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Internal Migration in Mexico from 1990-2010: A New Economic Geography Approach

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Abstract

This research is focused on explaining the drivers behind individual decisions to migrate internally in Mexico. Migration essentially arises in response to the per capita income disparities between regions; as such, these flows are directly related to the production geography in Mexico. In that sense, the New Economic Geography provides that the forces of agglomeration have a geographic impact on migration due to the economic influence of wages and employment levels, derived from the concentration of economic activity in just a few regions.

Keywords: Internal migration, new economic geography, migrant laborers, gravity equation, data panel.

INTRODUCTION

Individuals migrate for multiple reasons: some migration can be explained by political motives or the desire to reunite with family members living in other regions. However, in reality, much of migration is driven by economic aspects. In this sense, Brakman, Garretsen, and Van Marrewijk (2009) asserted that migration is the result of the widening gap in per capita income between wealthier and poorer regions, which explains the fact that migrants predominantly leave regions with low GDP per capita and go to regions with high GDP per capita.

This fact is fundamental for the economic geography, because the decision to migrate is explained in large part by the real salary gaps between two regions. Moreover, another important factor in the New Economic Geography (NEG) is that migration from poor regions to wealthy regions reinforces agglomeration patterns.

There is a strong correlation between the spatial distribution of the population and industry throughout the various stages of economic development (Tabuchi and Thisse, 2002). In the early phases of economic growth, urban concentration will likely increase and salary differences will be exacerbated. As development continues, spatial decentralization and wage differences will be reduced. As such, falling transportation costs and heterogeneous perceptions of regional differences interact and impact the location of companies and workers, thereby affecting the geographic patterns of industry and population.

This paper analyzes the relationship between migrant workers and the production geography, examining employment and wage differences among the Mexican states between 1990 and 2010. The objective is to present empirical evidence to support migration models based on the NEG approach. In this sense, forces of agglomeration are expected to have a geographic impact on migration, due to the economic influence of salaries and employment levels as the result of the concentration of economic activity in a certain region.

This paper is divided into three sections. The first addresses the NEG theory and describes the model of labor mobility between regions. The second introduces empirical evidence for internal labor mobility in Mexico between 1990 and 2010, and the last section offers some conclusions.

LABOR MIGRATION IN THE NEW ECONOMIC GEOGRAPHY (NEG)

According to Krugman and Venables (1995), there is a clear difference between the international and regional economies when it comes to labor mobility within a space; in the international economy, labor is considered to be fixed or imperfectly mobile between countries, while in the regional economy, labor is said to be mobile among regions. Kaldor (1970) demonstrated that in the realm of geography, this difference is expressed in the fact that inequalities between regions are not as severe a problem as those that exist between countries.

The NEG can be used as the basis for a model of the internal migration process. This process is triggered by the heterogeneous concentration of production among different regions, especially due to the existence of growing yields. Krugman (1991) set forth the idea of a Myrdal-type circular cumulative causation in which two basic mechanisms act as centripetal forces: *i*) market access—firms tend to be concentrated in the biggest markets to take advantage of economies of scale and minimize transportation costs—and *ii*) cost of living—in agglomeration, price indices will be lower and real wages higher. As such, both workers and companies tend to be located and migrate to regions with greater market potential, unless there are forces of congestion that lead certain companies to leave the concentration in search of regions where competition is less strong.

Undoubtedly, demographers have long offered explanations for migration underpinned by wage differences; for example, the neoclassical migration model (Todaro, 1969; Harris and Todaro, 1970; Todaro, 1976). These explanations also take into account a wide range of other causes: household needs (Stark, 1984, 1991; Stark and Bloom, 1985), economic and social ties between migrants (Portes, 1999), social networks (Al-Ali and Koser, 2002), dual labor markets (Piore, 1979), or the structure of the global labor market (Portes and Walton, 1981; Morawska, 1990).

This means that if a worker moves from one region to another with better labor opportunities, it is necessary to consider not only salary costs, but also the costs of the move, the (immaterial) costs of leaving a familiar environment, and the costs of finding a new job in the new region. However, in light of improvements in transportation and communication technologies, the current costs of migration can be reduced, facilitating information to future migrants, which influences their migration prospects. Wage differences between regions and the market potential that engenders these differences are key factors in the migration process (Brakman *et al.,* 2009).

A region that facilitates access to an ample range of goods offers a lower cost of living, due to lower costs of transportation; when these two forces come together, they facilitate agglomeration, both for companies and workers (Crozet, 2004),

The resulting geography will be sensitive to initial conditions. If one region begins with a larger population than another, or if the costs of transportation fall below a critical threshold, this region may end up gaining population at the expense of the other region (Krugman, 1991).

THE AGGLOMERATION MODEL AND WORKER MIGRATION

It could be posited that labor migration is determined by wage gaps, mobility costs, the degree of risk associated with migrating, and the market potential in the host region. These factors are considered in Crozet's (2004) model, which proves the hypothesis that a market with major potential attracts production factors, in this case, labor.

Crozet's (2004) model assumes that the market is composed of *R* regions endowed with two factors: mobile and immobile labor. Each region produces three goods: a homogenous traditional good (*z*), non-traded services (*y*), and manufactured goods (*x*). Commodity *z* is assumed to be homogenous and produced under perfect competition, and is traded without cost between the regions, employing only immobile labor. The price of the *z* good and the wages of the immobile labor are the same everywhere, where the price of *z* is numeraire, which gives us $p_z = 1$ in all regions.

Both manufactured goods and services are monopolistically competitive industries that employ mobile labor to produce horizontally differentiated varieties. The production of each variety is subject to economies of scale; within each industry, the labor required to produce a quantity *q* is respectively:

$$\beta_x q_x + \varepsilon_x \text{ y } \beta_y q_y + \varepsilon_y \qquad (1)$$

Where β_x and ε_x (resp. β_y and ε_y are marginal and fixed input requirements for production in industry x (resp. y). If $n_{xi,t}$and $n_{yi,t}$ denote the number of varieties of good x and y produced in region i at date t, the sector employment can be defined as:

$$L^x_{i,t} = n_{xi,t}\left(\beta_x q_x + \varepsilon_x\right) \text{ y } L^y_{i,t} = n_{yi,t}\left(\beta_y q_y + \varepsilon_y\right) \text{where } i \in [1, R] \tag{2}$$

Where $L_{i,t}$ is the total number of mobile workers in region i in period t: $L_{i,t} = L^x_{i,t} + L^y_{i,t}$ Consumers have Cobb-Douglas preferences:

$$U_{i,t} = C^{\phi}_{yi,t} C^{\mu}_{xi,t} C^{1-\phi-\mu}_{zi,t}, \text{ where } i \in [1, R] \tag{3}$$

Where Φ, μ and (1 - Φ - μ) are expenditure shares for manufactured goods, services, and traditional goods, respectively;$C_{zi,\ t}$ is the quantity of traditional goods consumed in region i at date t; $C_{xi,\ t}$ is a variety of manufactured goods:

$$C_{xi,t} = \left(\sum_{m=1}^{n_{x,t}} c\left(m\right)_{xi,t}^{\left(\sigma_x - \frac{1}{\sigma_x}\right)} \right)^{\frac{\sigma_x}{(\sigma_x - 1)}} \text{where } i \in [1, R] \tag{4}$$

Where σ_x denotes the elasticity of substitution between varieties, $c(m)_{xi,\ t}$ is the quantity consumed of variety m in region$i$ at date t, and $n_{x,\ t}$ is the number of available varieties in the economy $(n_{x,t} = \sum_{i=1}^{R} n_{xi,t})$; consumers cannot import service varieties from othe regions. Therefore, the number of available y varieties in region i is the number of varieties produced within the region ($n_{yi,\ t}$) and $C_{yi,\ t}$ is:

$$C_{yi,t} = \left(\sum_{m'=1}^{n_{yi,t}} c\left(m'\right)_{yi,t}^{(\sigma_y - 1/\sigma_y)} \right)^{\sigma_y/\left(\sigma_y - 1\right)} \text{where } i \in [1, R] \tag{5}$$

It is assumed that all producers have the same profit-maximizing price, which is a constant markup over marginal cost, where $w_{i,\ t}$ denotes the wages of mobile workers in region i at time t, the price of a variety produced in region i is:

$$p_{xi,t} = \frac{\sigma_x}{\sigma_x - 1}\beta_x w_{i,t} \text{ y } p_{yi,t} = \frac{\sigma_y}{\sigma_y - 1}\beta_y w_{i,t}, \text{ where } i \in [1, R] \tag{6}$$

Free entry in each sector leads to zero-profits at equilibrium; therefore, using equations (2) and (6) and the equilibrium condition for each regional labor market, it is possible to derive the number of companies in each region:

$$n_{xi,t} = \frac{L^x_{i,t}}{\varepsilon_x \sigma_x} \text{ y } n_{yi,t} = \frac{L^y_{i,t}}{\varepsilon_y \sigma_y}, \text{ where } i \in [1, R] \quad (7)$$

If we take into account iceberg transport costs in shipping manufactured goods between regions, we assume that a fraction $\left(\tau_{ij} - 1\right) / \tau_{ij}$ of the goods is lost in transportation such that $\tau_{ij} > 1$ of the goods have to be exported from region *i* to deliver one unit to region *j*. This transport cost is assumed to be an increasing functioning of the distance between the two regions d_{ij}.

$$\tau_{ij} = \beta d^{\delta}_{ij} \curlyvee i, j \epsilon \left[1, R \right], \ \delta > 0 \text{ y } B > 0 \quad (8)$$

If the price of the traditional good is normalized to one, the real wage of mobile workers in region *i* is simply:

$$\omega_{i,t} = \frac{w_{i,t}}{P^{\phi}_{yi,t} P^{\mu}_{xi,t}}, \quad (9)$$

Where $P_{xi,\,t}$ (or $P_{yi,\,t}$) is the CES price index of the industrial goods in region *i*:

$$P_{xi,t} = \left[\sum_{r=1}^{R} \left(\sum_{m=1}^{n_{\lambda y,t}} \left(\tau_{ir} P_{xr,t} \right)^{1-\sigma_x} \right) \right]^{1/\left(1-\sigma_x\right)} = \left[\sum_{r=1}^{R} n_{xr,t} \left(B d^{\delta}_{ir} P_{xr,t} \right)^{1-\sigma_x} \right]^{1/\left(1-\sigma_x\right)}, \quad (10)$$

$$P_{yi,t} = \left(\sum_{m=1}^{n_{i,t}} p^{1-\sigma_y}_{yi,t} \right)^{1/\left(1-\sigma_y\right)} = n^{1/\left(1-\sigma_y\right)}_{yi,t} p_{yi,t}. \quad (11)$$

In (10), the price index of manufactured goods can be thought of as the inverse of a market potential function: it exhibits a comparable sum of market sizes in all regions weighted by distances. Therefore, its interpretation is simple. The price index is higher in remote regions where consumers have to import a large part of their demand from distant locations. Similarly, maintaining nominal wage constant, wages are lower in regions offering a relatively small number of services varieties. This price index effect makes regions with a high density of services and low-cost access to large manufacturing markets more attractive places to live. It is precisely the Hirschman-type forward linkage that contributes to the cumulative process of spatial agglomeration.

MIGRATION CHOICE

Crozet (2004) considers a mobile worker *k* from region *j* who has the choice to locate among *R* regions; the migration choice is the result of a comparison of the perceived quality of life in the various regions. As such, it is assumed that the migration choice is designated by the following objective function:

$$\pi^k_{ji,t} = V^k_{ji,t} + \varepsilon^k_i = ln\left[w_{i,t} P_{i,t-1} \left[d_{ij} \left(1 + bF_{ij}\right)\right]^{-\lambda} \right] + \varepsilon^k_i i \epsilon \left[1, R\right] \qquad (12)$$

Where P_{it} is the employment probability for an immigrant in region *i* at date *t* and $\left[d_{ij} \left(1 + bF_{ij}\right)\right]^{\lambda}$ is the migration cost, which increases with the distance between home and host regions, λ and *b* are strictly positive coefficients, and F_{ij} is a dummy variable indicating whether regions *i* and *j* do not share a common border, ε^k_i is a stochastic component capturing *k*'s personal perception of the characteristics of region *i.* Additionally, it is assumed that the migration choices at date *t* are determined from a comparison of π^k_{ji} across regions at date *t - 1*. Therefore, individual *k* will select to locate in region *i* if $V^k_{ji,t-1} > V^k_{jr,t-1}, \ \curlyvee r \neq i$; the probability of migration to region *i* is given by the logit function:

$$P\left(M_{ji,t}\right) = \frac{e^{V^k_{ij,t-1}}}{\sum_{t=1}^{R} e^{V^k_{jr,t-1}}}. \qquad (13)$$

The expected migration flow between regions *j* and *i* is $L_{j,t} P\left(M_{ij,t}\right)$. Similarly, the total outflow from *j* is $L_{j,t}\left[1 - P\left(M_{ij,t}\right)\right]$, the share of emigrants from region *j* that choose to go to region *i* is:

$$\frac{migr_{ji,t}}{\sum_{i' \neq j} migr_{ji',t}} = \frac{e^{V^k_{ji,t-1}}}{\sum_{r=1}^{R} e^{V^k_{jr,t-1}} - e^{V^k_{ji,t-1}}} \qquad (14)$$

Using equations (6), (7), (9), (10), and (11), and the definition of $V^{k}_{ji,t}$, the resulting proportion can be written as:

$$ln\left(\frac{migr_{ji,t}}{\sum_{i'\neq j} migr_{ji',t}}\right) = ln\left[\left(L^{y}_{i,t-1}\right)^{\phi/(\sigma_y-1)}\right] + ln\left[\left(\sum_{r=1}^{R} L^{x}_{r,t-1}\left(w_{rt-1} d^{\delta}_{ij}\right)^{1-\sigma_x}\right)^{\mu/(\sigma_x-1)}\right] + \tag{15}$$

$$ln\left[w^{1-\phi}_{i,t-1} p_{i,t-1}\right] + ln\left[d_{ij}\left(1 + bF_{ij}\right)\right]^{-\lambda} + \hat{a}_{j,t-1},$$

$$\text{With } \hat{a}_{j,t-1} = -\ln\left(\sum_{r=1}^{R} e^{V^{k}_{jr,t-1}} - e^{V^{k}_{ij,t-1}}\right)$$

The above equation captures the decision that potential migrants face when they have to choose among several regions; the left-hand side of equation (15) is the proportion of migrants from a given region who have decided to move to region *i.*On the right-hand side of the equation, the third term represents the expected wage in the region, which increases with the host region's nominal wage and the probability of being employed in this region. The fourth term captures the impact of bilateral distance on migration flows and is interpreted as a mobility cost. The first two terms denote region *i*'s access to markets; in other words, the price indices for non-traded service varieties and for manufactured goods in region *i.* The second term of equation (15) is the most important term in the equation. It corresponds to a market potential function and relates labor migration to the location of industrial activities and can therefore be seen as the forward linkage from the NEG model.

Crozet (2004) applies this approach to the study of bilateral regional migration flows for five countries in the European Union, using annual data from 1980 to the beginning of 1990. He found in this study that:

> …parameters defining the market potential function are all significant. In accordance with the NEG model's prediction, access to manufactured commodities do (*sic*) influence workers' mobility since it is measured by a grounded market potential function (Crozet, 2004: 452).

It is therefore possible to affirm that an increase in the price of the factors (wages) in higher-potential markets would mean that the degree to which the market potential increases also drives the migrant attraction factor. Even though this is a somewhat spatially limited effect, the incentives for workers in the home region to migrate to a central region are somewhat weakened as the distance between regions increases. In that sense, agglomeration forces have a local impact (Brakman *et al.,* 2009).

In accordance with Crozet (2004), equation (15) is related to a gravity equation. Besides nominal wages and employment probability, the migration flow between two regions increases with the size of the host region and decreases with the geographic distance between the two locations. Such a relationship is a reduced form of equation (15), which provides a good analysis about how migrants and companies access bigger regional markets. This gravity equation permits the specification of a model for the NEG framework.

This model shows that the central proposal of the NEG is very close to what is called a gravity equation. The model of interactions between the two regions from which the gravity equation is derived was initially developed by Stewart (1947, 1948), through an analogy with the Newtonian gravity model, finding a strong correlation for traffic, migration, and communication between the two locations, by means of the product in the sizes of the populations. This relationship is inversely tied to the distance of the square that exists between the two regions.

A similar procedure was applied by Tinbergen (1962) to international trade between two countries. This model is known as the "gravity model" for the international economy. The model has been applied in various manners to provide a strong theoretical basis for the gravity equation based on imperfect competition and trade costs.

There are a few econometric nuances in the empirical analysis of the consequences of institutional change for trade flows, caused by the endogeneity bias. One of the papers that has been influential in this sense was written by Anderson and Wincoop (2003) about the terms of multilateral price resistance (MPR). They estimated the gravity equation and calculated the impact of institutional changes; the MPR effects reflect the price indices, which are related to the central model; it is important to include these terms due to bilateral trade flows, *ceterisparibus,* they are determined not only by the bilateral prices between two trade partners, but also by the ratio of the price to the price index (aggregate). This ratio reflects the fact that the bilateral prices between two countries can display different effects on bilateral trade between two trade partners, depending on the price index level. If the "rest of the world" is far away, the high transport costs will be reflected in a higher price index. Bilateral trade between trading partners increases if the "rest of the world" is close by, where the transport cost will be reflected in lower price indices.

The main disadvantage of this approach is the need for a specific non-linear least squares model, because there is no explicit solution for the estimator, and to calculate it, iterative numerical methods are required, which make the estimation more complex (Cameron and Trivedi, 2009). One way to solve this problem is by using regional fixed effects in panel data estimates (Brakman *et al.,* 2009), because in the majority of microeconometric models, the use of linear functions is inappropriate, principally because they do not take into account the heterogeneity among individuals. The advantage of the panel model is that it provides a correct model of the individual effect and therefore produces valid inferences (Cameron and Trivedi, 2005).

It is necessary to prove that this centripetal force exists and that it is the cause of attracting migrant workers to the bigger markets. This is the hypothesis proposed in the NEG framework. To prove this, we must conduct an econometric estimate with panel data of the gravity equation and analyze whether or not this relationship exists; this approach is addressed in the next section.

EMPIRICAL EVIDENCE FOR THE DRIVERS OF INTERNAL MIGRATION IN MEXICO, 1990-2010

The estimate in (15) is done using a gravity equation. Crozet (2004) asserts that it is necessary to calculate a proxy variable that is related to the probability that an individual finds a job in the host region. This variable may be the regional employment rate (equal to one minus unemployment rate). This variable is possibly correlated with nominal wages because, according to Harris and Todaro (1970), migration persists up until the point at which expected real wages are equalized. In other words, there is a long-term positive relationship between real wages and unemployment rates. In the contrary case, in regions with low levels of amenities, or regions that are experiencing negative impacts, it is possible for lower wages and high unemployment rates to appear simultaneously (Blanchflower, 1994).

To avoid the latent problem of possible multicollinearity, it is necessary to consider the expected nominal wage as a single variable defined by the product of the nominal wage and the regional employment rate ($probw_{i,\,t}$) (Harris and Todaro, *op. cit*).

It is moreover necessary to consider the logarithm of the area of the host region ($\log(S_i)$) in order to control for the bias resulting from the inclusion of unequally-sized regions in the sample; therefore, the gravity equation to be estimated is:

$$log\left(\frac{migr_{ji,t}}{\sum_{i'\neq j} migr_{ji',t}}\right) = a_j + \beta_1 \log\left(L_{i,t}\right) + \beta_2 \log\left(probw_{i,t}\right) + \beta_3 log\left(d_{ij}\right) + \beta_4 F_{ij} + \beta_5 \log\left(S_i\right) + v_{ij,t} \qquad (16)$$

Where $L_{i,\,t}$ is total employment in region i, F_{ij} denotes the dummy variable of proximity, indicating that two entities do not share a common border, v_{ij} is the error term, and a_i is the set of regional fixed effects. A region is more attractive when the expected wages rise and less attractive as the distance from the home region increases; it is possible to estimate a gravity equation in which regional employment is divided into three types of industries (services, manufactured goods, and agriculture).

It is relevant to note that gravity equation (16) is a reduced version of equation (15) and allows us to establish the impact of the principal causal factors in an NEG model: market potential, wage differences, and the effect of distance. It also considers, in the fixed effects term, the non-quantifiable elements of migrants' perceptions of the host region (institutional factors, comforts, violence, etc.).

If the idea were to offer a more complete estimate of the model with equation (15), it would be necessary to add disaggregated information about production, prices, and jobs by economic sector (agriculture and livestock, manufacturing, and services) in order to conduct mathematical simulations to estimate the parameters of the elasticity of substitution among varieties of goods (σ_y and σ_x in equation 15) and the iceberg transport costs (δ in equation 15). In this case, the choice was made to leave aside for future research the estimation of equation (15), in order to focus on equation (16). This is because the non-linearity inherent to the model makes it difficult to obtain analytical solutions (Quintana and Lecumberri, 2013).

To prove the impact of the centripetal forces, the gravity equation (16) was estimated for bilateral migration flows among Mexico's 32 states, using data from the Population and Housing Census from 1990, 2000, and 2010, conducted by the National Statistics and Geography Institute (INEGI).

The census data provide enough information to calculate the variable of interstate migration flows, because if individuals report a prior residence outside of the state in which they are surveyed, they can be considered migrants. Information was also gathered about the portion of the population working in each of the 32 states, in order to calculate the total employment variable and the employment by sector of economic activity variable.

Unemployment rates for each state were calculated, using information about the people actively looking for a job but unable to find one. In addition, the census provided information about the monthly incomes of the residents of the 32 states, making it possible to estimate the expected wage variable ($probw_{i,\,t}$).

The gravity equation (16) requires estimating the bilateral distances between the 32 states, as these distances are related to transportation costs and, therefore, the choice to migrate. To do so, a proxy variable was used for the bilateral distance between two regions, measured as the highway distance between the state capital cities. This was calculated using the “point to point” route application provided by the Ministry of Communication and Transportation through the General

Office for Roadway Development.[2] This tool makes it possible to calculate the shortest distance between two cities because it considers both toll highways as well as freeways, making it possible to obtain kilometer distances among the 32 states.

The variable denoting the logarithm of the surface area of the host region ($\log(S_i)$) was obtained from the National Economic Geography Institute. The data were calculated in square kilometers for each state. The table with these data is shown below.

It is essential to clarify that this variable corrects for the bias among the surface dimensions in the states of Mexico. The state with the largest surface in square kilometers is Chihuahua, with 247,087 square kilometers, while the smallest region is Mexico City, with a mere 1,499 square kilometers (see Table 1).

Table 1. Territorial Surface Area of the Mexican States in Square Kilometers

State	*Km²*	*State*	*Km²*	*State*	*Km²*	*State*	*Km²*
Chihuahua	247087	Baja California Sur	73677	Sinaloa	58092	México	21461
Sonora	184934	Durango	73677	Campeche	51833	Hidalgo	20987
Coahuila	151571	Veracruz	72815	Quintana Roo	50350	Querértaro	11769
Oaxaca	95364	Baja California	70113	Yucatán	39340	Aguascalientes	5589
Jalisco	80137	Nuevo León	64555	Puebla	33919	Colima	5455
Tamaulipas	79829	Guerrero	63794	Guanajuato	30589	Morelos	4941
Zacatecas	75040	San Luis Potosí	62848	Nayarit	27621	Tlaxcala	3914
Chiapas	73887	Michoacán	59864	Tabasco	24661	Distrito Federal	1499

Source: Created by the authors based on INEGI data, 2012.

In Figure 1, it emerges that there are two states with extreme values for immigration from 1990 to 2010: the State of Mexico and Mexico City. It also appears that in 1990, a good share of immigration existed in the northern region of the country, which was drastically reduced by 2010, likely due to the violence in the region, which pushed people to move towards the central and southern regions of the country.[3]

(See Figure 1)

Looking at income, in Figure 2, it appears that in 1990, regions with income superior to the 75% interquartile range were located primarily in the north of the country. However, a notable decrease was observed in this region, with a corresponding increase in the central and southeastern regions of the country, by 2010.

(See Figure 2)

Although there is no perfect correlation between the states that receive the most immigration and wage levels, there is a positive relationship between the two. The correlation coefficient oscillated between 24% and 29% between 1990 and 2010.

Looking at market potential, represented by job creation, in the Figure 3 maps, we can observe that the relationship between immigration and number of jobs in 1990, 2000, and 2010 was positive and intense. The coefficients of the regression slope that indicates the correlation between the two variables ranged between 81% and 90% of the association. Mexico City and the State of Mexico are located in the upper right quadrant, as top destinations for migration.

(See Figure 3)

Equation (16) was estimated using a panel data econometric technique, which allows us to measure the data at different points in time for various individuals or units, such as: companies, people, countries, or, in this case, the bilateral migration flows among the 32 states. This regression can capture variations across units, similar to the cross-sectional data regression, as well as variations over time (Cameron and Trivedi, 2009).

The equation for the bilateral migration flows among the 32 states was estimated using the base panel built off of the information from the population and housing censuses in Mexico for the years 1990, 2000, and 2010 (that is, a migration matrix was estimated with 32 rows by 32 columns, not considering the diagonal flow of the matrix, because these individuals did not migrate). A balanced and short panel was estimated. The first estimate of the gravity equation that considers the total aggregate employment variable is presented in Table 2.

The panel model with random effects estimate was calculated considering robust standard errors, due to the potential presence of heteroscedasticity in the residuals. The random effects model was chosen because it was so indicated by the Hausman test. The statistic that resulted allowed us to accept the null hypothesis that the random effects are suitable for the estimation and therefore consistent estimators were obtained.

Table 2 shows that the coefficients had a statistical significance at 1% and displayed the expected signs in accordance with the NEG; moreover, the Wald statistic indicates that all of the β parameters are significant jointly; the goodness of fit (R^2) statistic between groups is higher than within, meaning that the use of the random effects model is suitable; there is also a high intra-group correlation, due to the value reported for the ρ statistic.

The distance variable ($log(d_{ij})$) presents a negative sign, meaning that distance has a negative impact on migration, a clear sign that Mexican workers are reluctant to move to very far away regions. This is principally because the costs of migration rise as distance increases. The proximity variable (F_{ij}, which is also related to the cost of migrating, presents a negative coefficient, meaning that migration flows fall considerably when it becomes necessary to cross more than one regional border. The greatest amount of migration takes place between neighboring states.

Table 2. Gravity Equation for the Random Effects Panel Model with Total Aggregate Employment, Dependent Variable: $\log(migr_{ji,t} / \sum_{i \neq j} migr_{ji',t})$

Variables	*Coefficient*	*P Value*
Total Employment $\log(L_{i,t})$	0.5022802***	0.000
Probable Wage $\log(probw_{i,t})$	0.0070714***	0.006
Distance $log(d_{ij})$	-0.551769***	0.000
Proximity F_{ij}	-1.525609***	0.000
Surface Area $\log(S_i)$	0.1133997***	0.001
Constant:	3.683155***	0.000
Wald Ji^2 (5)	840.55***	0.000
Number of obs.	2976	
Number of groups	992	
R^2		
Within	0.0034	
Between	0.4066	
General	0.3695	
σ^{α}	1.2089146	
σ^{ε}	0.63208997	
ρ	0.78531162	
Hausman Test	**Statistic**	**P Value**
Ji^2 (2)	0.94**	0.6253

Note: The null hypothesis of the Hausman test is that the individual effect behaves as a random effect; *statistical significance at 10%; **statistical significance at 5%; and ***statistical significance at 1%.

Source: Created by the authors based on data from INEGI and the Ministry of Communications and Transportation

The expected wage variable ($log(probw_{i,t})$) presents a positive sign, in keeping with the NEG theory. This means that there are significant regional inequalities, because the centripetal forces of attraction of these zones have an impact on migration. In other words, the regional differences in the industrial structure enhance the opportunities for workers from lagging regions (with low wages) to find jobs in a central region (with better wages) (Faini *et al.,* 1997).

The coefficient for the total employment variable ($log(L_{i,t})$) presents a positive sign, in keeping with the NEG theory. This result confirms that migration patterns are driven by the dynamics of centripetal forces, because market size influences migration flows. The larger the market, the bigger the migration flow destined for it.

Additionally, the gravity equation was estimated by taking into account the number of jobs per sector of primary, secondary, and tertiary economic activity. Similarly, a short and balanced panel was estimated, using the random effects model. This second version of the gravity equation (16) is presented below.

In Table 3, we observe that the coefficients are statistically significant. The manufacturing job variable is significant at 5%, while the rest were significant at 1%. The signs of the coefficients are all in keeping with the NEG theory. All of the regressors are significant jointly as indicated by the Wald statistic, and the Hausman test demonstrates evidence in favor of the random effects in the panel model.

This second estimate corroborates the results obtained in the first estimate, because once again both the distance variable ($log(d_{ij})$) and the proximity variable (F_{ij}) present negative signs. While the coefficient for expected wage ($log(probw_{i,\ t})$) had a positive sign, these results are in keeping with the NEG, and these interactions were already explained in the preceding paragraphs.

The coefficients for the manufacturing employment variable ($log(L^{x}_{i,t})$) and the services employment variable ($log(L^{y}_{i,t})$) are significant and have positive signs, also in keeping with the NEG framework. This result indicates that the positive influence of regional economy size is principally derived from manufacturing and service activities. In this sense, it is important to note that employment in the agricultural sector ($log(L^{z}_{i,t})$) displayed a significant and negative sign, due to the fact that the spatial distribution of the agricultural sector did not influence workers' location decisions. This behavior signals that workers move to obtain better access for the manufacturing sector, corroborating the price index effect, around which the NEG revolves, and enhancing the incentives to migrate to said regions.

Table 3. Gravity Equation for the Random Effects Panel Model with Total Disaggregate Employment, Dependent Variable: $\log(migr_{jit} / \sum_{i \neq j} migr_{ji't}$

Variables	*Coefficient*	*P Value*
Agricultural Employment $\log\left(L^{Z}_{i,t}\right)$	-0.241350***	0.000
Manufacturing Employment $\log\left(L^{X}_{i,t}\right)$	0.2157233**	0.011
Services Employment $\log\left(L^{Y}_{i,t}\right)$	0.3972818***	0.000
Probable Wage $\log\left(probw_{i,t}\right)$	0.0076489***	0.002
Distance $log\left(d_{ij}\right)$	-0.620483***	0.000
Proximity F_{ij}	-1.479775***	0.000
Surface Area $\log\left(S_{i}\right)$	0.2192565***	0.000
Constant:	5.039244***	0.000
Wald Ji² (5)	1205.05	0.000
Number of obs.	2976	
Number of groups	992	
R^2		
Within	0.0898	
Between	0.4582	
General	0.4251	
σ^{α}	1.121501	
σ^{ε}	0.59837276	
ρ	0.77840898	
Hausman Test	**Statistic**	**P Value**
Ji² (2)	4.72	0.0942**

Note: The null hypothesis of the Hausman test is that the individual effect behaves as a random effect; *statistical significance at 10%; **statistical significance at 5%; and ***statistical significance at 1%.

Source: Created by the authors based on data from INEGI and the Ministry of Communications and Transportation.

CONCLUSIONS

Migration is a phenomenon that responds primarily to economic factors and can basically be explained by income differences between zones with higher and lower wage levels, where migration from poorer to wealthier regions reinforces agglomeration patterns.

The concentration of companies in a single region offers an agglomeration of workers with specific industrial capacities, ensuring both a low likelihood of being unemployed and a low probability of labor shortages; under these conditions, it is more desirable to live and produce near a concentration of manufacturing production, because it is less expensive to purchase the goods these hubs provide. The resulting geography will be sensitive to the initial conditions. If one region has a slightly bigger population than another, transportation costs may fall below a critical level and that region will end up gaining population at the expense of another region.

The empirical evidence analyzed in this paper suggests that market access has a positive influence on the choice to migrate. In other words, a market with a lot of potential attracts production factors.

The empirical evidence in the Crozet (2004) model that estimates a gravity equation using the panel method validates the NEG hypothesis, because it proves that a market with high potential attracts production factors, in this case, the labor factor. In the estimate, it was found that the expected wage variable was a significant factor in the migration choice, which is a sign that there are major regional inequalities. The total employment coefficient was also positive and significant, confirming that migration patterns are induced by the dynamics of centripetal forces, in response to market size, which influences migration flows. In addition, the statistical significance at 1% of the distance and proximity variables with negative coefficients indicates that the effects of centripetal forces fade as distance increases. As a result, the migration choice considers the effect of distance due to its impact on cost.

The empirical evidence gathered in this paper indicates that migration is explained in large part by economic factors and, in Mexico, is the outcome of unequal development among regions.

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[2] Available at http://www.sectur.gob.mx/wb2/sectur/traza_tu_ruta_carretera

[3] According to the National Demographic Dynamics Survey (Enadid) 2014, 6.4% of Mexicans that moved to another state over the past five years did so due to public insecurity and violence.