

Road Transport Infrastructure and Manufacturing Location: An Empirical Evidence and Comparative Study between Tijuana and Nuevo Laredo, Mexico

Infraestructura de transporte y localización manufacturera: Evidencia empírica y comparación entre las ciudades fronterizas de Tijuana y Nuevo Laredo, México

Saúl OBREGÓN-BIOSCA
saul.obregon@uaq.mx

José Manuel CHÁVEZ-USLA
jchavez@hoatsa.com.mx

Eduardo BETANZO-QUEZADA
betanzoe@uaq.mx

Universidad Autónoma de Querétaro

ABSTRACT

Transport infrastructure influences the location of manufacturing firms in that sense, this paper compares the influence of accessibility to ports for export and the location of manufacturing firms in two municipalities in the northern Mexico border. The tools used include the management of a geographic information system and micro-level data of the industrial parks of each municipality. Statistical analysis was based on the application of Poisson models to estimate the sets placement options. The results show that accessibility and market size have greater significance in the location of firms in both cities.

Keywords: 1. transport infrastructure, 2. manufacturing, 3. econometric modelling, 4. Tijuana, 5. Nuevo Laredo

RESUMEN

La infraestructura de transporte influye en la localización de empresas manufactureras, por ello el presente trabajo compara la influencia de la accesibilidad al puerto fronterizo y la localización de empresas manufactureras en dos municipios de la frontera norte de México. Las herramientas utilizadas incluyen el manejo de un sistema de información geográfica y datos a nivel micro de empresas. El análisis estadístico se basa en modelos de Poisson, estimando los conjuntos de opciones de ubicación. Los resultados muestran que la accesibilidad y el tamaño del mercado presentan mayor significación en la localización de las empresas en ambas ciudades.

Palabras clave: 1. infraestructura de transporte, 2. manufacturas, 3. modelación económica, 4. Tijuana, 5. Nuevo Laredo

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INTRODUCTION

The discussion on the effects of investment on transport infrastructure and economic development is not new. Since the first highways and railroads were built, one of the main discussions has been the resulting impact of the new infrastructure on production costs. Transport investment has territorial repercussions that modify space and the economic activities and lifestyles it contains, ultimately causing or hastening changes in the structures and dynamics of the group affected. Initially, since network interconnection was limited, impacts were clearly identified and causal relationships could be deduced.

In the mid 1980s the Mexican economy embarked on a profound structural transformation, driven by a change in international trade, reaching a peak in 1994 with the passage of the North American Free Trade Agreement (NAFTA).

In the first five years after NAFTA took effect (1995-2000), Mexico experienced an average growth rate of 7.8 percent driven by the development of its export sector. During that period, the northern border experienced a growth rate of seven percent (significantly higher than in the southern states of the country, where the average was three percent). As noted by Rodríguez and Sánchez (2002), this growth was driven by the maquiladora industry; however, these improvements did not take place throughout the country. According to Bustamante (1981), one characteristic of border cities that distinguishes them from the rest of the country is their international dimension. In other words, they are the site of intense social interaction that involves individuals and institutions from both countries. From an economic point of view, social interaction particularly permeates the occupational structure of the border, as in the case of the maquiladora industry.

A critical aspect in the decision to set up a firm is precisely where to locate the business. It is a question firms and entrepreneurs often analyze in depth, knowing that the answer may determine the success or failure of a new productive activity. Accordingly, public administrations attempt to guide these decisions and increase the probability of success through initiatives involving changes in land use, the construction of transport infrastructure, and tax and financial aid (Owens and Sarte 2002). Location therefore entails a continuous re-allocation of substantial public and private resources. However, knowledge of what leads a firm or facility to locate in a geographical area as opposed to other potential locations is still relatively limited (Hayter, 1997).

The purpose of this paper is to examine and compare the relationship between land transport infrastructure and the establishment of manufacturing industries in two municipalities in states on Mexico's northern border. To this end, accessibility parameters will be analyzed using the model proposed by Holl (2004a) on firm location, extending the use of variables such as specialization indices of industrial parks, accessibility, rental costs and distance to the border port. As a hypothesis, market size and accessibility are the variables with the greatest bearing for agglomeration economies in the location of manufacturing firms in the fields under review. The two municipalities under study were chosen because of the importance of their international ports and the similarity of the manufacturing processes established in each.

The article begins with a theoretical presentation of transport and industrial location, including modern location theories and mathematical location models. Of the latter, it shows the profit maximization models, which consider agglomeration economies, and centrifugal and centripetal forces. It then explains the methodology based on the calculation of the accessibility index, model specification, generalized linear models, and the estimation of fixed and random effects. For the implementation of the proposed models, data requirements and localization determinants are explained on the basis of the characteristics of the municipalities of Nuevo Laredo (Tamaulipas) and Tijuana (Baja California). In the third step, the empirical results obtained through the verification of the Regression Model, the estimation of fixed and random effects and the results in the probability of location are presented and discussed. The article ends with conclusions and suggestions for future research lines.

LITERATURE REVIEW

Studies on location theories are based on the historical model of analysis of the principle of accessibility, linked to the name of Von Thünen (1826). The first direct reference to the structure of an urban economy in a theoretically conscious way was made by Hurd (1903). In the early 20th century, Weber (1909) developed a theory whose basic lines are still valid, analyzing the location of an isotropic space. The positions of Von Thünen (1826) and Weber (1909) have been expanded by scholars of the economics of location, such as Losch (1959), Isard (1956) and Dunn (1954), among other authors. And so transport has become a major feature of theories about how economic activities are distributed

and land values develop. As for commercial and service activities, Christaller (1933) sought the solution to the optimal location of vendors in a region, a proposal he developed on the basis of two key concepts: the physical extent of the market and the demand threshold.

Recent studies have indicated that there is a strong link between economic development and transport investment (Aschauer, 1989). Regarding the economic impact, one of the most complete works is the one by Banister and Berechman, (2000) which addresses the effect on economic development caused by transport infrastructure, concluding that it is difficult to construct causal relationships that support the data, such as the effects of external factors (in other words, as regards time and stage of development), since these can influence the direction and strength of the impact. They also evince the undisputed role played by accessibility changes in economic development (demographic changes, location of activities, employment and so on).

Forkenbrock and Foster (1990) have studied economic benefits on the basis of highway investment in two metropolitan areas in the U.S. Midwest. Using an input-output model, they conclude that road investments promote local economic development by reducing transport costs relative to other places. Boarnet (1998) explored how highway investments redistribute economic activity and divided economic impact into areas close to freeways and those further away. Carrillo (2002) studied the income differences relative to the market. The issue of whether a reduction in transport costs brought new areas and products into the market has been discussed (Rostow, 1960), and Mitchell (1989) concludes that the conditions indicated by Rostow had already been met in the United Kingdom before railways were built, stating that there was no major immediate effect on the economy. As noted earlier, new roads create economic development by encouraging industries to set up. The Standing Advisory Committee on Trunk Road Assessment (SACTRA, 1999) report presents two scenarios that form the basis of this vision: the first is the advantage for the user of direct roads and the second is that highway construction is an efficient means of attracting economic development. Road infrastructure improvements reduce transport costs (primary effect), while low production costs in relation to changes in distribution costs improves the optimal production and distribution of firms (secondary effect) (Mackie and Simon, 1986). The effects of road infrastructure are now considered necessary but not sufficient for economic development (Huddleston and Pangotra, 1990). If a region has all the economic factors required for growth, then its full potential will

not be achieved without additional transport investment. This type of discussion has been central to regional development theory.

Modern Location Theories

Theories have emerged that not only take into account geographical aspects but also returns to scale, externalities and spatial competition, giving rise to the new economic geography (Dixit and Stiglitz 1977; Fujita *et al.*, 1999; Krugman, 1998). In the 1970s, this trend analyzed the field of industrial organization, when theorists first developed more practical competence models that consider the presence of increasing returns to scale. In particular, Dixit and Stiglitz's model (1977) deals with monopolistic competition. Although the assumptions of this model does not fully reflect reality, it is a means of simplifying the use of geographical analysis (Fujita *et al.*, 1999). The new economic geography not only makes it possible to determine where industries will be concentrated, but also to know what kind of industries are concentrated in a particular place.

Mathematical Location Models

According to Hayter (1997) industrial location work can be grouped into three schools: neoclassical, behavioral and institutional (Alañón *et al.*, 2005). From a theoretical point of view, the approach to industrial location should be addressed from an eclectic perspective, since the three approaches outlined above are valid elements which, in many cases, may be complementary.

Profit Maximization Models

Holl (2004a) designed a model to analyze the location of firms in Spanish municipalities. Using micro-level data and techniques from geographical information systems (GIS), he analyzed the impact of highway infrastructure on setting up industries between 1980 and 1994, a period when road infrastructure underwent significant improvements. Through Poisson regressions, panel data, and controlling heterogeneity at the municipal level, the author shows that new roads affect the spatial distribution of manufacturing at the municipal level. The model used by Holl (2004a) takes into account quality factors and improvements in road infrastructure, in addition to location, cost, demand, and agglomeration economies.

$$\pi_j = \sum_{k \in P} \sum_{k \in M_r} p_{jk}(T_{jk}^D) q_{jk} - c_j(w_j, g_j(T_{jk}^S), q_i) - f_j$$

The firm expects profits from a representative municipality j , which will depend on the sum of the expected revenue from sales in all markets and local production costs. By selling the output produced in municipality j , q_{jk} in place k within region r , the firm obtains an average turnover of $P^{jk}(T_{jk}^D)$, which depends on transport costs, due to location j, k, T_{jk}^D . Thus, revenues from sales in different places are not only determined by the size of the market for firms in these places, q_{jk} , but also by access to these markets T_{jk}^D .

It assumes that since firms cannot incur transport costs in the sale of production within the municipality itself or income in the local market, it will merely depend on price and demand, meaning that, in terms of costs, variable production costs c_j are functions of the prices of the main factors, w_j , the average cost of intermediate inputs, $g_j(T_{jk}^S)$ and the q_j output produced, may vary in different locations because of differences in input transport costs, T_{jk}^S , which will depend on the availability of nearby suppliers. Lastly, fixed costs, f_j are at the firm level. In this case, Holl (2004a) does not directly consider the price of land, wages or labor costs.

Studies by Manjón and Arauzo (2006) for the location of new industrial establishments in Catalan municipalities find that the classic location determinants (density, urbanization, etc.) are unimportant and at the same time, show the importance of institutional (capital) and geographical (proximity to the coast) factors. They use two kinds of models (Poisson, Negative Binomial) to consider the existence of unobservable heterogeneity between municipalities. Their results show that the deciding criterion is based on profit maximization (expected) and they assume that they contain an identically distributed stochastic term and that the probability of choosing site j by firm i may be expressed in terms of a discrete random variable that embodies the result of this choice. This variable is the basis on which discrete choice models (Guimarães *et al.*, 2000) are constructed. Alañón and Arauzo (2008), in their study of accessibility and industrial location in border areas of France with Spain, using spatial statistical techniques and Poisson models, find a positive importance of accessibility in attracting new industries.

It might seem logical that a better connected municipality would be more attractive to businesses and better able to promote the endogenous development

of business initiatives. There are several studies that show the positive effects of the existence of transport infrastructure in terms of employment or production levels (García-Mila and McGuire, 1992; Carlino and Mills, 1987; Carlino and Voith, 1992) or the set of infrastructure in general (Aschauer, 1989) since they have the ability to improve productivity levels in the private sector that uses them. Moreover, based on the fact that the services offered by infrastructure are provided in the area where they are located, these places will enjoy comparative advantages. However, other studies show how the effect of improved accessibility on firm location cannot be generalized to all industrial sectors, since there are considerable sectoral specificities that require analysis (Chandra and Thompson, 2000). Thus, although positive spillovers may occur, the resulting spillovers may also be negative (Boarnet, 1998). Beyond these sectoral aspects, it is essential to clarify that although theoretical contributions highlight the role of infrastructure investment on economic growth, empirical evidence provides mixed results depending on the type of territorial area.

Sánchez (2004) states that the effects are less favorable in non-metropolitan areas. In his analysis, he examines the historical relationship between changes in land use and location of road projects in Oregon between 1970 and 1990. Boarnet (1998) states that the effects in terms of the relocation of economic activity are a little studied phenomenon in the literature. Another Spanish case study, by Obregón and Junyent (2011), analyzes the short-term impact of *Eix Transversal de Catalunya*. Using the classic *ex-ante*, *ex-post* method, they compare the evolution of socioeconomic variables before and after the construction of this infrastructure. Their results undeniably show the positive effect this route has had on its territory, influencing spatial planning, population growth and economic development, and at the same time reflecting changing patterns of population mobility. The effect of this infrastructure was compared with a Mexican infrastructure, two territorial areas with some similarities but also with obvious social differences. Obregón (2010) concludes that the development patterns induced by both roads are very similar and that the main difference lies in the level of economic development in the two countries.

Models Considering Agglomeration Economies

An alternative way of analyzing the impact of these infrastructures is to consider agglomeration economies, whose existence has traditionally been a major locational factor. However, actions involving an overall improvement in the highway transport network can be considered to have an effect in terms of weakening these

agglomeration economies (Haughwout, 1999). Specifically, these improvements entail greater ease of moving goods and people between the center and the periphery, which may lead to less need to be at the center and therefore to a decrease in the positive effects of agglomeration.

The firm's activity sector will have different requirements regarding the need to transport inputs and outputs and the frequency of this transport. Greater proximity to the market or improved accessibility also often implies a higher price floor. In any case, apart from the considerations indicating that improved accessibility has a positive impact on the areas that benefit from it, these considerations must be refined, particularly in an economic context of steadily decreasing transport costs and increasing non-material flows (Holl, 2004a). Therefore, many authors now question whether transport costs can be considered a location factor. This position represents a significant change in relation to the ideas held in economics today, particularly as regards Weber's work (1909).

In this respect, Holl (2004b) shows how the process of construction of the highway network in Portugal (from 1986 to 1997) has affected the spatial distribution of the firm location, since municipalities with improved accessibility to the highway network have seen an increase in their ability to attract new businesses. Thus, this process has led to a concentration of economic activity, whereby previously peripheral municipalities that have increased their accessibility have attracted a growing percentage of new businesses. Another study on the Spanish economy, conducted by Arauzo (2005), shows the existence of evidence of the impact of highways on firms' location decisions. The main results show the usual findings in this type of work: municipalities located near the highway network increase their locational appeal over other municipalities, and this impact varies by manufacturing sector.

Models considering Centrifugal and Centripetal Forces

The role of an improved road network can also be approached from the perspective of the balance between centrifugal and centripetal forces (Mendoza, 2007). There are several studies in the literature describing the role of transport costs within the spatial configuration of economic activity. If we consider two extreme cases, one in which transport costs are very high and one in which they are very low, the spatial distribution of economic activity varies considerably. Thus, according to the first assumption, firms will opt for the dispersion of their activities, in order to be located close to consumers and end-markets, and thereby save transport costs.

Conversely, according to the second assumption, firms prefer to concentrate their activities in a few locations where they will distribute their products for the set of markets in which they operate. This effect appears to contradict what one would expect from a general improvement in accessibility, such as a greater dispersion of activity.

The above argument shows how the role of transport costs (accessibility) in the distribution of economic activity in a particular area is neither particularly clear nor obvious, since improved accessibility may have an opposite effect in terms of the ability to attract new businesses. In any case, it is essential to consider that investment in transport infrastructure influences the spatial distribution of economic activity, so that while some areas benefit (from the improvement in firms' ability to attract) (Mendoza, 2007), others suffer (due to the expulsion of business to areas that have increased their accessibility) because of this improvement in infrastructure (Haughwout, 1999). Given these opposing effects, it is important to know the net result for the whole region. The net effect could be studied on the basis of business relocations, but unfortunately, in this particular case study, existing databases lack information on business relocations. Obregon and Junyent (2011) underscore the importance of highway infrastructure as a key factor in the economic development and organization of an area, because this type of investments contribute to the structuring of the area, facilitating access and the mobility of people and goods. In general, Obregón (2010) states that the capacity for induction or the possibility for development offered by a highway infrastructure will depend on the conditions inherent in every municipality and region and on their willingness to attract investment projects.

METHODOLOGY

As noted earlier, several studies have examined the relationship between various factors in the location of manufacturing firms. Given that there are factors that play a role in the decisions to do business or where to locate or relocate, it is important to combine more effective mechanisms and thereby maintain high economic development. One of the key factors that play a fundamental role in a region for its development is the presence of an efficient transport infrastructure. Unlike other studies, this paper analyzes the effect of accessibility to the border port using micro data from 2011. The various indices and models used in this study are defined below.

Specialization index: the specialization index of each industrial park is defined on the basis of the classification of each of the firms located in each of the parks in each municipality, and the total number of firms in each municipality:

$$IE_k = X_{kj} / X_j$$

Where:

X_{kj} = number of areas of firms based in park k in municipality j

X_j = number of areas of total firms installed in municipality j

Distance and travel time from each industrial park to the border port: in the case of Tijuana, this was calculated using the international Port of Otay, and in the case of Nuevo Laredo, it was calculated using the International Trade Bridge. The grapho was drawn (considering the border port, industrial parks and highway network) on the basis of a geo-referenced satellite image in transport modeling software (TransCAD) for each of the cities. Thus, the shortest distances to the border port were obtained from the matrix with the resulting shortest routes. Travel speeds were estimated in free flow, considering the threshold speed of the arches and the physical characteristics of each road according to the procedure established by the *Transportation Research Board*, (2000).

Accessibility Index: To evaluate the transport system and its link with the firms installed in parks in every municipality, once the distances and travel times for each of the parks to their border port were determined, the accessibility index proposed by Wilson (1967) and used by Holl (2004a) was determined.

$$ACC_j = \sum W_K e^{(-bC_{jk})}$$

Where: W_K is the measure of the size of the market in destination k ; C_{jk} is the distance or time between source j , and destination k and b reflect the impedance function.

One of the key factors in the economic prosperity of a region is the provision of infrastructure and reliable, efficient transport services. Since demand in the markets to which firms have access is primarily determined by the size of the local market, it is easily driven by the service of a good transport system, since this demand could have less influence on the location of firms with transport costs. The population is recorded through local market demand and border metropolitan areas, obtained through the population over 18 years old in each of the areas studied (Nuevo Laredo-Laredo, Texas and Tijuana-San Diego, California)

reported by the 2010 Instituto Nacional de Estadística y Geografía (National Institute of Statistics and Geography) Census and the United States Census Bureau. Although the legal working age varies between Mexico and the states of California and Texas, considering the age of 18 allows one to compare the information from the census results of the two countries and avoid a discussion between federal and state laws and the population under 18 reported as being engaged in paid activity.

Model Specification

The decision to locate a business may be made by modeling the number of establishments in a municipality or may also be determined by local benefits. The equation proposed by McFadden (1974) shows that the location decision may be taken by modeling the number of new manufacturing firms in municipality j ,

$$\eta_{ijt} = f(x_{jt}) + \varepsilon_{ijt}$$

Where:

η_{ijt} is the number of new establishments in sector i in each municipality j in period t and x_{jt} is the vector of municipal characteristics that affect expected benefits. These benefits will be considered as formulated in Holl's equation (2004a) and ε_{ijt} is a random error term.

In McFadden's equation, (1974), local benefits are determined by the accessibility of production to the market. By reducing transport costs, infrastructure provides changes in the accessibility of production to the market, such as quality factors and improvements in road infrastructure, in addition to location, cost, demand, and agglomeration economies. However, if we consider that the number of establishments in each municipality is not a negative number, Poisson distribution is often a reasonable description for events that occur randomly and regardless of time. This is a first natural supposition for the calculation of this issue, while the advantage of its specification lies in the fact that:

a) Most of the forms are analogous to families with economic regression specification.

b) In particular, $E(n_{it}|X_{it}) = \lambda_{it}$. Moreover, estimates of unknown parameters are simple and performed either by a technique of weighted iteration of least squares or by an algorithm with maximum probability.

For the analysis in this paper, Poisson regression models are used that will link the number of firms established, considering 13 areas in each industrial park and in each municipality as the response or dependent variable; and indices of firm specialization, accessibility, rental costs, distance or time to the border port, as regressive or explanatory variables. Thus, assuming that the deciding criterion is based on profit maximization (expected) and that they contain an identically distributed stochastic term, the probability of choosing location j by firm i can be expressed in terms of a discrete random variable that embodies the result of this choice. Once these individual decisions have been combined, probability could easily refer to the number of firms located in a given area and period of time, a random variable that would have Poisson distribution. While *logit* models based on utility maximization provide a suitable framework for modeling firms' decisions, as noted by Guimarães *et al.*, (2003), in practice the implementation of this method is problematic when one has to handle complex scenarios with a large number of spatial alternatives, which is why the Poisson regression is an attractive solution for this approach.

Mathematically, if n_{ijt} reflects this random variable governed by a parameter λ Poisson distribution (the ratio of occurrence of the event of interest), then the density function, given a vector of explanatory variables, is x . Thus, the probability that a facility will be located in park j in period t is:

$$Prob(n_{ij}) = \frac{e^{-\lambda_{ijt}} \lambda_{ijt}^{n_{ijt}}}{n_{ijt}!}$$

Where: λ_{ijt} is the average number of establishments located in park j in period t , as a property of Poisson distribution and λ_{ijt} is equal to the conventional mean and variance:

$$E(n_{ijt}) = \text{Var}(n_{ijt}) = \lambda_{ijt}$$

The expectation of n_{ijt} , λ_{ijt} is log-linearly independent of the explanatory variable, as in:

$$\ln(\lambda_{ijt}) = \beta_j' x_{jt}$$

β_j is a parameter vector that can be estimated and X_{jt} represents the vector of zonal observables.

Generalized Linear Models

The computer application used in this study was R. In this application, generalized linear models were used, which are adapted to the non-normal response distributions and simple linear transformations. The generalized linear model may be described in terms of the following sequence: there is a response y of interest and stimulus variables x_1, x_2, \dots whose values influence the distribution of the response. Generalized linear models in R show Gaussian, binomial, Poisson, inverse Gaussian and gamma response distributions. Each distribution of response admits a link function that connects the mean to the linear predictor.

In order to develop the models, the Poisson parameter was denoted as λ . The specification of log form $\lambda = X\beta$ will be considered, where X is the regressive vector, which describes the characteristics of the unit observed over a period of time t , in this case, the location of each firm in each industrial park in each municipality. It is not uncommon in Poisson models to observe that variance is greater than the empirical mean, according to Hausman *et al.*, (1984). Moreover, the number of firms deviates from what would be their mean. This indication may be due to the failure to consider factors with fixed effects, supplied by the firms and random effects provided by the municipality itself.

Estimation of Fixed and Random Effects

The estimation of unobserved effects in each municipality in attracting the establishment of new manufacturing plants. In this case, fixed effects effectively control the potential problem of concurrency in the ratio of the park infrastructure to accessibility. For Holl (2004a), this refers to a possible positive association, because transportation infrastructure planning does not occur randomly and instead is contingent on the spatial patterns of economic activity (road infrastructure can attract the establishment of firms, and the concentration of the latter can promote the nearby construction of infrastructure with greater capacity and improved service levels). The goal is to find additional assumptions for unobservable heterogeneity that will make it possible to have consistent estimators. Thus, not only will the random effects estimator be consistent, but the fixed effects estimator will be more efficient in exploiting more information. Nevertheless, this author argues that if the location decision is finite, it is necessary to consider entrepreneurs' decisions that may encourage irrelevant alternatives. That is why it is reasonable to assume the existence of factors that influence location decisions, such as geographic

attributes or services. In this respect, a dispersion factor possibly caused by rental costs and the distance and time to their border port was also considered. The use of this information allows the estimation of fixed and random effects for unobserved heterogeneity in the two municipalities, and potential concurrency problems in firm location. The same software was used for this estimate, using a hierarchical general linear model. Furthermore, given the results of Hausman *et al.* (1984), it is common to use a Poisson model with a response distribution of gamma random effects (Lee *et al.*, 2006).

LOCATION DATA AND DETERMINANTS

The municipality of Nuevo Laredo is located in the state of Tamaulipas, on the banks of the Rio Grande, adjacent to the city of Laredo, Texas. The 2010 Census recorded a population of 384 033 inhabitants (its population rose by 24.56 percent between 2000 and 2010), which, together with the neighboring area, makes a total population of 634 337 (Nuevo Laredo and the Laredo metropolitan area). The town's main road is Federal Highway 85, linking Nuevo Laredo to the Federal District. Over 36 percent of the goods driving international trade to the U.S. and Canada, Mexico, Central and South America pass through Nuevo Laredo, ranked as the busiest international land port in Mexico. The town has four international bridges to Laredo, Texas: the Gateway to the Americas International Bridge, for pedestrians and vehicles. The Juarez-Lincoln International Bridge for passenger buses and light vehicles. The railway bridge and the World Trade International Bridge, dedicated exclusively to freight vehicles (the subject of this study, with 1 327 518 loaded truck crossings to the United States in 2012).

The municipality of Tijuana is located in the state of Baja California, in the United States-Mexico border neighborhood of San Diego County, California. The 2010 census recorded a population of 1 559 683 inhabitants (its population rose by 41.3 percent between 2000 and 2010), which, together with the neighboring area, makes a total population of 4 654 996 (Tijuana and the San Diego metropolitan area). Unlike Nuevo Laredo, it does not have a major road axis to the center of the country, while its main regional hubs are Federal Highway 2, connecting Tecate to Mexicali and Federal Highway 1 to Rosarito and Ensenada. There are two border ports in San Ysidro and Otay, both for passenger buses and light vehicles, and a feeder road from the latter, devoted exclusively to freight vehicles (the subject of this study). The port has the second

largest capacity for loaded trucks traveling by land from Mexico to the United States (544 173 crossings).

In this paper, one of the main problems that had to be overcome was the limited statistical information with economic content available for the basic political unit of territorial aggregation in Mexico (municipality). This made it impossible to use certain key variables from the point of location, such as labor costs, production costs, total export costs, import and export duties and GDP.

The space imposes restrictions on the movement and choices determined by accessibility. Therefore, in order to test the hypothesis for this study, the exploratory analysis of this research was carried out in two municipalities on the northern border, based on the classification of manufacturing firms according to the North American Industry Classification System (NAICS, 2011). Thirteen of the 21 manufacturing areas established by the NAICS are present in each of the municipalities in the two areas of study.

This research uses data at the micro level, analyzing the location of firms established in eight industrial parks in 2011 in the case of Nuevo Laredo and 46 parks in the case of Tijuana based on the NAICS classification. This made it possible to examine the impact of highway infrastructure through accessibility in each of the parks to their corresponding border port. Thus, the variables studied are: number of firms established in each of the parks, classification by area of the firms set up in each of the parks in each municipality, specialization index, distance and time from each industrial park to the border port, accessibility index, rental cost of each of the parks, average salary and educational attainment.

In the municipality of Tijuana, the parks and the number of established firms belonging to that organization were located through the information provided by the Corporación de Desarrollo Económico e Industrial de Tijuana-Corporation of Economic and Industrial Development of Tijuana (DEITAC). In Nuevo Laredo, the parks and the number of established firms belonging to the organization were located through the Instituto para la Competitividad y el Comercio Exterior-Institute for Competitiveness and Foreign Trade (ICCE).

Information was obtained from the Directorio de Parques Industriales (Industrial Park Directory) published by Tijuana City Hall to determine the cost of ground rent of each industrial park, and from its counterpart in Nuevo Laredo for that municipality. The remaining data used were obtained from the Instituto Nacional de Estadística y Geografía (National Institute of Statistics and Geography) (Inegi).

EMPIRICAL RESULTS

Since the location decision may be made by modeling the number of manufacturing firms in municipality j as indicated in the expression provided by McFadden (1974), local benefits are determined by the accessibility of production to the market. By reducing transport costs, infrastructure provides changes in production's accessibility to the market. As mentioned earlier, in our case study, the Poisson regression model was used to determine the relationship between the number of firms located in 13 areas in each industrial park of each municipality as the dependent variable, with the firms' specialization index, accessibility index, rental costs and distance to border port being utilized as explanatory variables. The results of the model with the best significance of the items analyzed are shown in Table 1.

TABLE 1. Models Obtained for each Municipality*

	Nuevo Laredo		Tijuana	
	<i>Estimate</i>	<i>Std.Error</i>	<i>Estimate</i>	<i>Std.Error</i>
Distance to export port	-0.0841	0.03	-0.002478	0.011626
Accessibility Index	-0.7845	0.01159	-0.71181	0.12168
Cost of Rental	22.48	0.9111	2.055618	0.49233
Specialization Index	8.6777	0.14302	20.379427	0.90475

* In all cases $P < 0.05$

Source: Compiled by the author.

The relative influence of each attribute is given by the coefficient. The regression shows that for the case of Nuevo Laredo, utility coefficients of the rental cost and specialization of firms are approximately 0.38 (8.67/22.48), and 9.94 (20.37/2.05) for the case of Tijuana. These coefficients are more important compared with the other two parameters considered. For the case of distance to the border port and the accessibility index, they show a negative sign, which has a deterrent effect on the decision to locate a firm (regardless of its area). A comparison shows that the largest negative effect is the accessibility index for the case of Nuevo Laredo (a deterrent effect of approximately 10 percent compared to Tijuana). This could be due to the fact that the calculation of accessibility coefficients involves the size of the market between each Mexican city and the

North American areas. Tijuana and the San Diego area, have a greater accessibility index with improved travel time and distance between the parks and the border port. To support the above, Table 2 provides descriptive statistics of the minimum distances between industrial parks and the border port. Distances are greater in Nuevo Laredo than in Tijuana, which corroborates what was observed in the accessibility index.

TABLE 2. Descriptive Statistics of Distance from Industrial Parks to Border Port (in Kilometers)

	N	Mean	SE Mean	StDev	Variance	Minimum	Q1	Median	Q3	Maximum
<i>Nuevo Laredo</i>	8	22.43	1.54	4.34	18.88	17.66	18.67	20.64	27.18	28.73
<i>Tijuana</i>	38	13.744	0.885	5.454	29.741	3.58	11.16	13.945	16.39	26.98

Source: Compiled by the author.

The rental cost coefficient is 10 times higher, (22.48/2.05), while Nuevo Laredo's coefficient is more important than Tijuana's. This could be due to the lack of other industrial parks with a better accessibility coefficient for businesses, as described in the preceding paragraph, showing the deterrent effect of accessibility. The coefficient in the specialization index of firms in Tijuana represents 42.5 percent (20.37/8.67) of Nuevo Laredo's. This is a result of higher values in obtaining this index per industrial park in Tijuana, which has a mean of 1.004, as opposed to 0.44 in Nuevo Laredo. This is directly linked to the number of firms established between the two municipalities, areas and parks (Nuevo Laredo has 5.89 percent (39/662) of the total number of firms located in Tijuana, in 11 different industries, as opposed to 13 in Tijuana). Nuevo Laredo has greater specialization, with 69 percent of its businesses concentrated in four industries, as opposed to six in Tijuana.

Regression Model Verification

Table 3 shows the deviation and Chi-square goodness of fit tests for the null hypothesis of Poisson variance (Dobson, 1990). At the same time, the Durbin-Watson test was applied to rule out the self correlation of data.

In the case of Nuevo Laredo, p values close to the unit are found, indicating that the model does not fit properly given the dispersion of the data, affected by the behavior of the variance. In contrast, in Tijuana they are virtually zero, which can be explained by the number of firms in each of the municipalities. Self-correlation of the variables is practically zero for both cases, meaning that this hypothesis is considered valid in the model.

TABLE 3. Goodness of Fit Tests for the Models Obtained

	Nuevo Laredo		Tijuana	
	<i>Stat</i>	<i>p</i>	<i>Stat</i>	<i>p</i>
Chi-squared	0.61	0.894	149.329	0.000
Deviance	0.592	0.898	122.32	0.000
Durbin-Watson	1.647104	0.054	2.054	0.024

Source: Compiled by the author.

Estimate of Fixed and Random Effects

In regard to the estimate of unobserved effects in each municipality to attract manufacturing plants, in this case, the fixed effects effectively control the problem of simultaneity in the relationship between park infrastructure, accessibility and additionally, a dispersion factor caused by rent costs and the distance to the border port. The results of the model with the best significance of the data are shown in Table 4.

TABLE 4. Calculation of Fixed and Random Effects

	Nuevo Laredo		Tijuana	
	<i>Estimate</i>	<i>Std.Error</i>	<i>Estimate</i>	<i>Std.Error</i>
Distance to export port	-0.0841	0.03	-0.002478	0.011626
Accessibility Index	-0.7845	0.01159	-0.71181	0.12168
Cost of Rental	22.48	0.9111	2.055618	0.49233
Specialization index	8.6777	0.14302	20.379427	0.90475

Source: Compiled by the author.

As one can see from the table, the fixed effect determined by the specialization index of the park shows a value of approximately 50 percent more for Nuevo Laredo. This is consistent because even though there are fewer firms in Nuevo Laredo, the larger number of establishments are classified into a smaller number of industries, enabling them to generate greater benefits for the location decision, since for these industries that are integrated by firms create a more highly specialized labor force. However, the dispersion caused by the cost of rent in combination with the distance to the border port is almost four times higher in Nuevo Laredo than Tijuana. This may indicate that most of the parks are located within a similar range, with greater importance being placed on rental costs. This is consistent with the results obtained, where distance to the border checkpoint reflects a deterrent impact, while the cost of rent indicates a positive effect. In Tijuana, the effect is more regular due to the heterogeneity of the location of the parks, while the random effect that could be caused by the area is smaller (about 70 percent). In Nuevo Laredo, this is due to the lack of land with a better location, and from the point of view of scale economies, the small number of firms in this municipality.

Results of Probability of Location

Lastly, the probability of locating a firm in a particular industrial park depending on its industry according to the NAICS classification was determined. Considering the parameters described, it was observed that applying the probability of location on the basis of accessibility to the border port yields 71 percent of valid responses in Tijuana and 75 percent in Nuevo Laredo. The reliability of the model is primarily borne out by the petroleum, computer equipment and other industries in Tijuana, and in Nuevo Laredo by the machinery and equipment, petroleum products, computer and transport equipment sectors. Standard behavior is not obtained, due to the complexity of the two municipalities. For example, in the case of the textile industry, the municipality of Tijuana shows that the higher probability value is linked to the better accessibility value in comparison with Nuevo Laredo. This type of behavior could be based on the type of production, which would be also linked to the market. Another influencing factor would be the cost of rent in combination with the cost of transport. Wrong probabilities occurred mainly in the basic metals and computer equipment sectors in Tijuana, whereas a significant relationship was not observed in this industry in Laredo. However, they are located around the mean of the accessibility index in the field of study, whereas in Tijuana, a striking proportion of parks with a lower acces-

sibility index was recorded. For example, in the case of Tijuana, the food industry obtained an accessibility index of 3.59E-21, while only one firm installed in this same industry has the highest probability value, with 72.1 percent, ruling out the probability of locating in a park with greater accessibility. Such behavior can be said to stem from the size of the local market. Whereas Tijuana has a larger market for the consumption of edible products, the case of Nuevo Laredo is less attractive in terms of size, suggesting that it could have better accessibility to the more attractive market. This assumption is based on the framework of location theories mentioned earlier (Fujita *et al.*, 1999). Economies of scale also play a key role in location. This situation was modeled as a random factor of unobserved effects in each municipality, with a 75 percent more adverse value being obtained in Nuevo Laredo than in Tijuana.

CONCLUSIONS

Research has focused on the influence of accessibility to border ports in locating manufacturing firms. Unlike the studies shown in the literature review, and confirming the line of research using micro data, this article directly considers rental costs, accessibility, market size, the industry of the firm, distances or times to border ports in each industrial park. It compares variations in the coefficients of the variables in two municipalities on Mexico's northern border, maximizing expected benefits through some of the indices considered in location theories, showing that the municipalities analyzed, market size and accessibility are variables that have greater significance than agglomeration economies in attracting manufacturing firms in the case study, validating the initial hypothesis.

From a practical point of view, lack of statistical information at the municipal level means that the approach in this paper is closer to the neoclassical approach, given the impossibility of building the characteristic indicators of behavioral and institutional schools, although the maximization model was regarded as being of interest, since it highlights the importance of transport. The research reflects the importance of accessibility in the choice of location. Although the firm's industry suggests that geographical specialization has also been a major force, the highway network and land availability also play a key role in industry location.

The model used by Holl (2004a) takes into account the factors of quality and improvements in road infrastructure in addition to location, cost, demand, and agglomeration economies. However, it does not consider each industrial park, in-

dustry and rental cost in the different municipalities in a disaggregated manner as analyzed in this paper. It is important to note that the affordability index is closely correlated to distance and market size while economies of scale are not as important as specialization. If only firms from one industry are found, this ensures a more highly specialized labor force, as in the case of Nuevo Laredo, where in the calculation of fixed effects, they generate a considerable coefficient in the index, despite having a smaller number of firms. This contrasts with the value obtained in the specialization of enterprises or agglomeration economies, since whereas Tijuana has a value of 20.37, for Nuevo Laredo only 8.67 is obtained, generated no doubt by the low diversity of industries. Tijuana has 662 firms, which include the 13 installed industries studied in all the industrial parks. Nuevo Laredo has only 39 firms, comprising 11 of the industries specified. Consequently, both the fixed and random effects in combination with the dispersion parameters, yielded different probabilities of location for the firms' different industries within the same municipality. Thus, the results show that individual sectors respond to varying kinds of accessibility, considering the dispersion parameters.

The probabilities of location determined by the firms in the two municipalities analyzed showed that the food business prefers to locate in Tijuana rather than Nuevo Laredo (with a probability of 72.10 and 51.1 percent respectively). Although other industries have a greater preference for locating in Tijuana, the difference is much smaller compared to the food industry, with probabilities of 53.8 and 50.4 percent respectively in the paper industry and 52.8 and 51.7 percent in manufacturing classified as other. The data analyzed in the areas of study of this article, such as market size, accessibility and park area, are significant factors that contribute to attracting the location of manufacturing firms.

The above makes it possible to reflect on possible changes in the explanatory variables studied: less specialization of firms will have a greater impact on the result in Nuevo Laredo than in Tijuana. In this respect, a higher cost of rental would decrease the expected number of new openings, with greater significance in Nuevo Laredo. This variable has a lower impact on Tijuana possibly due to the greater supply of land, as seen in the park area variable. In terms of location, the distance to the border port has a greater effect in Nuevo Laredo, possibly because of the link between the lower number of parks installed and greater distances to the port, since the mean is 63 percent higher in Nuevo Laredo than in Tijuana, which is why location, land and industry have less of an influence in the municipality of Tijuana.

Future lines of research could include the analysis of the historical data of each firm installed in the parks. Using this methodology would make it possible to obtain a clearer idea of the performance of factors that maximize location profits for the industry of each manufacturing firm. Researchers could also compare the changes caused by the establishment of firms considering the effects of accessibility on the employment rate and transport costs with respect to the location of employees' housing and the location of the employment center. These aspects were not included in this paper due to the impossibility of obtaining reliable data.

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