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Miguel Flores , Mary Zey & Nazrul Hoque
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Economic Liberalization and Contemporary Determinants of Mexico's Internal Migration: An Application of Spatial Gravity Models

MIGUEL FLORES, MARY ZEY & NAZRUL HOQUE

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ABSTRACT *This paper examines the determinants of interstate migration flows in Mexico for the period between 1985 and 2005. The aim is to explore internal changes in the Mexican economy as a result of the impact of trade and financial liberalization to identify factors contributing to or deterring migration flows. Internal migration is modelled using extended spatial gravity models that are then properly estimated using Poisson estimation techniques. The findings suggest a structural break in terms of a reduction of interstate migration flows in the post-NAFTA period. The evidence suggests that much of this effect could be attributed to higher levels in the indicators of trade liberalization, which appear to also offset the expected effects of wage differentials.*

Libéralisation économique et déterminants contemporains de la migration interne au Mexique : une application de modèles à gravité spatiale

RÉSUMÉ *La présente communication se penche sur les facteurs déterminants des flux migratoires entre états, au Mexique, au cours de la période de 1985 à 2005. Son objet est l'examen de changements internes survenus dans l'économie du Mexique à la suite de l'impact de la libéralisation commerciale et financière, afin d'identifier des facteurs contribuant aux flux migratoires, ou les dissuadant. On procède à la modélisation de la migration interne en utilisant des modèles à gravité spatiale étendus, dont on effectue ensuite une estimation correcte, en appliquant les techniques d'estimation de poisson. Les résultats permettent d'en conclure une rupture structurelle sous forme d'une réduction des flux migratoires entre états au cours de la période post-NAFTA. Les documents à l'appui permettent d'affirmer que cet effet pourrait être attribué, dans une grande mesure, à des niveaux supérieurs dans les indicateurs de la libéralisation commerciale, qui semblent compenser, en outre, les effets imprévus des écarts salariaux.*

Miguel Flores (to whom correspondence should be sent), Institute for Demographic and Socioeconomic Research, University of Texas at San Antonio, 501 West Durango Blvd, Monterey Building, 4th Floor, San Antonio, TX 78249, USA. Email: miguel.flores@utsa.edu. Mary Zey, Department of Demography, University of Texas at San Antonio, San Antonio, TX, USA. Email: Mary.Zey@utsa.edu. Nazrul Hoque, Department of Demography, University of Texas at San Antonio, San Antonio, TX, USA. Email: Nazrul.Hoque@utsa.edu.

Liberalización económica y determinantes contemporáneos de la migración interna de Méjico: una aplicación de modelos de gravitación espacial

EXTRACTO *Este estudio examina la determinación de los flujos de migración interestatal de Méjico entre 1985 y 2005. El propósito es explorar los cambios internos en la economía mejicana como resultado del impacto de la liberalización comercial y financiera, para identificar factores que contribuyen a, u obstaculizan, los flujos de migración. La migración interna se modela utilizando modelos extendidos de gravitación espacial que luego se estiman apropiadamente aplicando técnicas de estimación de Poisson. Los descubrimientos apuntan hacia una ruptura estructural en términos de la reducción de los flujos de migración interestatal en el período post-NAFTA. La evidencia sugiere que gran parte de este efecto podría atribuirse a niveles más altos en los indicadores de liberalización comercial, que también parecen compensar los efectos esperados de los diferenciales de sueldos.*

经济自由化和墨西哥国内迁移的时代因素：空间引力模型的一个应用。

摘要：本文研究了1985到2005年间墨西哥州际迁移的影响因素。目的在于通过探索贸易和金融自由化对墨西哥经济内部变化的影响，找到促进或者抑制国内迁移的因素。先使用拓展的空间引力模型对国内迁移进行建模，然后使用泊松估计方法进行准确估计。结果发现国内迁移呈现结构性断层——在后NAFTA时代州际迁移减少。有证据表明，在很大程度上，更大的贸易自由度导致了这一现象，它似乎还改变了工资差异的预期效果。

KEYWORDS: *Internal migration; spatial gravity models; NAFTA; Poisson models*

JEL CLASSIFICATION: C21; R12; R23; O15

1. Introduction

Over the past three decades, Mexico has experienced the opening of its economy through the liberalization of trade. The process began in the late 1980s, culminating with the implementation of the North American Free Trade Agreement (NAFTA) in 1994, with the aim of gradually eliminating barriers to trade and to financial flows between the member countries (Canada, Mexico, and the United States). NAFTA represents a watershed in global trade policy, not just because of the size of the free trade area it created, but also because of the implications for foreign and domestic investment, labour markets (wages and employment), industrial concentration, and related policies, for each of the NAFTA partners (Ayhan Kose *et al.*, 2004).

As a result of economic liberalization, the internal structure of the Mexican economy was altered in terms of its composition, size, and the geographical location of industrial concentration. These changes have directly, and to some extent, differentially influenced regional socioeconomic development as a result of the allocation of important input factors, namely labour, capital, and land. It follows that the geographical outcomes for economic activity due to the effects of NAFTA, meaning essentially the occurrence of regions of industrial concentration, will also have established poles of attraction for population mobility within the country. Internal migration is an important channel whereby people respond to economic changes, with direct implications for both short- and long-term regional economic growth.

In studying the contemporary determinants of internal migration in Mexico there are three major developments that will be of particular interest to scholars in different areas of the social sciences. First, the once massive migration of large portions of the Mexican population from rural to urban areas has declined in importance, with most recent migration going from medium-sized cities to urban and large metropolitan areas within the country (CONAPO, 2009). These changes have received little systematic quantitative analysis. Second, some regions within Mexico have been disproportionately exposed to international trade and foreign direct investment (FDI), with direct implications upon local labour markets. The extent to which trade variables have contributed to or deterred internal migration and the mechanisms associated with it are questions explored in this study. Third, the cost of migrating to the United States has increased considerably since US laws were strengthened to eliminate illegal migration. Increased enforcement has reduced the stream of illegal migration, while increasing the cost incurred by would-be migrants (Orrenius, 2001). Nowadays, potential migrants are less likely to come from the most deprived areas of the country where there are few resources, a development that is particularly important for rural migrants who face the most serious financial constraints and who now prefer to initially migrate internally in order to obtain the necessary economic resources prior to eventually crossing the border.

In line with Aroca & Maloney (2005), our focus is on the role of trade liberalization variables as possible push or pull factors for internal migrants occurring around the time of the enactment of the NAFTA agreement. However, the present analysis extends their study in two ways. First, we analyse panel data by considering two additional periods, 1985–1990 and 2000–2005, thus allowing us to analyse the pre- and post-NAFTA determinants of internal migration. This will help us to see whether economic liberalization has not only played a major role in restructuring the economy, but also has had an effect on population mobility across Mexico. Second, spatial gravity models which analyze origin–destination interstate migration flows are estimated using Poisson estimation techniques, which are appropriate given the nature of the data and the potential for unreliable estimates.

Recent migration patterns are shown in Figures 1 and 2. Figure 1 shows the total number of migrants for each of our periods. Internal migration flows were at their highest total during 1995–2000, when approximately 3.5 million Mexicans changed their state of residence. This represented a slight increase of 3% from 1985 to 1990. By 2005, roughly 2.4 million people were reported as being internal migrants, which is a reduction of approximately 32% compared to the previous period. The cumulative net interstate migration in each Mexican state for these three periods is shown in Figure 2. As illustrated, the states of Baja California Norte, Tamaulipas, Estado de Mexico, and Quintana Roo have the highest concentration of internal in-migration flows, while Distrito Federal (Mexico City), Veracruz, Guerrero, Oaxaca, and Chiapas show the highest internal out-migration flows.

2. How Does Trade Liberalization Affect Internal Migration?

The question of whether trade and migration are complements or substitutes has been the focus of much research and has become a major topic of debate in developing countries. Although the impact of economic liberalization on migration

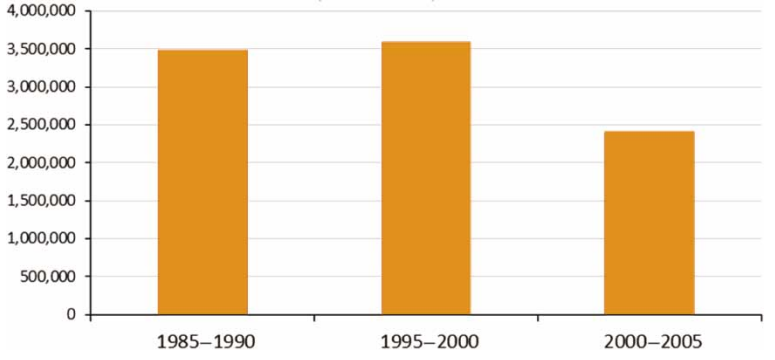

Figure 1. Total interstate migrants in Mexico, 1985–1990, 1995–2000, and 2000–2005.

could be studied from different perspectives, here we are focussing on the role of labour market variables (wages and employment) as mediating mechanisms as well as considering their effects on the financial constraints experienced by potential migrants.

From the seminal work of Todaro (1980) it can be argued that people's motivation to migrate is directly associated with positive expected wage difference between places of origin and destination. However, credit or financial constraints may prevent some individuals from migrating even in the presence of positive net effects from migration. This is a particularly strong deterrent for the poorest strata of the population who have limited resources and who are unable to save or borrow to finance migration.

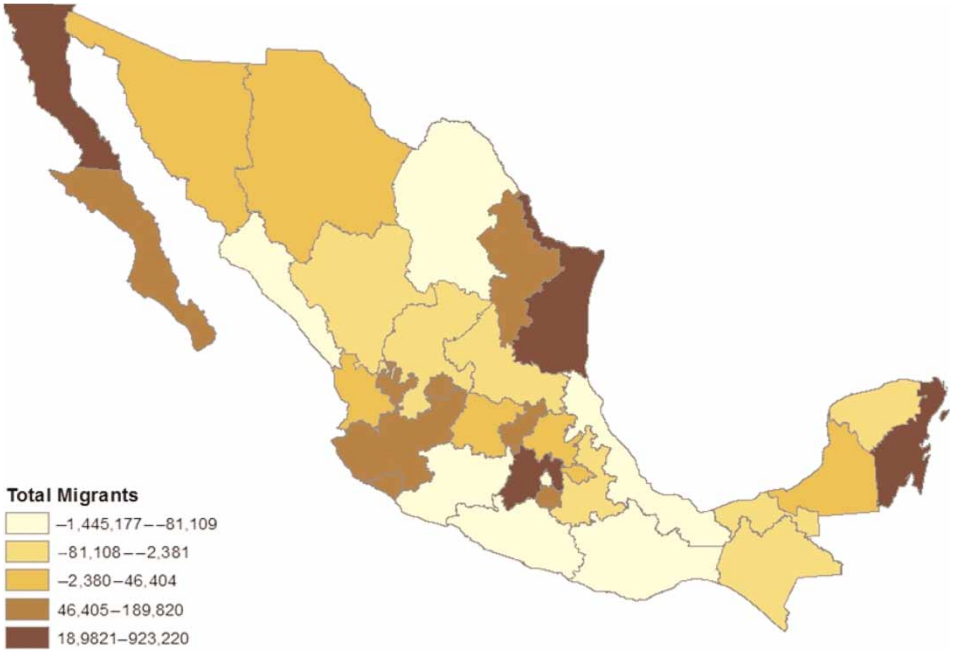

Figure 2. Cumulative net interstate migration, 1985–2005.

The classical Hecksher–Ohlin (H–O) model states that factor endowment differences create trade incentives, which in turn lead to factor price equalization. This means that the price of capital and labour will converge across countries as trade takes place. In other words, international trade leads to a convergence in wages, thus creating no incentives for people to migrate. However the proposition that trade equalizes factor prices will not hold if countries have, as in the real world, either different technologies of production or factor endowments (Krugman & Obstfeld, 1999) and, as a consequence, differences in wages and the returns to capital may continue to be maintained across countries, and the resulting cross-country differences in wages could then generate migration.

In analyzing internal changes in labour market outcomes, evidence suggests that Mexico's inter-regional wage differentials have increased following the economic liberalization associated with NAFTA (Hanson, 2003; Airola & Juhn, 2005; Chiquiar, 2008), and several different explanations, from different theoretical perspectives, have been proposed to explain this increase in regional wage inequality. Some authors have argued that the widening relative wages gap is the result of skill-biased technological changes that have created an increase in the demand for skilled workers but not for unskilled workers. The consequence is that unskilled workers are more likely to migrate (Markusen & Venables, 1997; Hanson, 2003).

In contrast, the 'new-economic geography' literature has attributed widening wage differentials to the increasingly uneven distribution of economic activity across regions in Mexico after NAFTA. This theory focuses on the importance of a region's 'market access', leading to a more competitive position for international trade in those states or regions with lower transportation costs (Fujita *et al.*, 2001). Evidence from research on Mexico suggests that trade reforms altered the geographic agglomeration of manufacturing firms looking to gain 'market access', encouraging the relocation of manufacturing away from the capital (Mexico City) to the US border region. From this perspective it is reasonable to suppose that economic liberalization, via geographic agglomeration, will have increased migration from central or southern parts of Mexico to the US border region.

An additional theory focuses on the effect of trade on financial constraints experienced by potential migrants and hence on migration patterns. If trade liberalization increases the level of wages, then the financial constraints will be relaxed and, consequently, migration will increase. In this context, López & Schiff (1998) developed a theoretical framework that incorporates migration costs and credit constraints with the aim of establishing the conditions under which trade liberalization is likely to affect out-migration. They show that trade and the migration of unskilled workers are complements but that a substitution effect is present for the more skilled part of the labour force.

An empirical study by Aroca & Malloney (2005) analyzed the impact of trade-related variables such as FDI and *maquiladora*[1] value-added factors on internal migration in Mexico. They were interested in examining the role of trade variables with a relaxation of credit constraints, which has the outcome of positively affecting internal migration flows. Their findings suggest a substitutability relationship between trade and migration. They also highlight an overall deterrent effect of trade variables on internal migration, which appears to work through labour market variables, such as household earnings and employment levels.

However, analyses of Brazilian data show mixed results for the relationship between free trade and migration. For example, Aguayo-Tellez *et al.* (2008)

explored the role of multinational enterprises and found that migrants were attracted by the growth of employment opportunities in the states with high concentrations of foreign-owned establishments. However, Kovak (2008) found a negative effect on labour demand with consequent decreases in regional wage levels. More recently, Hering & Paillacar (2009) found a positive effect on attracting migrants to states with a high level of access to international markets.

In the present study, we focus on the link between the economic restructuring process in Mexico due to NAFTA and internal movements of migrants. It seeks to explain the determinants of interstate migration flows for the period of 1985–2005, aiming to tie changes in the law (NAFTA) to internal shifts in Mexico's economy, as depicted in factors such as wage differentials, employment opportunities, FDI, and geographic industrial concentration. While one might expect trade variables to be associated with increased migration by means of a relaxation of financial constraints, the overall effect is unknown *a priori*. As discussed above, the mediating effects of higher wages and employment composition due to regional exposure to trade in the origin states may offset the effect of financial constraints, particularly in the states from which migration originates. Hence, we develop a series of hypotheses to be tested.

(a) The relative wage differentials among states are positively related to internal migration flows.
(b) Foreign direct investment acts as a deterring factor (negative association) for interstate out-migration.
(c) The maquiladora value-added experienced in Mexican states deters (negative association) out-migration.
(d) Relative specialization in the manufacturing sector attracts (positive association) internal migrants.

3. Estimation of the Spatial Gravity Models

3.1. Modelling Origin–Destination Migration Flows

Our data comprise origin–destination bidirectional flows between Mexican states. The model typically used for such data is a modified gravity-type model of migration, relating migration flows between origins and destinations to the distance between them (Wilson, 1970; Foot & Milne, 1984). A theoretical microeconomic foundation for these types of model can be found in earlier studies, such as Niedercorn & Bechdolt (1969), who provided a formal derivation of gravity models based on utility maximization. More recent analyses, such as Letouzé *et al.* (2009), reaffirmed the appropriateness of these models for migration analysis.

As is well known, in its most basic formulation, the gravity model takes the number of people M_{ij} moving from region i to region j to be directly proportional to the population size in each of the other possible regions, P_i and P_j, and as inversely proportional to the distance between the two regions, D_{ij}:

$$M_{ij} = k^{\beta_0} \frac{P_i^{\beta_1} P_j^{\beta_2}}{D_{ij}^{\delta}} \tag{1}$$

where k is a constant and βs are the parameters to be estimated. Distance (D_{ij}) is usually used as a proxy to measure all the costs that are unspecified but are believed to affect migration flows over distance and δ is the parameter to be estimated.

Extending the basic gravity model to include social, economic, and non-economic factors (push and pull factors) leads to a more general model; typically one takes logs on both sides of Equation (1) and adds a vector of variables $z(.)$ to account for the labour market and other attributes at origin and destination. The specification then becomes:

$$m_{ij} = \beta_0 + \beta_1 p_i + \beta_2 p_j - \delta d_{ij} + \gamma z(.) + \varepsilon_{ij} \tag{2}$$

where the lowercase variables in Equation (2) represent logs and ε_{ij} denotes the error term.

The empirical estimation of Equation (2) via Ordinary Least Squares (OLS) leads to concerns about the appropriateness of OLS for migration data in which the numbers of migrants are integer values that cannot ever be negative. One should make these restrictions explicit in the model set-up by means of an appropriate probability distribution such as the Poisson. In addition, the error terms in the usual log linear specification of the gravity equation tend to show heteroskedasticity, as pointed out by Santos Silva & Tenreyro (2006). In the presence of heteroskedasticity, the parameter estimates obtained through OLS may be biased and inefficient (Flowerdew & Aitkin, 1982; Westerlund & Wilhelmsson, 2009). Ignoring this issue may result in misleading hypothesis testing and incorrect findings from the estimated model.

A well-known response to these issues (see for example Santos Silva & Tenreyro, 2006) is by means of Poisson regression. The assumption here is that migration flows from state i and j have a Poisson distribution with a conditional mean (μ) that is a function of a set of independent variables. Formally, this is specified as follows:

$$\Pr\left[I_{ij}\right] = \frac{\exp\left(-\mu_{ij}\right)\mu_{ij}^{I_{ij}}}{I_{ij}!}, \left(I_{ij} = 0, 1, \ldots\right) \tag{3}$$

Note that the conditional mean, μ_{ij} is linked to an exponential function of X_{ij}, the set of the independent variables:

$$\mu_{ij} = \exp\left(\alpha_0 + \beta' X_{ij} + \delta d_{ij} + \lambda_i + \eta_j\right) \tag{4}$$

where α_0 is a proportionality constant, X_{ij} is a row vector of explanatory variables with corresponding parameter vector β, δ denotes the parameter related to distance, λ_i is the state of origin fixed effect, and η_j is the corresponding state of destination effect. The resulting specification can then be estimated using a Poisson pseudo-maximum likelihood (PPML) estimator.

However it is also well known that the standard Poisson model is vulnerable to overdispersion and excess-of-zero migration flows, and not correcting for over-dispersion typically leads to consistent but inefficient estimation of the model

parameters. In order to correct for overdispersion, a negative binomial regression model (Equation (5)) is most frequently used (Burger *et al.*, 2009), in which

$$\Pr\left[I_{ij}\right] = \frac{\Gamma\left(I_{ij} + \alpha^{-1}\right)}{I_{ij}!\Gamma(\alpha^{-1})}\left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_{ij}}\right)^{\alpha^{-1}}\left(\frac{\mu_{ij}}{\alpha^{-1} + \mu_{ij}}\right)^{I_{ij}} \tag{5}$$

where $\mu_{ij}=\exp(\alpha_0+\beta' X_{ij}+\delta d_{ij}+\lambda_i+\eta_j)$, Γ is the gamma function, and α is the parameter that determines the degree of dispersion in predictions, thereby allowing the conditional variance to exceed the conditional mean.

3.2. Data

The interstate migration data were drawn from the General Census of Population and Household for 1990 and 2000 and from the National Count of Population for 2005. Interstate migration is determined by looking at the population aged five and older that, by the time of the interview, were living in a different Mexican state than where the respondents were living five years prior. A panel data set for the 32 Mexican states covering the periods 1985–1990, 1995–2000, and 2000–2005 was created and these data resulted in a matrix of migration flows from state *i* to state *j* of 2,976 observations.[2]

3.2.1. Spatial gravity model variables. The standard variables in gravity models are distance and population size. The origin population size (P_{it}) represents the pool of potential migrants, where larger states are likely to contribute more migration. However, destination population size (P_{jt}) may also be a proxy for attraction of potential migrants (Greenwood, 1997). Consequently, state population size is included in the regression models with the expected positive signs, the former acting as a push factor and the latter as a pull factor for migration flows. The distance between each origin–destination is often included as a proxy for costs of moving. The costs include transportation costs, moving costs, opportunity costs, and other costs related to migration (Aroca & Maloney, 2005). The distance ($DIST_{ij}$) between states *i* and *j* is measured as the kilometre distance between the capitals of each pair of states. In general, the literature considers the distance as a 'decay' factor, where it is hypothesized that the greater the distance between *i* and *j*, the higher the costs associated with moving, and these costs negatively affect migration. Thus, we expect distance (spatial gravity) to negatively impact migration flows.

The simple version of the gravity models is extended by adding two variables accounting for migration networks and contiguity effects into the analysis. The importance of social networks is well recognized in the migration literature. As Lucas (1997, p. 743) states, persons having access to kinship and other networks at a destination are more likely to choose that place. Migration networks can also facilitate a shorter adjustment or assimilation period for newcomers at the destination and thus lowering the migration cost. Hence, the stock of internal migrants ($MSTOCK_{ijt}$) includes persons that have migrated from state *i* to state *j* prior to the beginning of each of the periods considered. It is expected that migration network variables will be positively associated with migration flows between origin and destination places. Contiguity effects may have an associated impact on interstate migration, since many of the flows are between contiguous

states. This is because migrants may have moved over short distances between neighbouring areas and geographical distance has little relevance for such moves (Herting *et al.*, 1997). Hence, we introduce a dummy variable ($CONT_{ij}$) representing a common border among states, and it might be expected to have a positive effect on migration flows.

3.2.2. Labour market variables. One of the challenges of the empirical analysis was to gather data for the independent variables for each of the 32 states, particularly for the years prior to 1990. Specifically, information on labour market variables, such as wages and unemployment rates, is not available for each state. Although the National Survey of Urban Employment (ENEU by its acronym in Spanish) is usually used for generating this type of information, the early years of this survey include a sample of cities but not for all states. In order to be able to work with balanced panel data, we use the 1990 General Census of Population and Housing to estimate comparable measures of wages, unemployment rates, and relative industrial specialization in the manufacturing sector to run the analysis for the entire period.

The main argument of the neoclassical economic theory of migration is that populations tend to migrate from areas with low wages and high unemployment rates to areas with high wages and low unemployment rates (Todaro, 1980). Higher average wages in destination states are expected to act as a pull factor for migrants, while higher wages in origin states are expected to deter out-migration. The unemployment rate is commonly included to identify the relative impact of unemployment on the size and composition of migration flows (Karemera *et al.*, 2000).

Nonetheless, not only are absolute wages in origin and destination regions substantively significant, but so are relative wages between origin and destination regions. According to the relative deprivation hypothesis, household members undertake migration not necessarily to increase their household's income but rather to improve their household's position (in terms of relative deprivation) with respect to a specific reference group (Stark & Taylor, 1991, p. 41). Hence, differences in relative levels are expected to have greater statistical significance in predicting migration patterns. In keeping with the work of Aroca & Maloney (2005), relative wages and relative unemployment rates are modelled by taking the differences between the log forms in the destination and origin states: $RELWAGE_t = \log(WAGE_{jt}) - \log(WAGE_{it})$; and $RELUNEMP_t = \log(UNEMP_{jt}) - \log(UNEMP_{it})$. The regressions also include wages and unemployment rates in origin states (both in log form) to control for labour market conditions. It is then expected that internal migration flows will be positively associated with higher relative wages, while negatively associated with higher wages in origin states. Furthermore, migration flows are expected to be negatively related to destination areas with high relative levels of unemployment and positively related to origins with high levels of unemployment.

3.2.3. Disamenities. The inclusion of amenities variables in empirical migration models is believed to account for the attributes of a location that a resident or potential migrant would be willing to pay for but cannot be directly traded in markets (Randall, 1987). In the economics literature, amenities are those public goods that can only be enjoyed by being present in a particular location. By their nature, amenities propitiate externalities. Whether externalities are positive or negative depends on the type of amenities in question. For example, locations with socioeconomic indicators of poor resources—such as a lack of access to clean water, poor housing conditions, or a lack of electricity—are likely to generate negative

externalities. This is the case of disamenities, which generate an intrinsic cost for potential migrants either moving in or out.

In the case of Mexico, differences in the level of regional economic development have long been recognized, where the southern region has been historically associated with high levels of poverty and with a lack of socioeconomic development in general. This analysis includes a proxy variable for disamenities in origin and destination states using the level of marginalization ($MARG_{it}$, $MARG_{jt}$) as calculated by the CONAPO (1994, 2001, 2006) for the years 1990, 2000, and 2005. The index is calculated through a principal component analysis that uses several variables: the percentage of illiteracy for populations older than 15; the percentage of population older than 15 without an elementary school education; and the percentage of population living in dwellings without toilets, electricity, or access to water and with some level of overcrowding, with an earthen floor, in localities with less than 5,000 inhabitants, and with a total income lower than two minimum wages.

3.2.4. Trade liberalization variables. The main goal of this research is to investigate the extent to which economic liberalization has affected internal migration flows in Mexico. As stated earlier, the focus of the analysis is on three variables: FDI, maquila value-added, and the relative industrial specialization (concentration) in the manufacturing sector. Foreign direct investment (FDI_{it}, FDI_{jt}) is measured as the total flow of investment (in millions of dollars) received by each state in 1990 and the average of the periods 1991–1995 and 1996–2000. Following Aroca & Maloney (2005), a dummy variable (Mexico City) for the capital state of Mexico is included in the regressions in order to control for the possible bias in FDI flows, since firms tend to register investment in the location of their headquarters, which are greatly concentrated in Mexico City.

The maquiladora value-added ($VAMAQ_{it}$, $VAMAQ_{jt}$) is a proxy for state-level exports, given that maquiladora firms are mainly exporters (Aroca & Maloney, 2005). The data were gathered for the year 1990, the 1991–1995 average values, and the average values for the years 1996–2000. Unfortunately, these data are available for only 17 of the 32 states. To avoid the issue of potential selection bias, regressions were run with a restricted sample of 816 observations. As in the case of FDI, maquiladora value-added is expected to be negatively associated with interstate migration flows.

The level of industrial concentration is associated with internal structural changes in states' employment composition. For example, the manufacturing sector increased its total employment, particularly in northern states. This may generate an intrinsic pull factor for newcomer workers to the states with higher levels of industrial concentration. To empirically assess the effects of industrial concentrations upon migration flows, manufacturing sector location quotient coefficients in origin and destination states ($LQMAN_{it}$; $LQMAN_{jt}$) are calculated, thus measuring a region's employment share relative to the national employment share and identifying type-varying patterns of employment concentration. Specifically, the location quotient in manufacturing for each state is calculated as follows:

$$LQMAN_{it} = \frac{L_{mS}/L_S}{L_{mN}/L_N} \tag{6}$$

where L_{mS} denotes manufacturing employment in state S, L_S is the total employment in state S, L_{mN} represents the national manufacturing employment, and L_N denotes

the total national employment. It is expected that higher levels of industrial specialization act are positively associated with internal migration flows.

Table 1 provides a description of the study variables, operational definitions, and data sources. Table 2 provides the descriptive statistics of the variables included in the estimated models. Notice that the distribution of the total internal migrants and the rest of the variables are symmetric between all origin states, *i,* and all destination states, *j*. That is, in a closed internal migration system, all origin states will eventually serve as destination states. Thus, each of the variables for states *i* and *j* shows the same numerical values.

4. Results

As discussed above, the estimation of spatial gravity models through PPML regression models may suffer from overdispersion caused by the presence of

Table 1. Description of the variables and source

	Description	Source
M_{ij}	Measured as the gross aggregate migration flow from origin state *i* to destination state *j*	Census of Population and Housing for 1990 and 2000; and Count of Population and Housing for 2005
P_i, P_j	Total population in state in origin state *i* and state *j*	Census of Population and Housing for 1990 and 2000; and Count of Population and Housing for 2005
$DIST_{ij}$	Measured as the distance (kilometre) between state *i* and state *j*	Guia Roji (1995)
MSTOCK	Migrants stock of residents of state *j* living in state *i* five years before the period under consideration	Census of Population and Housing for 1990 and 2000; and Count of Population and Housing for 2005
CONT	Dummy variable (common border = 1, otherwise = 0)	
$AVWAGE_i$, $AVWAGE_j$	Measured as the average wage for the occupied population 14 years and older in state *i* and *j*	Own calculation with data from the Census of Population and Housing for 1990, Encuesta Nacional de Empleo Urbano for 2000; and Encuesta Nacional de Ocupacion y Empleo, for 2005
$UNEMP_i$, $UNEMP_j$	Percentage of total workforce who are unemployed but are looking for a paid job	Own calculation with data from the Census of Population and Housing for 1990, Encuesta Nacional de Empleo Urbano for 2000; and Encuesta Nacional de Ocupacion y Empleo, for 2005
$MARG_i$, $MARG_j$	Marginalization index in states *i* and *j*	Consejo Nacional de Poblacion, 1990, 2000, 2005
FDI_i, FDI_j	Foreign direct investment in states *i* and *j*	Secretaria de Economía, Dirección General de Inversión Extranjera
$LQMAN_i$, $LQMAN_j$	Location quotient in the manufacturing sector for states *i* and *j*	Own calculation with data from the Encuesta Nacional de Empleo Urbano for 1995 and 2000; and Encuesta Nacional de Ocupación y Empleo, for 2005
$VAMAQ_i$, $VAMAQ_j$	Maquiladora value-added in state *i* and *j*	Consejo Nacional de la Industria Maquiladora y Manufacturera de Exportación, AC
Mexico City	Dummy variable (Distrito Federal = 1, otherwise = 0)	
Post-NAFTA	Dummy variable (years: 1995–2005 = 1, otherwise = 0)	

Table 2. Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
M_{ij}	3,011.19	13,507.31	10	448,546
POP_i	3,136,669.00	2,869,117	424,041	1.40E + 07
POP_j	3,136,669.00	2,869,117	424,041	1.40E + 07
$DIST_{ij}$	1,284.71	1,030.34	37	5,680.10
$MSTOCK_i$	8.97	21.624	0.13	521.25
CONT	0.13	0.33	0	1
$MARG_i$	−1.526E-07	0.984	−1.688	2.412
$MARG_j$	−1.526E-07	0.984	−1.688	2.412
$AVWAGE_i$	17.84	5.55	8.10	32.90
$AVWAGE_j$	17.84	5.55	8.10	32.90
$UNEMP_i$	2.04	1.19	0.70	5.50
$UNEMP_j$	2.04	1.19	0.70	5.50
FDI_i	395.06	1,611.9	0.1	14,569
FDI_j	395.06	1,611.9	0.1	14,569
$VAMAN_i$	1,193.13	1,804.35	1.0	6,808
$VAMAN_j$	1,193.13	1,804.35	1.0	6,808
$LQMAN_i$	0.98	0.05	0.83	1.08
$LQMAN_j$	0.98	0.05	0.83	1.08
Mexico City	0.06	0.24	0.00	1.00
Post-NAFTA	0.67	0.47	0.00	1.00

unobserved heterogeneity. This issue is addressed by comparing PPML with Negative Binomial Pseudo-Maximum Likelihood (NBPML) regression models; the latter is a modified Poisson model (Burger *et al.*, 2009, p. 173). To determine which type of regression models are most appropriate for the data, several models were tested, obtaining their respective likelihood ratio test of overdispersion (α).

In addition to the likelihood ratio test displayed in Table 3, three goodness-of-fit statistics are provided: the Akaike Information Criterion (AIC), the Bayesian Information Criterion (BIC), and the S&J goodness-of-fit statistic (Stavins & Jaffe, 1990). To facilitate comparison between the models, a full model specification for each of the trade liberalization variables, *FDI*, *LQMAN*, and *VAMAN*, was also examined. The results clearly indicate the presence of overdispersion in all of the PPML models since the α-statistics obtained from the negative binomial regressions are significantly different from zero. The results from the AIC, BIC, and S&J goodness-of-fit tests also tend to favour NBPML over PPML. Thus, the description of the results relies on the NBPML regression models described next.

The first set of results is shown in Table 4. Several regression specifications are presented that predict migration as a function of different groups of variables. Model 1 is the baseline model, which includes the extended spatial gravity variables and labour market variables. Model 2 adds the marginality index variable at origin and destination locations. Models 3a, 3b through 5a, 5b show the regression results associated with economic liberalization variables. Note that Models 3a, 4a, and 5a show the results when the specification considers two groups of variables, extended gravity and trade variables, but excludes labour market variables, while models 3b, 4b, and 5b show the results for the full model.

For each estimated model the AIC, BIC, and S&J goodness-of-fit statistics are reported. Cluster-robust standard errors are reported in parentheses under the coefficients to which they refer. Finally, the models also control for origin and destination fixed effects in order to account for inadvertently omitted variable bias, which in turn contributes to consistent parameters-of-interest estimation thus

Table 3. Statistics for comparison between PPML and NBPML models

	I[a]		II[b]		III[c]	
	PPML	NBPML	PPML	NBMPLE	PPML	NBPML
Overdispersion (α)		7.8**		6.8**		2.4**
−2 log pseudo-likelihood	−3,619,210	−48,396	−3,084,642	−48,051	−1,139,096	−14,153
AIC	7,238,458	48,432	6,169,322	48,087	−2,278,223	14,083
BIC	7,238,572	48,540	6,169,436	48,195	−2,278,298	14,158
S&J goodness-of-fit	0.66	0.73	0.68	0.75	0.70	0.70

Notes: *$p<0.05$; **$p<0.01$.

[a] Estimates correspond to the full model and *FDI*, controlling for origin–destination fixed effects (N=2,976).

[b] Estimates correspond to the full model and *LQMAN*, controlling for origin–destination fixed effects (N=2,976).

[c] Estimates correspond to the full model and *VAMAQ*, controlling for origin–destination fixed effects (N=816).

producing a proxy to satisfy the constraints on total state-specific inflow and outflow of migrants.[3]

4.1. Extended Gravity Variables

In the baseline specification of the extended gravity models (Model 1a), the estimated coefficients show the expected effects and significance levels, with the exception of the stock of former migrants. Specifically, both origin and destination population variables are positively associated with migration flows; nonetheless, the origin population seems to have stronger effects, since its coefficient is higher in magnitude than that of the destination population. The distance between states acts as a deterrent to migration, and its effects remain significant across models. Contrary to previous research that found positive effects of social networks due to earlier migration, no network effects were found in any of these models. This finding challenges the basic argument that a social connection with a former migrant at a particular destination is an important factor in facilitating future migration (Massey *et al.*, 1994). The argument of Massey and associates regarding the positive effects of networks on international Mexican migration may not apply to our study of internal migration.

The contiguity variable was included to control for the effects of short-distance migration flows between neighbouring states, where the dynamics upon the whole migratory system may be distinct from a distance effect. As expected, this variable is significant and positive across all the extended gravity models. This indicates that migration mobility among neighbouring states is particularly important in depicting the probability of interstate migration.

4.2. Labour Market Variables and Deprived Conditions

When labour market variables were added to the baseline model, relative wages between origin and destination states stands out as the most important (see Model 1). As expected, the results show a significant and positive effect on the probability of migration due to relative wages, while higher wages at places of origin deter migration. The findings indicate that if the relative wages between states increase by 10%, the probability of interstate migration increases by approximately 13%. However, this later effect does not hold for other specifications. That is, when the

Table 4. Negative binomial PML results for internal migration flows, 1985–2005

			Trade liberalization variables					
			Foreign Direct Investment		Value added of Maquiladoras (reduced sample)		Relative Specialization Manufacturing	
	1	2	3a	3b	4a	4b	5a	5b
P_i	0.944**	0.968**	0.865**	0.859**	0.699**	0.676**	0.987**	1.061**
	(0.0370)	(0.0371)	(0.0514)	(0.0546)	(0.1241)	(0.118)	(0.0511)	(0.0500)
P_j	0.548**	0.600**	0.388**	0.661**	0.541**	0.493**	0.498**	0.744**
	(0.0993)	(0.1052)	(0.1272)	(0.1123)	(0.1677)	(0.1684)	(0.1441)	(0.1004)
$DIST_{ij}$	−0.317**	−0.290**	−0.176*	−0.383**	−0.365**	−0.520**	−0.223*	−0.333**
	(0.0743)	(0.0841)	(0.0870)	(0.0848)	(0.1294)	(0.1027)	(0.0966)	(0.0767)
$MSTOCK_{ij}$	0.056	0.069	0.038	0.017	−0.007	−0.012	−0.371	−0.013
	(0.0838)	(0.0762)	(0.0999)	(0.0709)	(0.1539)	(0.133)	(0.0963)	(0.066)
$CONT_{ij}$	1.528**	1.555**	1.681**	1.578**	1.482**	1.390**	1.665**	1.583**
	(0.0980)	(0.0921)	(0.0937)	(0.089)	(0.1850)	(0.1755)	(0.1124)	(0.0881)
RELWAGE	1.325**	0.331		0.371		0.415		0.292
	(0.2851)	(0.3845)		(0.4084)		(0.551)		(−0.389)
$WAGE_i$	−0.875**	−0.049*		0.194		0.148		−0.272**
	(0.2099)	(0.1562)		(0.1779)		(0.2623)		(0.1327)
RELUNEMP	−0.404	−0.769**		−0.760**		−0.549		−0.663**
	(0.2809)	(0.2568)		(0.2483)		(0.3195)		(0.2136)
$UNEMP_i$	−0.522*	−1.079**		−1.075**		−0.841*		−0.885**
	(0.2860)	(0.2738)		(0.2676)		(0.2836)		(0.2303)
$MARG_i$		−0.087		−0.019		−0.543**		−0.328**
		(0.0823)		(0.0861)		(0.1502)		(0.0822)
$MARG_j$		−0.460**		−0.500**		−0.467**		−0.631**
		(0.098)		(0.0865)		(0.2393)		(0.1198)
Relative FDI			0.153**	−0.024**				
			(0.0365)	(0.0345)				
FDI_i			0.079**	−0.060**				
			(0.0304)	(0.034)				
Relative VAMAQ					0.126**	0.062		

Table 4 (*Continued*)

			Trade liberalization variables					
			Foreign Direct Investment		Value added of Maquiladoras (reduced sample)		Relative Specialization Manufacturing	
	1	2	3a	3b	4a	4b	5a	5b
					(0.0423)	(0.0543)		
$VAMAQ_i$					0.061⋆	−0.044⋆		
					(0.0399)	(0.0236)		
Relative LQMAN							0.129	0.870⋆⋆
							(0.3292)	(0.1165)
$LQMAN_i$							−0.561	−1.445⋆⋆
							(0.3518)	(0.2187)
Mexico City (dummy)			0.957⋆⋆	0.979⋆⋆	0.409	0.118	0.532⋆⋆	0.399⋆⋆
			(0.1552)	(0.1508)	(0.3356)	(0.3192)	(0.1635)	(0.1585)
Post-NAFTA period (dummy)	−1.475⋆⋆	−0.371⋆⋆	−0.482⋆⋆	−0.461	−0.669⋆⋆	−0.535	−0.338⋆⋆	0.105
	(0.2747)	(0.1908)	(0.0915)	(0.209)	(0.1278)	(0.2969)	(0.0653)	(0.194)
Constant	−12.833⋆⋆	−12.495⋆⋆	−9.85⋆	−11.565⋆⋆	−7.712⋆	−5.482	−12.54⋆	−15.693⋆⋆
	(1.7887)	(1.9424)	(2.2592)	(2.0996)	(3.0850)	(3.0903)	(2.3876)	(1.7865)
Observations	2,976	2,976	2,976	2,976	816	816	2,976	2,976
Origin-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Destination-fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AIC	48,791.7	48,570.7	48,856.0	48,386.9	14,292.1	14,185.5	48,899.4	48,570.7
BIC	48,869.7	48,660.7	48,928.0	48,500.9	14,348.6	14,260.7	48,971.3	48,660.7
S&J goodness-of-fit	0.67	0.68	0.51	0.73	0.47	0.70	0.56	0.75

Notes: ⋆$p<0.05$; ⋆⋆$p<0.01$.
Cluster-robust standard errors are shown in parentheses.

regression includes marginality conditions (see Model 2), only wages at the origin keep their negative and significant effects as a deterring factor of interstate migration. In addition, the inclusion of trade liberalization variables, specifically FDI and maquiladora value-added, appears to offset the significance of wages given that its relative form and log form become less significant (see for example Models 3b and 4b). Only when the model captures manufacturing sector specialization (see Model 5b) do wages in origin states becomes significantly negatively associated with migration flows.

The results show that unemployment rates have significant detrimental effects upon interstate migration, particularly in regressions that include marginality conditions (see Model 2). The relative and log form coefficients show negative and significant effects although unemployment rates in origin states appear to be capturing the conditions in the labour market to a greater extent. The results show that a 10% increase in unemployment between paired states reduces the probability of migration by approximately 7.6%, while the reduction in origin states is approximately 10%.

As expected, deprived living conditions in either origin or destination states have a negative impact on the probability of migration. The deterring effects are particularly important in destination states across all estimated models due to the negative and statistical significant coefficient $MARG_j$. Furthermore, the inclusion of deprived conditions seems to increase the negative effects of unemployment rates on migration flows.

4.3. Trade Liberalization Variables

Two regression models are estimated for each of the trade variables, one excluding labour market variables (Models 3a, 4a, and 5a) and the other considering the full model (Models 3b, 4b, and 5b). In the case of FDI, the estimated parameters in both models show high levels of statistical significance but switching signs depending on the specification. Specifically, when labour market effects are removed from the model (as in Model 3a), a positive impact of FDI on the probability of migration emerges. However, once labour market variables are added to the model, for example in the full models, deterrent effects related to FDI investment appear. Notice that both the relative form and the log standard form show negative effects on the probability of migration. Specifically, for any increase of 10% in FDI flows between origin and destination states (see the relative term), the probability of migration diminishes by approximately 0.24%. Likewise, for each 10% increase in FDI at the origin state, the probability of migration diminishes by approximately 0.6%.

In analyzing the effects associated with maquiladora value-added, a positive impact upon migration flows appears only when the model excludes labour market variables. This is shown by the coefficients in the relative and log form of Model 4a. Nonetheless, the log form coefficient ($VAMAQ_i$) becomes negative once the model considers all control variables. This result suggests a reduction of 0.4% in the probability of interstate migration due to a 10% increase in maquiladora value-added.

Finally, the results related to the relative specialization in the maquiladora sector show significance only for the full model (see Model 5b). Thus for an increase of 10% in the relative manufacturing specialization between a pair of states, the

probability interstate migration increases by roughly 8.7%. However there is a reduction of approximately 14% in the probability of migration in origin states given a 10% increase in the specialization in the manufacturing sector.

4.4. Post-NAFTA Structural Break

In order to investigate a structural break in internal migration flows, a dummy variable accounting for those flows that occurred after NAFTA was added. The estimated coefficients show negative and highly significant effects on internal migration in Models 1, 2, 3a, 4a, and 5a. This supports the hypothesis of a reduction in internal migration flows in the post-NAFTA era. Note that once trade variables were added to the equation (see Models 3b, 4b, and 5b), the dummy variable lost statistical significance. This latter result favours the argument that trade liberalization variables appear to be capturing all the deterrent effects on internal migration flows in Mexico.

4.5. Results by Periods

Table 5 shows the variations on the estimated trade liberalization coefficients for each of three migration periods: 1985–1990, 1995–2000, and 2000–2005. Each model presents the results considering all control variables previously discussed. The estimated parameters indicate the negative impact of FDI on migration in origin states, the effect of which strengthens during the post-NAFTA period. The estimated coefficient, FDI_i, indicates a reduction of 4.6% in the probability of migration as a result of an increase of 10% in FDI flows during the period of 1995–2000. The maquiladora value-added in origin states also shows deterrent effects on the probability of migration but only during the first two periods, with substantial diminishing effects in the second period. The results by periods also suggest that relative specialization in the manufacturing sector among states serves as pull factors

Table 5. Variation in the estimated coefficients of trade liberalization variables by periods: 1985–1990, 1995–2000, and 2000–2005

	Results by periods[a]		
	1985–1990	1995–2000	2000–2005
Relative FDI	−0.067	−0.161	−0.066
	(0.0437)	(0.0592)	(0.0624)
FDI_i	−0.061	−0.464**	−0.033*
	(0.045)	(0.0662)	(0.0233)
Relative VAMAQ	0.024	0.050	0.112
	(0.0398)	(0.0468)	(0.0469)
$VAMAQ_i$	−0.135**	−0.071*	0.040
	(0.0383)	(0.0374)	(0.0615)
Relative LQMAN	0.572*	0.321*	0.273*
	(0.1924)	(0.1505)	(0.1914)
$LQMAN_i$	−1.494*	−1.369*	−0.941*
	(0.1882)	(0.1800)	(0.2134)

Notes: *$p<0.05$; **$p<0.01$.

[a] One model for *FDI*, *VAMAQ* and *LQMAN* (in its relative and log form) was established for each period. Each model then includes the spatial gravity, labour market variables as well as the dummy for Mexico City.

for internal migrants with significant effects across periods. Finally, states' specialization in manufacturing has important deterrent effects on internal migration flows, even before the advent of NAFTA. The $LQMAN_i$ coefficient is the largest of the trade variable coefficients in each of the three periods.

5. Final Discussion

Our analysis has produced several major findings regarding the extent to which trade liberalization has affected internal Mexican migration. First, a structural break in migration flows when comparing pre- and post-NAFTA periods is observed. Second, there is a significant but partial effect of pure economic variables such as average wages and unemployment rates. Specifically, unemployment rates in origin states were found to be the most important labour market variable. While relative wages do not seem to be a factor influencing migration once we control for the exposure of economic liberalization, higher wages in origin states reduce out-migration.

Third, the associated impact of FDI, maquiladora value-added and specialization in the maquiladora sector has a substantial deterrent effect on migration flows from origin states. The only positive effect of trade liberalization is the one related to the relative specialization between states in the manufacturing sector, which acts as a pull factor for internal migrants.

An explanation for the negative impact of trade liberalization on migration could be related to the fact that access to foreign markets creates domestic economic opportunities, directly affecting employment and income growth. This, in turn, can reduce the expected relative returns of out-migration. It may also be the case that migrants value other job characteristics, such as stability or career opportunities, more than actual wages (Hering & Paillacar, 2009). Furthermore, our findings also suggest a null effect for regional exposure to trade variables on relaxing financing constraints, which may be due to limited migration during the study period. This is in line with Aroca & Maloney's (2005) study in which greater exposure to internal trade and integration of the economy turn out to be substitutes for labour flows within the country.

In analyzing the timing in which these effects took place, the FDI contribution was found to be a significant determinant of internal migration that occurred post-NAFTA, while maquiladora value-added and manufacturing industrial specialization had significant effects even before the enactment of the trade agreement.

It should be borne in mind that the present study is simply a point of departure for subsequent analysis that would more completely address some limitations and add further analytical dimensions. First, the analysis could be extended to allow origin–destination migration flows matrices by age, sex, and education. More importantly, further research could develop profiles of migrants (skilled vs. unskilled) and estimate factors related to internal movements while addressing potential endogeneity which has not been a consideration in the present study due to the lack of suitable instruments.

This is crucial as the hypothesized effect of trade upon financial constraints might differ by skill levels. On the one hand, if trade liberalization is affecting skilled through higher wages across the country, then it is possible that this would result in decreased labour out-migration. On the other hand, if financial constraints are not being relaxed for those in the bottom of the skill level distribution, no

increased out-migration would result since these individuals are the least likely to migrate due to limited resources. The combination of these two effects would result in an overall reduction in the interstate migration flows.

Second, there is a need to model spatial autocorrelation in spatial gravity models as a way of controlling for possible spatial dependence, given that the unit of analysis (states) represents geographic units. Third, future research could also be extended to consider a dynamic version of our extended spatial gravity models in order to more fully capture temporal variation in migration flows.

Notes

1. A *maquiladora* or *maquila* is the Mexican name for manufacturing operations in a free trade zone (FTZ), where factories import material and equipment on a duty-free and tariff-free basis for assembly, processing, or manufacturing and then export the assembled, processed, and/or manufactured products, sometimes back to the raw materials' country of origin.
2. For all variables, we use the subscripts *i*, *j* and *ij* to indicate whether the variable is at the origin, destination, or state pair level, respectively. In addition, we indicate with the subscript *t* whether the variable is a time-variant or not.
3. Robustness checks were also run by estimating models with origin and destination fixed effects separately. The estimated parameters in all specifications do not suffer major changes in terms of the estimated effect and significance. The presentation of the results has been kept to a minimum and only shows outcomes controlling for both origin–destination fixed effects. Nonetheless, the complete sets of tables are available upon request from the authors.

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