Economics Bulletin

Volume 33, Issue 4

Gravity and Localized Migration

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Abstract

I construct a simple gravity model of migration that explains the majority of variation in Mexico-US bilateral migrant stock sizes at the relatively localized state-state level. Relying on a novel dataset that permits the linking of Mexican migrants' US states of residence with Mexican states of origin, I show that the gravity model provides an important framework for examining the determinants of migration at the localized level, specifically addressing the choice of states of residence within the destination country by migrants spread across varied states of the origin country. This explicit inclusion of state (rather than national) characteristics allows for greater accuracy in measuring the potential determinants of migration within the gravity model, including the distance and mass variables fundamental to the gravitational relationship.

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Citation: Michael Good, (2013) "Gravity and Localized Migration", *Economics Bulletin*, Vol. 33 No. 4 pp. 2445-2453.
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Submitted: May 05, 2013. **Published:** October 03, 2013.

1. Introduction

The decision to migrate has often been treated as an individual (household) decision between many different country destination options, the decision ultimately resting upon the maximization of utility or well-being for the potential migrant(s). Whereas labor outcomes, specifically differences in real wages, are stressed by the labor literature that dominates the recent discussion of migration, other factors certainly play a role in the migration decision. In this article, I build on Lewer and Van den Berg (2008) in the use of a gravity model that incorporates both labor outcomes and other relevant factors in further understanding the determinants of migration. While Lewer and Van den Berg (2008) consider migration to 16 OECD countries, I contribute the examination of a more localized decision of migration, that of choosing a state of residence within a respective country destination. Specifically, I analyze the determinants of Mexican migration to the United States, differentiating between both states of destination and states of origin; the exploitation of a novel dataset of *matrículas consulares* (consulate cards) permits the connection of Mexican migrants' US states of residence with their Mexican states of origin.

The explicit inclusion of state (rather than national) characteristics allows for greater accuracy in measuring the potential determinants of migration within a gravity model, including the distance and mass variables fundamental to the gravitational relationship. This relatively localized specification potentially takes on even greater importance given a central result of Yilmazkuday (2013), the finding that the estimated coefficient for distance in the gravity-type models of determinants of international trade suffers from greater bias if not considering production location within countries (at the state or local level). Additionally, the Mexico-US case provides an especially appropriate setting for the examination of the migration decision at the state-state level, as US immigration and especially Mexican emigration are dominated by this bilateral relationship. Mexican migration provides 28.6% of the total recorded immigration received in the US; while there is certainly considerable Mexican emigration to alternative country destinations, the overwhelming majority (92.6%) of the more than 10 million Mexican migrants worldwide settles in the United States. [1]

2. The Gravity Model

With its beginnings in Tinbergen (1962) and Anderson (1979), the gravity model has enjoyed wide use throughout the trade literature (see Anderson and Yotov, 2012, and Arkolakis et al., 2012, for recent related contributions), having recently been employed in several studies regarding migration including Lewer and Van den Berg (2008), Mayda (2010), and Ortega and Peri (2009). In constructing the straightforward gravity model of migration in this article, I start with the standard gravity variables of population and distance between states. Larger populations, both in places of origin and destination, are associated with increased migration, as larger destination populations provide a larger labor market for migrants and larger origin populations translate into a higher probability of migration. Just as in the gravity models of trade, geographical distance proxies for moving costs; as distance between states increases, the costs related to migration are theorized to

[1] These calculations rely on 2000 data from the Global Migrant Origin Database of the Development Research Centre on Migration.

increase. I also include a dummy variable indicating geographical adjacency of states, however additional costs emphasized in the literature associated with differences in language, culture, legal systems, or colonial ties are not included as there is no variation of these factors within the US and Mexico.[2]

Among other explanatory variables theorized to affect migration, I include the ratio of state per capita incomes, as large wage gaps between US and Mexican states create clear economic incentives for Mexico-US migration. Good (2013b) pinpoints exact wage gains from migration through a household survey, finding average purchasing power parity-adjusted wage ratios of between 3.92 and 5.56, averaged across the various samples examined. These figures detail the immediate wage gains available to Mexico-US migrants by just crossing the border. Given the present data, the average ratio of US to Mexico state per capita incomes is 7.57, ranging from a minimum of 1.02 to a maximum of 26.77; this wide distribution of income ratios clearly creates varied economic incentives for Mexican migrants settling on a US state destination. Mayda (2010), Ortega and Peri (2009), and Good (2013b) emphasize restrictive immigration policies as an additional barrier to migration, however I do not include any measure of policy given that most immigration policy is set at the national level, resulting in no variation for the given context. In an alternative specification, I add the Gini coefficient as a measure of income distribution, the unemployment rate, and the percentage of population between ages 15-24 for US states, in addition to the average educational level and unemployment rate in Mexican states in order to investigate several further potential determinants of migration. Greater equality, lower unemployment rates, and a growing population may lower resistance to migration and make US states relatively more attractive for migrants; higher education levels and higher unemployment rates in places of origin may result in increased migration.

Migrant networks are often proxied in gravity models of migration as a determinant of migration location and migrants' outcomes, as clusters of migrants of similar geographic origin tend to materialize. Amuedo-Dorantes and Mundra (2007) and Bauer et al. (2007), among others, provide evidence of this phenomenon, focusing on location and wages and the location decision, respectively, while Card and Lewis (2007) signal the recent geographic diffusion of Mexican migrants to relatively "new" US destination states. The network effect has not been examined at the disaggregated state-state level in a gravity model framework, but theoretically could clearly exist for migrants of the same source state just as it is evidenced in the literature for migrants of similar national origin. However, the examination of this additional potential explanatory variable is left as a future path of exploration, as no currently available data provides sufficient observations to depict an accurate representation of the overall stock of Mexican migrants in the US at the state-state level. Even data such as *La Encuesta sobre Migración en la Frontera Norte de México* (EMIF) or the Mexican Family Life Survey, commonly used in the literature for the study of Mexico-US migration, do not perform well given the necessary disaggregation of the data into each combination of Mexican source states and corresponding US states of residence.

Given the theorized relationships above, the resulting baseline gravity equation is

$$m_{ij} = \alpha + \beta_1 inc_{ij} + \beta_2 pop_{ij} + \beta_3 dist_{ij} + \beta_4 Adj_{ij} + \varepsilon_{ij}. \tag{1}$$

[2] Although culture and language do vary slightly within each of these countries, the cross-state variation is minuscule compared to the cross-country differences emphasized in the literature, resulting in the assumption of zero associated variation and corresponding costs relevant to migration.

Lowercase letters represent variables in logarithmic form; m_{ij} is the flow of immigrants in US state i originating from Mexican state j summed over the available 2006-2010 data. inc_{ij} is the ratio of per capita income in US state i to per capita income in Mexican state j, pop_{ij} is the multiplication of US state population i and Mexican state population j, $dist_{ij}$ is the distance by land between the capital of US state i and the capital of Mexican state j, and Adj_{ij} is a dummy variable indicating adjacency between states i and j. When the unilateral variables of US state i Gini coefficient $Gini_i$, unemployment rate $Unemp_i$, and percentage of population ages 15-24 $Young_i$, and Mexican state j average education $Educ_j$ and unemployment rate $Unemp_j$ are added in the alternative specification, the augmented gravity equation results

$$m_{ij} = \alpha + \beta_1 inc_{ij} + \beta_2 pop_{ij} + \beta_3 dist_{ij} + \beta_4 Adj_{ij} + \beta_5 Gini_i + \beta_6 Unemp_i + \beta_7 Young_i + \beta_8 Educ_j + \beta_9 Unemp_j + \varepsilon_{ij}. \tag{2}$$

3. Econometrics

Although the crucial dataset of *matrículas consulares*, first employed in Good (2013a), allows for the previously untraceable connection between migrants' US states of residence with Mexican states of origin, it also presents a potential selection problem worth highlighting. The card is non-obligatory for Mexican nationals living abroad, giving holders access to services such as opening a bank account or obtaining a driver's license, depending on the particular country and state of residence. The fact that it is optional yet beneficial if used in lieu of other photo identification leads to clear concerns of selection, mainly that documented Mexican immigrants residing in the US have no strong incentives to obtain the card, resulting in self-selection biased toward the undocumented population. However, this fact does not necessarily strike the dataset from having a high level of representativeness of the state-state distribution of Mexican immigrants in the US if those actually obtaining cards do not have reason to select US state destinations differently than the general Mexican immigrant population. Good (2013a) compares the *matrícula consular* data with that of the US 2010 Census, arguing that there is no reason to believe that specific Mexican state of origin affects selection into obtaining the consulate card.[3] That study provides an extensive comparison with the Census distribution of Mexican immigrants across US states, irrespective of Mexican state of origin, confirming that the novel dataset indeed provides a high level of representativeness of the actual state-state distribution of the migrant population.

Among other concerns of econometrics are the inclusion of unilateral explanatory variables, the presence of zero-valued bilateral migration observations, and the sampling decision presented by Mexico's capital city. Equation (1) consists entirely of bilateral variables; however, the inclusion of various unilateral explanatory variables in Equation (2) can lead to biased estimates. I address

[3] One may assume that education level is associated with documentation status, in turn resulting in varied levels of selection correlated with varied levels of education across Mexican states of origin. However, this assumption appears to have no backing; the lack of evidence backing this assumption is signaled in Good (2013a), citing additional figures from Passel and Cohn (2009) and Caponi and Plesca (2012).

this by inserting state-specific dummies in the alternative specification, corresponding to the solution proposed in Anderson and van Wincoop (2003) of country-specific dummies. Mexico-US state-state migration numbers are large, the *matrícula consular* count averaging 3038 per bilateral combination over the 2006-2010 period examined;[4] however, 3.9% of the 1536 observations are equal to zero, presenting clear problems given subsequent logarithmic transformation. Just as Lewer and Van den Berg (2008), I adopt the common method of scaled ordinary least squares in resolving this issue, permitting all available information on state-state migrant counts to enter the gravity equation. Finally, there is ambiguity regarding the inclusion of migrants originating in Mexico City, as it is listed as an origin "state" in the raw data, but due to its federal district status, is not technically a state. Due to this ambiguity, I opt to estimate Equations (1) and (2) twice each, both including and excluding Mexico City from the list of Mexican states, resulting in sample sizes of 1536 (48 US states and 31 Mexican states + Mexico City) and 1488 (48 US states and 31 Mexican states) state-state observations, respectively.[5]

4. Estimation Results

Table 1 highlights the results of the four estimations of Equations (1) and (2). The ratio of state incomes per capita, combined population, and distance are all consistently statistically significant at the 1% level, with the hypothesized signs on each respective coefficient. Each respective R^2 indicates that the majority of variation in bilateral migration is indeed accounted for by the variation in the included explanatory variables. Notably, adjacency is not a significant determinant of migration, a result also found in Mayda (2010) and Ortega and Peri (2009); as Good (2013a) finds a positive, statistically significant effect of adjacency on US-Mexico state-state international trade, this provides evidence backing the suggestion of Lewer and Van den Berg (2008) that people move more easily than goods across multiple borders.

The magnitude of the coefficients exhibits little change when including Mexico City observations in columns (1) and (3), or due to the addition of fixed effects with the various unilateral explanatory variables in columns (3) and (4). A more equal income distribution and lower unemployment rate in US destination states, as well as a higher unemployment rate in Mexican states, all have statistically significant positive effects on Mexico-US bilateral state-state migration.

[4] Summing the card registrations over 2006-2010 presents no problem of double-counting of individual migrants, as the *matrícula consular* only needs to be renewed every five years. My dataset is therefore the sum of the most recent five years for which data is readily available.

[5] The non-contiguous US states of Alaska and Hawaii, as well as Washington D.C., do not enter in the conversation as to inclusion or exclusion, as they are not included in the available migration data. Table 2 in the Data Appendix provides a descriptive summary of the complete dataset.

Table 1. OLS estimation, dependent variable: ln(immigrants)

	(1)	(2)	(3)	(4)
Relative income	0.81***	0.91***	1.17***	0.85***
	(0.08)	(0.09)	(0.19)	(0.18)
Population	1.35***	1.31***	1.63***	1.48***
	(0.03)	(0.04)	(0.04)	(0.04)
Distance	-2.26***	-2.33***	-2.99***	-2.83***
	(0.14)	(0.14)	(0.14)	(0.14)
Adjacency	-0.32	-0.32	0.07	0.17
	(0.57)	(0.57)	(0.47)	(0.48)
Gini (US)			-16.31***	-16.66***
			(2.25)	(2.29)
Unempl. (US)			-0.10**	-0.10**
			(0.04)	(0.04)
Young pop. (US)			-0.03	-0.04
			(0.05)	(0.05)
Education (Mex)			0.05	0.04
			(0.12)	(0.14)
Unempl. (Mex)			0.62***	0.27**
			(0.16)	(0.13)
Constant	-19.55***	-18.10***	-25.91***	7.55
	(1.56)	(1.61)	(3.43)	(5.43)
Fixed Effects	No	No	Yes	Yes
Observations	1536	1488	1536	1488
R^2	0.61	0.61	0.92	0.91

*** and ** denote statistical significance at the 1% and 5% levels, respectively.

5. Conclusion

The gravity model most often used in the trade literature also finds a useful application in the study of migration at the national level; in this article I show that the same gravitational forces also apply to the migration decision at a more localized level, measuring all relevant variables with higher levels of accuracy (at the state rather than national level) than previously possible for both places of destination and origin. The examination of these forces of gravity along with other theorized factors affecting migration results in evidence that the model indeed is useful for testing the marginal influence on migration of the studied explanatory variables. Using Mexican migration to the United States measured by the novel *matrícula consular* dataset as a testing ground for the gravity model of migration, state-pair relative incomes, bilateral population magnitudes, distance between states, income inequality and unemployment rates in destination states, and unemployment rates in states of origin are all statistically significant predictors of bilateral state to state international migration. As more data at the localized level become available in the future, the gravity model of migration clearly provides a clean method for further exploration of the relative importance of the determinants of migration not only at the country-country level, but also at the relatively localized state-state level as well.

Data Appendix

The 2006-2010 *matrícula consular* data is available from the website of the *Instituto de los Mexicanos en el Exterior*. Population and income variables rely on statistics from the US Bureau of Economic Analysis (BEA) and the Mexican *Instituto Nacional de Estadística y Geografía* (INEGI), respectively. Incomes are converted to 2011 US dollars by using historical monthly exchange rates and the CPI-U series. Additionally, I calculate the distance as the number of miles between each respective state capital pair; US Gini coefficients, unemployment rates, and percentage of the population between ages 15-24 stem from the American Community Survey, Bureau of Labor Statistics, and Census Bureau, respectively, while the INEGI provides the years of average education and unemployment rates across all Mexican states. Means, standard deviations, and minima/maxima for the 2005 (other than *matrícula consular*) data used in the calculation of all variables included in the gravity models are highlighted in Table 2 in regular print, in parentheses, and in italics, respectively.

Table 2. Descriptive statistics

Variable	$n = 1488$	$n = 1536$	Variable	$n = 1488$	$n = 1536$
Immigrants	2938	3038	Mex. GSP (billions USD)	2,514.13	2,969.87
	(13,634)	(13,772)		(1,975.85)	(3,197.62)
	0/270,201	*0/270,201*		*529.45/9,235.81*	*529.45/17,097.79*
US population	6,296,601	6,296,601	US Gini coefficient	0.45	0.45
	(6,850,940)	(6,850,940)		(0.02)	(0.02)
	563,626/37,253,956	*563,626/37,253,956*		*0.42/0.50*	*0.42/0.50*
Mex. population	3,338,241	3,510,517	US unempl. rate	4.89	4.89
	(2,818,553)	(2,935,383)		(0.99)	(0.99)
	637,026/15,175,862	*637,026/15,175,862*		*3.4/7.9*	*3.4/7.9*
Distance (miles)	2077	2078	US young pop.	14.04	14.04
	(600)	(597)		(0.66)	(0.66)
	239/3681	*239/3681*		*12.7/16.2*	*12.7/16.2*
Adjacency	0.006	0.006	Mex. years education	8.54	8.6
	(0.078)	(0.076)		(0.77)	(0.83)
	0/1	*0/1*		*6.7/9.8*	*6.7/10.5*
US GSP (billions USD)	34,392.30	34,392.30	Mex. unempl. rate	4.54	4.54
	(39,909.53)	(39,909.53)		(1.11)	(1.09)
	2,950.91/218,967.32	*2,950.91/218,967.32*		*2.33/6.6*	*2.33/6.6*

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