exception of the productive specialization index.

The U_{it} error related to the explicative variables of inefficiency is modelled as follows:

$$U_{it} = \delta_0 + \delta_1 esp + \delta_2 lnesc + \delta_3 t + \delta_4 t^2 + \delta_5 arm + \delta_6 cnor + \delta_7 nor + \delta_8 cen + \delta_9 sur + \delta_{10} tlcan + \delta_{11} zm \quad (7)$$

There are 11 variables which model variance in inefficiency or the stochastic factor: *esp* is a referent of productive specialization; *lnesc* is education level; *t* denotes non-observable variations across time; t^2 the squared trend; *arm* the dichotomous variable that identifies whether the unit of analysis contains an assembly plant. This last variable has been included because of the type of capital and the technology present in assembly plants. The fact that these plants can house more sophisticated production structures (with improved technology and organization) may impact on productive efficiency of the *cnor*, *nor*, *cen*, and *sur* units of analysis. These are dichotomous variables which indicate whether the units of analysis belong to either the central-northern, northern, central, or southern region of the country, respectively. *Tlcan* is an instrumental version which has been introduced to measure the impact of NAFTA, with a view to establishing if NAFTA has improved productive efficiency in the automotive sector; *zm* is a dichotomous variable which indicates whether or not the unit of observation belongs to a metropolitan zone and has been included to evaluate the unobservable effects of (Goldstein and Gronberg, 1984).

In Mexico, as well as other countries, various studies have estimated technical efficiency using the enveloping method as much as they have using SFA, particularly when focusing on the manufacturing sector. Notable studies which employ the enveloping analysis methodology include Bannister and Stolp (1995), Navarro and Torres (2006), Arellano and Cortés (2010), Montiel (2012), and Becerril *et al*. (2012). Notable studies which employ SFA include Becerril *et al*. (2012), Gutiérrez (2011), Chávez-Martín del Campo and Fonseca (2013), with studies such as Peón and Casimiro (2017) and Álvarez-P. *et al*. (2015) focusing on states' potential tax revenues.

Technical Efficiency and Stochastic Frontiers

This paper analyzes the automotive industry during the 1994–2009 period for the industrial sectors 3361 (motor vehicle manufacturing), 3362 (motor vehicle body and trailer manufacturing), and 3363 (motor vehicle parts manufacturing), according the North American Industry Classification System (NAICS). The study period includes the 1994, 1999, 2004, and 2009 economic censuses.[2] 1999 relates to sector 3841 (automotive industry). Added Value, Fixed Assets, Employed Personnel, and Electrical Energy Consumption are used as variables within these sectors. These variables will be described later on in this paper.

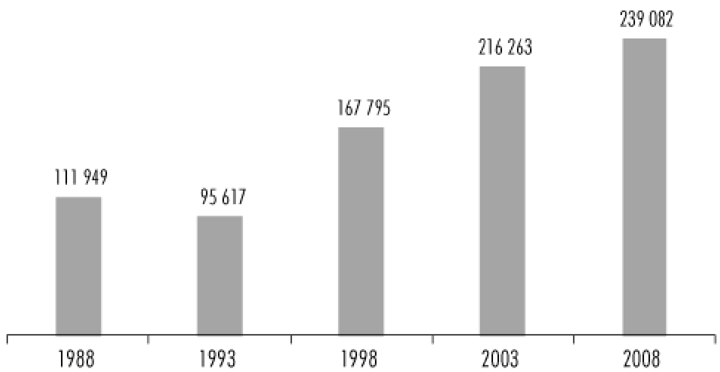
Panel data balanced with 72 cross-sections was used to estimate the technical efficiency model. Of these 72 cross sections, 38 are metropolitan areas and 34 are ungrouped municipalities in which automotive production took place during the census period described. Metropolitan zones were determined using to the National Population Council (CONAPO, 2010), with municipalities being determined using INEGI's National Geostatistical Framework.

Technical efficiency is modeled using a group of variables which estimate the production possibility frontiers (determining factor) and technical inefficiency (stochastic factor). There is some debate regarding which variables should be included in each factor (Álvarez-P. *at al.,* 2017), but generally control variables for the frontier can also be included in the efficiency factor. However, which variables can be included in each factor depends on the specifics of each analysis.

The (y) dependent variable used to estimate the SFA model is automotive added value, which is deflated for each period of time according to the 2010 National Consumer Price Index (CPI). The variable was converted to natural logarithms to model to determining factor.

Figure 1 shows that across practically the entirety of the study period, Automotive Added Value grew in real terms. In the 20 years between 1988 to 2008, automotive production increased by 115.5%, more than $127 billion MXN. However, growth was not constant over the study period, and 1993 saw a 14% decrease in relation to the previous period.

Figure 1. The added value of the automotive industry across the census period (billions of pesos, 2010 values)



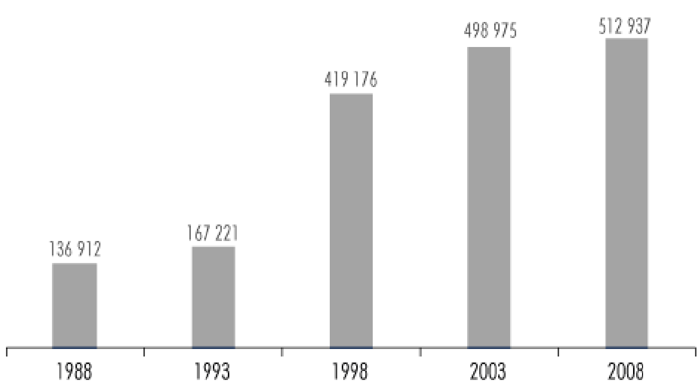
Source: compiled by the authors using data from INEGI's economic censuses.

The independent variables used to explain production are: labor, capital and electrical energy consumption. The total personnel employed in sectors of the automotive industry is expressed as the number workers for each time period, converted to natural logarithms. The number of workers in this industry grew across the entirety of the study period, particularly in the first few years after the implementation of NAFTA, with 1993-1998 seeing an increase of 150.6%, incorporating an additional 251,955 workers in five years, as can be seen in figure 2.

Capital (K) is represented by the fixed assets variable with values deflated to 2010 levels, also expressed as natural logarithms. Fixed assets grew 68.2% across the 20-year study period. This variable decreased by 28.5% from 1988 to 1993, as did the Added Value variable. This can be seen in figure 3.

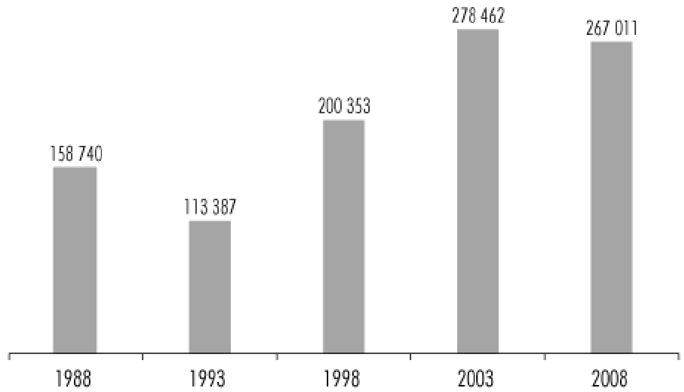
To control for heterogeneity, three production function variables are also included. The first is intermediate inputs, the second is productive specialization and the third is population. The introduction of intermediate inputs to production function as a control variable to estimate the parameter value has been tested in other studies such as Levinsohn and Petri (2003). The control variable which will be used as a proxy of intermediate inputs is electrical energy consumption, deflated to 2010 values according to the CPI. The variable has also been converted to logarithms in the modelling. Due to the lack of data, electrical energy consumption for 1988 was estimated using interpolation. Electrical energy grew constantly across the entirety of the study periods. In 1988, the automotive industry consumed over $1.5 billion MXN, with consumption growing by 498% during the period 1988-2009.

Figure 2. Total personnel employed in the automotive industry across the census period



Source: compiled by the authors using data from INEGI's economic censuses.

Figure 3. Fixed assets in the automotive sector across the census period
(billions of pesos, 2010 values)



Source: compiled by the authors using data from INEGI's economic censuses.

To measure the impact of productive specialization levels in the automotive industry, a regional productive specialization index has also been included (Asuad, 2001), which has been calculated as follows:

$$Esp = \frac{A_i / At_i}{A_r / Ar_i} \qquad (8)$$

Here:

A_i: Automotive value added by municipality or metropolitan zone i.

At_i: Total added value of municipality or metropolitan zone i.

A_r: National automotive added value i.

Ar_i: Total national added value i.

This index allows each unit of analysis' economic specialization to be identified in relation to each other and with other geographical areas. The index is analyzed using automotive added value to compare productive specialization between regions, analyzed in relation to national specialization. If *Esp* > 1, the region has a higher level of automotive specialization in comparison to the rest of the country; is *Esp* < 1, it has a lower level of automotive specialization in relation to the rest of the country; if *Esp* = 0, the region or country has the same level of automotive specialization.

The population variable has been included as part of the deterministic factor so as to be able to monitor productive heterogeneity in the units of analysis. Data pertaining to the years 1990, 2000, and 2010 was obtained from the Census of Population of Housing Units.[3] Data pertaining to the two intercensal periods 1995 and 2005 was obtained from the Intercensal Estimate, specifically, the population levels of the units of analysis. This variable is converted to natural logarithm in the empirical factor.

A group of variables is included to model technical inefficiency, with a view determining the impact each one has on the functioning of each factor. The education level variable is incorporated, defined as the average education level for the population aged 15 and older in each municipality and metropolitan zone. Metropolitan zones are defined using the average in the constituent municipalities, obtained, as is population data, from population censuses and converted to natural logarithm in the empirical factor. Trend variables were included to capture unobserved temporary effects which impact on the units of analysis' productive efficiency. A dichotomous variable was constructed using data pertaining to the year each automotive plant commenced operations, so as to evaluate the impact of automotive assembly plants on the units of analysis and to identify if automotive assembly plants play a significant role in reducing technical inefficiency, given that figures obtained from economic census show that there is a large amount of very small and unsophisticated productive units.

To measure the regional impact of technical efficiency, four instrumental variables were included that establish whether the geographic unit of analysis belongs to one of the four regions shown in table 1. The instrumental variables for the empirical factor, therefore, are: *nor* for the north of the country, *cenor* for the center-north, *center* for the center, and *sur* for the south. After inserting these variables, it is possible to contrast findings with other studies on the behavior of regional manufacturing technical efficiency and to verify whether the automotive sector obtains similar results to those of the manufacturing sector.

Table 1. Bank of Mexico Regionalization (2011)

North	*Center-north*	*Center*	*South*
Baja California	Aguascalientes	Mexico City	Campeche
Coahuila de Zaragoza	Baja California Sur	Guanajuato	Chiapas
Chihuahua	Colima	Hidalgo	Guerrero
Nuevo León	Durango	Mexico	Oaxaca
Sonora	Jalisco	Morelos	Quintana Roo
Tamaulipas	Michoacán	Puebla	Tabasco
	Nayarit	Querétaro	Veracruz
	San Luis Potosí	Tlaxcala	Yucatán
	Sinaloa		
	Zacatecas		

Source: compiled by the authors using data obtained from the Bank of Mexico (2011).

An instrumental variable was included to evaluate the impact of NAFTA on the technical efficiency of the automotive industry. The validity period of this variable is the years preceding 1993. Similarly, an instrumental variable which distinguishes between units of analysis which are metropolitan zones and those which are municipalities with automotive production was used to estimate the impact of productive efficiency resulting from metropolitan zones.

5. ESTIMATE AND DESCRIPTION OF FINDINGS

Table 2 shows the productive specialization of the automotive industry in Mexico by listing the states and main areas with the greatest degree of specialization in automotive production in the country during the five time periods studied.[4]

It can be seen that the geographic zones with the highest degree of specialization in 1988 are made up of municipalities from the south of the country, such as Ocotlán de Morelos in Oaxaca, where automotive added value is representative rather than elevated. However, in subsequent periods it can be seen that the north of the country begins to specialize in automotive manufacturing, especially after economic liberalization. For example, only two northern zones are contained in table 2, in 1988 and 1993: Saltillo (1999 and 1993) and Chihuahua in (1988). In contrast, in 1988 and during subsequent years, the northern zones appear in the primary specialized zones 4, 5, and 6 times, respectively, particularly in Coahuila and Chihuahua. Using this data, it is possible to investigate the second research question regarding what is the effect of specialization on the technical efficiency of the automotive industry. We will return to this later.

Table 2. Municipalities with the highest specialization indices

State	*Municipality*	*Year*					*Category*
		1988	*1993*	*1998*	*2003*	*2008*	
Coahuila	Acuña			7.5	9.7	8.4	M
Sonora	Agua Prieta					5.1	M
Aguascalientes	Aguascalientes		6.2	5.8	4.6	8.7	Z. M.
Hidalgo	Alfajayucan			10.9		9.3	M
Chihuahua	Chihuahua	4.3					Z. M.
Morelos	Cuernavaca	10.1	10.1				Z. M.
Sonora	Hermosillo			6.6			M
Chihuahua	Juárez				4.3	5.4	Z. M.
Guanajuato	León			8.9	7.2		Z. M.
Chihuahua	Nvo. Casas Grandes				18.3	6.8	M
Tamaulipas	Nuevo Laredo					4.9	Z. M.
Oaxaca	Ocotlán de Morelos	5.5	15.6				M
Querétaro	Pedro Escobedo	14.9	17.8	15.6			M
Puebla-Tlaxcala	Puebla-Tlaxcala	3.4	7.1	7.2			Z. M.
Nuevo León	Sabinas Hidalgo			6.1	6.5		M
Coahuila	Saltillo	12.5	8	6.7	6.6	8.7	Z. M.
Mexico	Tenango del Valle		6.5	6.7	4.4		M
Hidalgo	Tepeapulco	5.5	16.9				M
Mexico	Tianguistenco	9.1	17.3	8.7	8.6	13.8	Z. M.
Mexico	Toluca	4.2	6.5				Z. M.

Source: compiled by the authors using data obtained from economic censuses by INEGI.

Table 3 displays the findings of the technical efficiency models used to attempt to find the determinants at the municipalities and metropolitan zone levels. Additionally, it can be seen in this estimate that NAFTA contributed to reduction of technical inefficiency in Mexico and verifying that there is indeed a significant difference in technical efficiency between automotive production regions.

Table 3. Findings of the Stochastic frontiers model.
Dependent variable: lny

Variable	*Parameter*	*Coef.*	*Variable*	*Parameter*	*Coef.*
Intercept	β_0	0.296	Inefficiency		
		-0.44	Intercept	δ_0	4.41
Capital (K)	β_2	0.232			(0.929) ***
		(0.029) ***	Productive specialization (esp)	δ_1	-1.327
Labor (L)	β_3	0.518			(0.325) ***
		(0.048) ***	Education level (esc)	δ_2	-0.819
Energy (E)	β_4	0.12			(0.496) *
		(0.0427) ***	Trend (t)	γ_1	-1.278
Productive specialization (esp)	β_5	0.104			(0.362) ***
		(0.0121) ***	Trend squared (t2)	γ_2	0.183
Population (pop)	β_6	0.3774			(0.0485) ***
		(0.054) ***	Assembly plants (arm)	δ_3	0.175
					(-0.305)
			Center-north (cnor)	θ_1	-0.179
					-0.179
Usigma	σ_μ	0.64	North (nor)	θ_2	-1.066
					(0.368) ***
Vsigma	σ_v	0.452	Center (cen)	θ_3	-0.332
					(0.173) ***
Lambda	Δ	1.416	South (sur)	θ_4	Colinealidad
Observations	NxT	332	NAFTA (tlcan)	δ_4	0.832
					(0.318) ***
Log-likelihood		-313.8	Metropolitan zone (zm)	δ_5	0.173
					-0.15

Source: compiled by the authors.

In the production possibility frontier estimate, coefficients estimated with maximum likelihood in accordance with Battese and Coelli's (1995) previously mentioned methodology show that the productive factors (L) and Capital (K) are 99% statistically significant and have positive signs in the maximum productive frontier, as can be seen in table 3. The labor factor is more elastic (0.51) than capital (0.23), which implies that the labor force has a higher share in automotive production in Mexico. The coefficient related to electrical energy was found to be 99% statistically significant with a positive sign (0.12). Specialization reported a positive coefficient (0.104) and was 99% statistically significant, which indicates that productive specialization contributes to increasing automotive added value. Finally, the population coefficient, similar to those already mentioned, is positive (0.37) and 99% statistically significant.

The model's stochastic factor (or the inefficiency factor) has been interpreted differently. The coefficients for variables with a positive sign imply that there is a higher "distancing" of units of analysis in relation to the maximum efficient frontier, with the optimal frontier units having a negative sign, meaning that it can be expected that the coefficients also have a negative sign (Cooper *et al*., 2011).

The productive specialization coefficient for the stochastic factor was found to be negative (-1.32) and is 99% statistically significant. This corroborates the hypothesized advantages of economies of localization and agglomeration. Education level has a negative coefficient (-0.81) and 90% statistically significant, which implies that the population's average education level contributes to reducing automotive technical inefficiency. Previous studies (Chávez-Martín del Campo and Fonseca, 2013) find significant negative coefficients for the entire manufacturing industry.

The trend (t) and trend squared (t2) coefficients are 99% statistically significant, although with contradictory signs. The negative sign for the lineal trend coefficient (t) suggests that there is a reduction in technical inefficiency across the study period. The positive sign for trend squared (t2) suggest that technical efficiency decreased over time. In other words, although there is evidence that the technical change reduces automotive technical efficiency, this decreases over time.

Disparities in statistical significance were found among the coefficients related to regions. Although the center-north was found to have the predicted sign, as the comparison region was not found to be statistically significant, perhaps due to similarities with the contrast region's (south) productive structure, which has been omitted due to collinearity. The coefficients related to the northern and central regions are 99% statistically significant and have the predicted negative sign. This suggests that automotive technical inefficiency is lower in the north and south of the country. Other studies (Chávez-Martín del Campo and Fonseca, 2013; Álvarez-P. *et al*., 2017) made similar findings for manufacturing in these regions.

NAFTA was introduced as a binary variable and is 99% statistically significant with a positive sign (0.83). Technical inefficiency in the manufacturing sector rose after the signing of NAFTA, which coincides with findings from other authors (Álvarez-P. *et al.*, 2017), who point out that findings can have mixed effects on other knowledge. Care should be taken when interpreting the coefficient related to the liberalization phase, as the impact of NAFTA is most likely mixed with other important events such as the "tequila effect" crisis (1995), the 9/11 attacks, or the integration of China into the WTO.

Basing production in a metropolitan zone was not found to statistically significant, as the coefficient related to this binary variable suggests. Finally, the value of λ is the result for the standard deviations ratio for *u* and v (σ_u/σ_v), which indicates the model's inefficiency not explained by the independent variables. Table 4 shows the units of analysis (metropolitan zones and municipalities) which reported automotive activity within the efficiency range to which they belong, additionally identifying the type of territorial unit, state, and region in which these entities are located. Findings are divided into four parts and the table shows only those territorial units that were found to have increased productive efficiency, with the complete findings shown in the statistical appendixes.

Table 4. Areas with the highest indices of technical efficiency

State	*Municipality*	*Year*										*Category*	*Region*
		1988		*1993*		*1998*		*2003*		*2008*			
		Pos		*Pos*		*Pos*		*Pos*		*Pos*			
Puebla	Acatzingo			14	0.9							M	Center
Coahuila	Acuña					6	0.96	2	0.97	2	0.96	M	North
Sonora	Agua Prieta			13	0.91	14	0.92	17	0.89	10	0.94	M	North
Aguascalientes	Aguascalientes			11	0.93	11	0.94	9	0.92	5	0.96	ZM	Cen. Nor.
Hidalgo	Alfajayucan			4	0.98	3	0.97			4	0.96	M	Center
Guanajuato	Celaya	9	0.87									ZM	Center
Chihuahua	Chihuahua							15	0.89	19	0.86	ZM	North
Morelos	Cuernavaca	3	0.97	6	0.97	13	0.92					ZM	Center
Sonora	Hermosillo			9	0.95	5	0.96			8	0.94	M	North
Chihuahua	Juárez					16	0.89	11	0.92	12	0.93	ZM	North
Guanajuato	León					2	0.97	3	0.96	14	0.91	ZM	Center
Nuevo León	Linares							18	0.89	9	0.94	M	North
Tamaulipas	Matamoros	7	0.9	15	0.87			8	0.93			ZM	North
Baja California	Mexicali			16	0.86							ZM	North
Coahuila	Monclova-Frontera									18	0.87	ZM	North
Chihuahua	Nuevo Casas Grandes					10	0.94	1	0.98	6	0.95	M	North
Tamaulipas	Nuevo Laredo	19	0.86	12	0.91	16	0.89			11	0.94	ZM	North
Oaxaca	Ocotlán de Morelos	6	0.93	5	0.98							M	South
Querétaro	Pedro Escobedo	1	0.98	2	0.98	1	0.98	12	0.91	16	0.89	M	Center
Puebla-Tlaxcala	Puebla-Tlaxcala	11	0.84			12	0.92	7	0.95	7	0.95	ZM	Center
Querétaro	Querétaro			17	0.85			13	0.91	17	0.88	ZM	Center
Nuevo León	Sabinas Hidalgo					9	0.95	4	0.96	15	0.91	M	North
Coahuila	Saltillo	2	0.98	7	0.96	7	0.95	6	0.95	3	0.96	ZM	North
Mexico	Tenango del Valle			10	0.95	8	0.95	10	0.92			M	Center
Hidalgo	Tepeapulco	5	0.94	3	0.98							M	Center
Mexico	Tianguistenco	4	0.97	1	0.98	4	0.97	5	0.96	1	0.97	ZM	Center
Mexico	Toluca	8	0.9	8	0.95	15	0.9	14	0.9	20	0.86	ZM	Center

Note: Pos = position or place in the rankings. M = municipality ZM = Metropolitan zone

Source: compiled by the authors using data obtained from economic censuses.

Efficiency was measured using the previously estimated model and each of the units of analysis was evaluated according to each variables' value in each period. The most efficient zones can be found in two of the four regions studied, namely the northern and the central regions. The case of Aguascalientes in the center-north is noteworthy, as is Ocotlán de Morelos in the south, which reported an elevated efficiency level between 1988-1993, the period before the implementation of NAFTA. Of the remaining 28 municipalities or metropolitan zones in the most efficient group, 13 are located in the north, 12 in the center, and one in the center-north.

A concentration of automotive productive efficiency from the center or south towards the north of the country is not the only expression of economic liberalization. There have also been changes in productive capacity in the sector at state level. In Guanajuato, the Celaya metropolitan zone reported a high level of efficiency before the implementation of NAFTA, with the León metropolitan zone later becoming the most efficient one (1998-2008), achieving second and third place in the productive efficiency rankings in 1998 and 2003, respectively.

The automotive industry emerged during the import-substitution stage, with the economic liberalization of the mid-1990s restructuring the sector and attracting new ventures to setup alongside the more entrenched sectors of Mexican industry. The sectors which date from this first period reported high levels of efficiency during the phase preceding the implementation of NAFTA, but after tend to serve as a reference point. This is the case for the metropolitan zone of Cuernavaca and, to a lesser extent, Mexicali. Yet another group are those areas which established themselves in the context of the strong automotive industry of the past, and who became even stronger after the implementation of NAFTA, such as Saltillo, Coahuila, Tianguistengo and Toluca, in Mexico State, Escobedo in Querétaro, Nuevo Laredo in Tamaulipas, and the Puebla-Tlaxcala metropolitan zone. The new developments in the automotive industry related to economic liberalization are those in León, Guanajuato, Querétaro capital, Sonora, Hermosillo and Agua Prieta, and Coahuila, Acuña.

Another case in point is the state of Chihuahua, where the metropolitan zones Chihuahua and Ciudad Juárez are in a state of chaotic regional competition for preeminence in productive efficiency. The two states have similar starting positions, with Juárez ultimately reporting a higher level of efficiency. Both processes took place in the period after the implementation of NAFTA, meaning that not only must the periods before and after NAFTA be compared, but also that it is possible to evaluate the balance of NAFTA itself within regions which have benefited from free trade.

The findings obtained and described above suggest that productivity in the automotive sector can be explained largely due to the existence of a well-trained and disciplined workforce rather than the contribution made by capital invested in the sector. The entry into force of NAFTA does not seem to have resulted in greater efficiency among businesses in the sector, at least not in a stochastic sense among our sample set. To the contrary, the coefficient related to economic liberalization is positive. Here it must be clarified that it was not possible to isolate the effects of NAFTA from other economic and historic events that impacted on the Mexican economy at the commencement of NAFTA, such as China's entry into the WTO or the so-called "tequila effect" crisis in the mid 1990s.

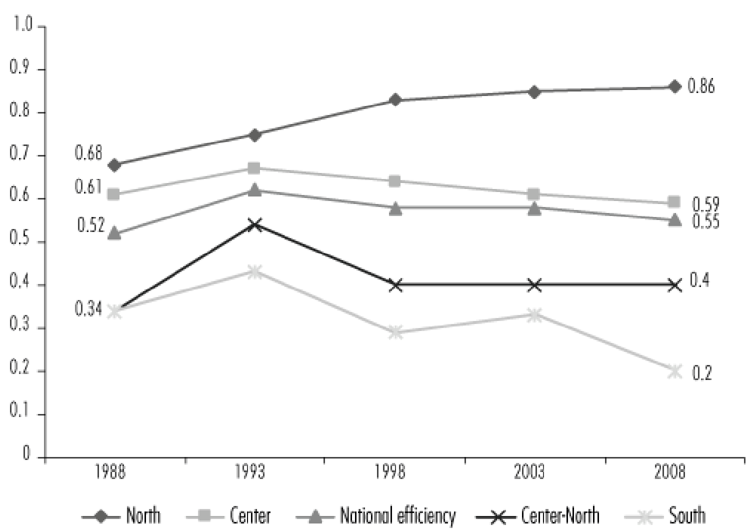
Findings also indicate that the regions with the highest levels of efficiency are located in the central and northern regions of the country and have the highest levels of automotive industrial activity, such as the states of Guanajuato, Coahuila, Sonora, Puebla, or Mexico State.

Education level, a factor of human capital, is a significant variable which impacts on automotive technical efficiency. Workers' education level, therefore, has a positive effect on productive resource exploitation. The north of the country, particularly following economic liberalization, began to specialize in automotive manufacturing, mainly in Coahuila, Chihuahua, Tamaulipas, and Sonora. In regards to the impact specialization on technical efficiency, a negative coefficient which was 99% statistically significant was reported, corroborating the hypothesis that productive specialization contributes to improving levels of technical efficiency due to the advantages It brings: higher-quality data, cost reduction, proximity to skilled labor and customers, consistent with the theoretical approach adopted in this paper (Krugman, 1991).

The coefficient related to the binary variable to indicate whether the unit of analysis belongs to a metropolitan zone was not found to be statistically significant, meaning there was no evidence of unobserved effects from economies of urbanization (Goldstein and Gronberg, 1984).

Technical efficiency in the north of the country was, on average, higher than efficiency in other regions from the start of the study period, as can be seen in figure 4. The southern and central regions experienced the opposite effect, with the south experiencing a much more significant decrease of 41.2%. Average national technical efficiency grew by 5.8% across the study period, although it has been decreasing since reaching its peak in 1993.

Figure 4. Average regional efficiency index, 1988 – 2008



Source: Estimated by the authors based on Battese and Coelli (1995).

6. CONCLUSIONS

The estimation theories and techniques reviewed and applied to the available census data on the Mexican automotive sector verify this paper's hypothesis, namely that the recent development of the automotive sector bolstered productive specialization in regions which export automotive goods, and that these regions are at the industry's production possibility frontier. Additionally, specific research questions which motivated the current study based have also been answered.

The findings obtained and described above suggest that productivity in the automotive sector can be explained largely due to the existence of a well-trained a disciplined workforce rather than the contribution made by capital invested in the sector. Nevertheless, both of these factors have an impact on productivity, as can be seen in the findings. It may seem that this effect contradicts both the empirical evidence and the claim that technical innovation is related to capital investment. However, the database used here -national census data rather than only from automotive production regions-, does not allow for confirmation of the predicted effects.

At the maximum efficient frontier, productive factors are 99% statistically significant and reported a positive sign. The labor factor reports a higher degree of elasticity than the capital factor, which implies that the labor-force has a greater share in automotive production's efficient frontier. Additionally, in regards to intermediate goods, the coefficient related to electrical energy was found to be statistically significant and positive. The specialization and population variables are robust determinants for the production possibility frontier, as expected.

It is worth pointing out here that the majority of the control variables added with a view to finding answers to questions which guided the research show trends which explain the regions' distance from the efficient production frontier.

The findings confirm that productive specialization brings regions closer to the efficient production frontier, as does education level, which contributes to reducing automotive technical inefficiency, as corroborated by earlier studies such as Chávez-Martín del Campo and Fonseca (2013). The influence of trends on technical efficiency reported contradictory signs. The short-term trend across the study period tended to reduce distance to the efficient frontier, but this trend reversed in the long term. At the regional level, it can be seen that automotive technical efficiency is lower in the northern and central regions, where the sector's main industrial activities are concentrated. This also concurs with findings from the productive specialization index. Other studies have obtained similar results for the manufacturing industry in these regions of the country (Chávez-Martín del Campo and Fonseca, 2013 and Álvarez-P. *et al.*, 2017).

The entry into force of NAFTA does not seem to have triggered greater efficiency in businesses in the sector, and instead seems to have had a negative impact on automotive productive efficiency. Many internal and external factors may account for this, such as the scale of the sample analyzed or the period or regionalization of automotive production. In any event, a more focused study could help to clarify the influence of the economic integration implemented.

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APPENDIX

Table A1. Descriptive statistics of the model’s variables

Year	*1988*	*1993*	*1998*	*2003*	*2008*
Variable: Labor (L)					
Observations	72	72	72	72	72
Average	1 868	2 279	5 296	6 028	6 275
Sta. Dev.	5 478	6 219	13 390	12 535	12 332
Minimum	2	2	2	1	2
Maximum	41 814	45 903	96 894	81 915	76 485
Variable: Capital (K)					
Observations	72	72	72	72	72
Average	2 174 856	1 547 622	2 718 904	3 817 511	3 621 275
Sta. Dev.	6 865 632	4 649 464	6 737 338	12 000 000	8 863 489
Minimum	13	0	50	0	11
Maximum	41 700 000	31 400 000	31 700 000	86 600 000	51 200 000
Variable: Electrical energy consumption (E)					
Observations	72	72	72	72	72
Average	18 616	28 383	45 409	68 029	119 249
Sta. Dev..	49 207	66 045	92 774	139 708	226 228
Minimum	0	3	2	1	3
Maximum	285 376	333 431	389 999	677 434	913 542
Variable: Added value (Y)					
Observations	72	72	72	72	72
Average	1 536 475	1 317 774	2 264 689	2 794 772	3 151 164
Sta. Dev.	5 024 446	3 726 894	5 059 971	6 440 608	6 715 709
Minimum	0	88	41	73	3
Maximum	31 400 000	25 200 000	28 300 000	38 500 000	35 500 000

Source: compiled by the authors using data obtained from economic censuses from the relevant years

Table A2. Indices of each unit of analysis’ productive specialization

Key	*Metropolitan zone / municipality*	*Efficiency*				
		1988	*1993*	*1998*	*2003*	*2008*
1	Aguascalientes	2.000	6.200	5.800	4.600	8.700
2	Tijuana	0.100	0.200	0.200	0.200	0.700
3	Mexicali	0.600	1.400	1.300	1.100	1.400
4	La Laguna	0.400	1.100	0.500	0.700	1.100
5	Saltillo	12.500	8.000	6.700	6.600	8.700
6	Monclova-Frontera	0.000	0.100	0.700	2.100	2.100

8	Colima-Villa de Álvarez	0.000	0.000	0.000	0.100	0.200
10	Tuxtla Gutiérrez	0.000	0.000	0.000	0.300	1.100
11	Juárez	0.300	0.500	3.700	4.300	5.400
12	Chihuahua	4.300	0.400	2.800	3.400	2.700
13	Valle de México	0.600	0.800	0.100	0.100	0.100
14	León	0.100	0.100	8.900	7.200	4.300
18	Pachuca	0.400	0.600	0.000	0.000	0.000
19	Tulancingo	0.100	0.100	0.100	0.000	0.000
21	Guadalajara	0.100	0.600	0.200	0.300	0.400
24	Toluca	4.200	6.500	3.500	3.300	2.600
25	Morelia	0.000	0.000	0.000	0.000	0.000
26	Zamora-Jacona	0.000	0.000	0.000	0.000	0.000
28	Cuernavaca	10.100	10.100	3.600	1.500	1.900
29	Cuautla	0.000	0.100	1.300	2.000	2.300
30	Tepic	0.000	0.000	0.000	0.000	0.000
31	Monterrey	0.400	0.600	0.900	1.000	1.100
32	Oaxaca	0.000	0.100	0.000	0.000	0.000
34	Puebla-Tlaxcala	3.400	2.800	5.200	7.100	7.200
35	Tehuacán	0.000	0.000	0.000	0.000	0.000
36	Querétaro	2.100	2.200	2.500	3.600	3.400
38	SLP-S. de Graciano Sánchez	0.800	0.800	1.100	1.700	1.800
43	Reynosa-Río Bravo	0.000	0.100	1.500	0.900	0.800
44	Matamoros	2.800	1.900	2.000	3.600	4.600
45	Nuevo Laredo	1.900	3.400	2.700	2.600	4.900
46	Tlaxcala-Apizaco	0.000	0.300	0.400	0.100	0.200
47	Veracruz	0.000	0.000	0.000	0.000	0.000
49	Poza Rica	0.000	0.000	0.000	0.000	0.000
50	Orizaba	0.000	0.000	0.000	0.000	0.000
53	Córdoba	0.000	0.000	0.000	0.000	0.000
54	Acayucan	0.000	0.000	0.000	0.000	0.000
57	Celaya	2.000	1.500	2.700	1.600	2.100
58	Tianguistenco	9.100	17.300	8.700	8.600	13.800
2001	Ensenada	0.100	0.100	0.400	0.600	0.500
5002	Acuña	0.400	0.800	7.500	9.700	8.400
7019	Comitán de Domínguez	0.000	0.100	0.100	0.100	0.000
8050	Nuevo Casas Grandes	0.000	0.100	4.900	18.300	6.800
10005	Durango	0.000	0.000	0.000	0.000	0.400
11017	Irapuato	0.100	0.000	0.000	0.000	0.100
12057	Técpan de Galeana	0.000	0.200	0.000	0.000	0.000
13006	Alfajayucan	4.600	16.100	10.900	1.600	9.300
13061	Tepeapulco	5.500	16.900	2.500	0.100	0.300
13063	Tepeji del Río de Ocampo	0.000	0.100	0.100	0.000	0.100
14093	Tepatitlán de Morelos	0.000	0.400	0.100	0.000	0.000
15090	Tenango del Valle	0.000	6.500	6.700	4.400	2.200
15113	Villa Guerrero	0.000	0.000	0.000	0.000	0.000
16076	Sahuayo	0.000	0.000	0.000	0.000	0.100
16079	Salvador Escalante	1.300	0.400	0.000	0.300	0.000
16102	Uruapan	0.200	0.000	0.000	0.100	0.000
16107	Zacapu	0.000	0.000	0.000	0.000	0.000
19004	Allende	0.100	0.100	0.100	0.000	0.000
19033	Linares	0.800	0.500	1.800	2.100	4.700
19044	Sabinas Hidalgo	1.000	1.100	6.100	6.500	3.300
20068	Ocotlán de Morelos	5.500	15.600	2.200	0.100	0.100

20068	Ocotlán de Morelos	[illegible]	[illegible]	2.200	0.100	0.100
21004	Acatzingo	1.500	3.700	1.200	1.000	0.800
21164	Tepeaca	0.000	0.000	0.000	0.000	0.000
21208	Zacatlán	0.100	0.100	0.000	0.000	0.200
22012	Pedro Escobedo	14.900	17.800	15.600	3.500	3.000
22016	San Juan del Río	0.100	0.500	0.100	0.100	0.100
25001	Ahome	0.000	0.000	0.300	0.700	0.700
25006	Culiacán	0.000	0.000	0.000	0.000	0.000
25012	Mazatlán	0.000	0.200	0.000	0.000	0.000
26002	Agua Prieta	0.300	0.600	3.200	2.300	5.100
26030	Hermosillo	1.400	4.700	6.600	1.500	4.600
26043	Nogales	1.300	0.200	0.800	0.400	1.100
30015	Angel R. Cabada	0.600	0.100	0.000	0.000	0.000
30141	San Andrés Tuxtla	0.000	0.000	0.000	0.000	0.000

Source: compiled by the authors using data obtained from economic censuses from the relevant years.

Table A3. Each unit of analysis' technical efficiency

Key	*Metropolitan zone / municipality*					*Efficiency*
		1988	*1993*	*1998*	*2003*	*2008*
1	Aguascalientes	0.69	0.93	0.94	0.92	0.96
2	Tijuana	0.58	0.68	0.61	0.67	0.73
3	Mexicali	0.58	0.86	0.88	0.82	0.85
4	La Laguna	0.53	0.81	0.57	0.68	0.8
5	Saltillo	0.98	0.96	0.95	0.95	0.96
6	Monclova-Frontera	0.43	0.62	0.76	0.87	0.87
8	Colima-Villa de Álvarez	0.34	0.36	0.2	0.67	0.26
10	Tuxtla Gutiérrez	0.2	0.32	0.27	0.55	0.64
11	Juárez	-	0.66	0.89	0.92	0.93
12	Chihuahua	-	0.35	0.88	0.89	0.86
13	Valle de México	0.46	0.67	0.11	0.25	0.23
14	León	-	0.54	0.97	0.96	0.91
18	Pachuca	0.65	0.83	0.35	0.2	0.39
19	Tulancingo	0.41	0.36	0.56	0.21	0.23
21	Guadalajara	-	0.78	0.36	0.46	0.46
24	Toluca	0.9	0.95	0.9	0.9	0.86
25	Morelia	0.19	0.3	0.2	0.21	0.22
26	Zamora-Jacona	0.17	0.52	0.23	0.18	0.25
28	Cuernavaca	0.97	0.97	0.92	0.86	0.85
29	Cuautla	-	0.41	0.88	0.86	0.83
30	Tepic	0.05	0.29	0.16	0.18	0.2
31	Monterrey	-	0.7	0.71	0.75	0.72
32	Oaxaca	0.13	0.74	0.15	0.17	0.07
34	Puebla-Tlaxcala	0.84	0.8	0.92	0.95	0.95
35	Tehuacán	0.43	0.51	0.24	0.16	0.26
36	Querétaro	0.83	0.85	0.88	0.91	0.88
38	SLP-S. de Graciano Sánchez	0.6	0.69	0.79	0.8	0.7
43	Reynosa-Río Bravo	-	0.47	0.82	0.74	0.71
44	Matamoros	0.9	0.87	0.87	0.93	0.92
45	Nuevo Laredo	0.86	0.91	0.88	0.89	0.94
46	Tlaxcala-Apizaco	-	0.46	0.57	0.46	0.44
47	Veracruz	-	0.39	0.29	0.2	0.14

49	Poza Rica	-	0.29	0.12	0.17	0.11
50	Orizaba	0.15	0.1	0.15	0.17	0.06
53	Córdoba	-	0.28	0.22	0.2	0.21
54	Acayucan	-	0.24	0.19	0.26	0.22
57	Celaya	0.87	0.78	0.88	0.75	0.79
58	Tianguistenco	0.97	0.98	0.97	0.96	0.97
2001	Ensenada	-	0.72	0.72	0.74	0.75
5002	Acuña	-	-	0.96	0.97	0.96
7019	Comitán de Domínguez	-	0.66	0.37	0.62	0.21
8050	Nuevo Casas Grandes	-	0.73	0.94	0.98	0.95
10005	Durango	0.26	0.17	0.41	0.1	0.45
11017	Irapuato	-	0.27	0.44	0.25	0.17
12057	Técpan de Galeana	0.17	0.72	0.31	0.45	0.06
13006	Alfajayucan	-	0.98	0.97	0.65	0.96
13061	Tepeapulco	0.94	0.98	0.84	0.44	0.38
13063	Tepeji del Río de Ocampo	0.32	0.64	0.6	-	0.5
14093	Tepatitlán de Morelos	0.22	0.8	0.62	0.34	0.39
15090	Tenango del Valle	-	0.95	0.95	0.92	0.63
15113	Villa Guerrero	0.03	0.26	0.24	0.16	0.29
16076	Sahuayo	-	0.64	0.2	0.22	0.49
16079	Salvador Escalante	0.79	0.55	0.2	0.38	0.2
16102	Uruapan	0.66	0.35	0.14	0.44	0.19
16107	Zacapu	0.05	0.36	0.26	0.29	0.32
19004	Allende	0.31	0.63	0.61	0.62	0.54
19033	Linares	-	0.64	0.84	0.89	0.94
19044	Sabinas Hidalgo	-	0.83	0.95	0.96	0.91
20068	Ocotlán de Morelos	0.93	0.98	0.74	0.35	0.3
21004	Acatzingo	0.65	0.9	0.72	0.67	0.47
21164	Tepeaca	0.22	0.19	0.16	0.57	0.26
21208	Zacatlán	0.21	0.31	0.28	0.15	0.75
22012	Pedro Escobedo	0.98	0.98	0.98	0.91	0.89
22016	San Juan del Río	0.41	0.76	0.38	0.59	0.44
25001	Ahome	-	0.5	0.63	0.75	0.69
25006	Culiacán	0.14	0.47	0.43	0.38	0.17
25012	Mazatlán	0.23	0.79	0.34	0.27	0.2
26002	Agua Prieta	-	0.91	0.92	0.89	0.94
26030	Hermosillo	0.81	0.95	0.96	0.87	0.94
26043	Nogales	-	0.84	0.84	0.83	0.79
30015	Angel R. Cabada	0.41	0.3	0.15	0.51	0.03
30141	San Andrés Tuxtla	-	0.18	0.13	0.15	0.07

Source: compiled by the authors using data obtained from economic censuses from the relevant years.

[1] The composition of domestic content for exported automobiles was 36% in 1993, 28% in 1998, and 0% in 2004.

[2] The 2014 Economic Census has been excluded as it does not contain figures for the automotive sector at the municipal level which previous editions contained.

[3] https://www.inegi.org.mx/programas/ccpv/2010/default.html#Tabulados

[4] The specialization indices for all units of analysis are contained in the appendices.