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BORDER WALLS

Treb Allen
Cauê de Castro Dobbin
Melanie Morten

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ABSTRACT

What are the economic impacts of a border wall between the United States and Mexico? We use detailed data on bilateral ows of primarily unauthorized Mexican workers to the United States to estimate how a substantial expansion of the border wall between the United States and Mexico from 2007 to 2010 affected migration. We use these effects to estimate a general equilibrium spatial model featuring multiple labor types and quantify the economic impact of the wall expansion. At a construction cost of approximately $7 per person in the United States, we estimate that the border wall expansion harmed Mexican workers and high-skill U.S. workers, but benefited U.S. low-skill workers, who on average achieved welfare gains equivalent to an increase in per capita income of $0.28 per year.

Treb Allen
Department of Economics
Dartmouth College
6106 Rockefeller Hall
Hanover, NH 03755
and NBER
treb@dartmouth.edu

Melanie Morten
Department of Economics
Stanford University
579 Serra Mall
Stanford, CA 94305
and NBER
memorten@stanford.edu

Cauê de Castro Dobbin
Stanford University
dobbin@stanford.edu

1 Introduction

What are the economic impacts of a border wall between the United States and Mexico? While there exists a vigorous debate surrounding the issue, empirical evidence guiding the debate has lagged behind. This is partly due to the difficulty of disentangling the many mechanisms through which a border wall can affect the economy. The decision of whether and where to migrate requires a trade-off comparing the costs and benefits of each possible destination. While a border wall may directly increase the cost of migrating to certain destinations, it also can affect the benefits of migrating, as the changing behavior of workers can have general equilibrium effects on prices and wages in each destination. Moreover, these impacts may differ across space depending on the underlying geography and costs associated with the movement of goods and people.

In this paper, we use new detailed data on migration flows of primarily unauthorized workers between Mexican municipalities and U.S. counties to understand how a substantial expansion of the border wall from 2007 to 2010 affected migration flows. We then develop a general equilibrium spatial model where imperfectly substitutable workers of different nativities endogenously sort into labor markets that are separated by flexible trade and migration frictions. We estimate the key model elasticities using a transparent estimation procedure relying on the border wall expansion as the source of identification. We then use the framework to quantify the welfare impact of the wall expansion for workers of different types and in different labor markets. At a construction cost of approximately \$7 per person in the United States, we estimate that the border wall expansion harmed Mexican workers and high-skill U.S. workers, but benefited U.S. low-skill workers, who achieved average steady state gains equivalent to an increase in per capita income of \$0.28 per year.

The border wall expansion we study was a result of the Secure Fence Act of 2006, which authorized the construction of reinforced fencing in California, Arizona, New Mexico, and Texas. Between 2007 and 2010, 548 miles of wall were constructed along the 1,954-mile U.S.-Mexico border, bringing the total fencing to 658 miles. Since unauthorized migrants typically cross the border by foot (Massey, Durand, and Malone (2003)), the extension of the wall altered the relative costs of migration across origin and destination pairs. We combine this geographic variation with a confidental dataset of unauthorized migration flows between municipalities in Mexico and counties in the U.S. (the confidential version of the Mexican government's *Matrícula Consular* (Consular ID card) database. Using these rich data, we examine how the patterns of migration changed after the expansion of the border wall.

The analysis is complicated by the fact that, at the same time the wall was being built, the Great Recession occurred. One benefit of observing bilateral migration flows is that we can compare migration to a particular destination across different origins – some of which were impacted by the border wall expansion and some of which were not. In this way, we can control for shocks to a particular destination and, by similar logic, can control shocks to a particular origin by comparing migration to different destinations. Borrowing this "gravity" procedure (familiar from the trade literature, see e.g. Baldwin and Taglioni (2006) and Head and Mayer (2013)), we find that the border wall expansion caused a decline in migration flows: a 10% increase in the total travel time necessary to avoid the border wall resulted in a 1.4% reduction in bilateral migration flows. This result is robust to accounting for the response of border patrol enforcement, controlling for different types of border walls, and instrumenting the location of the wall expansion using geographic predictors of where the wall was built.

While the estimates are precise, the effects are small: our estimated elasticity implies the *direct* (partial equilibrium) impact of the Secure Fence Act was to reduce Mexico-to-U.S. migration by 0.5% – about 64,000 migrants. However, this calculation abstracts from any *indirect* (general equilibrium) impacts of the Secure Fence Act, including how it may change the pattern of migration from a particular origin (which would be absorbed in the origin fixed effect) or how it may impact the labor markets in the destination (which would be absorbed in the destination fixed effect). To estimate the *total* impact of the Secure Fence Act (including these indirect effects), we develop a general equilibrium spatial framework that comprises multiple types of labor who vary in their skill level and nativity, who work in one of many locations separated by both migration and trade frictions. Despite the many general equilibrium forces, we are able to characterize the equilibrium of the model and develop a new procedure that allows us to estimate the key structural parameters – the substitutability of different types of labor, the trade elasticity, and the migration elasticities – from a set of linear instrumental variables regressions, where the instruments are simply measures of the extent to which the Secure Fence Act affected each location and the identifying assumptions (exclusion restrictions) are equivalent to those of regressions typically run in the immigration literature. By showing that these estimation methodologies pioneered in the immigration literature can be applied in a general equilibrium context where labor markets are linked through trade and migration, the paper offers a key methodological contribution that helps to bridge the gap between the large immigration literature and the growing "quantitative spatial" literature.

Given our estimated parameters, we calculate the steady state economic impact of the border wall expansion by holding the underlying geography (productivities, amenities, and trade costs) constant at pre-expansion levels and increasing migration costs to match the gravity estimates above. We estimate that the total impact of the border wall expansion including all general equilibrium adjustments was to reduce the (long-run) number of Mexican workers residing in the United States by about 50,000 a decline of approximately 0.4%, or about 14,000 fewer migrants prevented than the partial equilibrium direct estimates imply. While the welfare impacts varied substantially across locations, on average both low-skill and high-skill Mexican workers were made worse off by an equivalent decline in annual per capita income of \$0.81 and \$1.82, respectively (driven primarily by the direct increase in the cost of migrating). Driven primarily by a decline in the relative scarcity of high-skill labor, the average high-skill U.S. worker was also harmed an amount equivalent to a decline in annual income of \$2.73. However, on average low-skill U.S. workers benefited by an equivalent of \$0.28 per year, as low-skill labor in the United States became more scarce. These figures do not include the direct cost of wall construction, which is approximately \$7 per person in the United States.

Finally, we calculate the steady state welfare impact of alternative (counterfactual) policies. First, we consider experiments that "fill in" some of the gaps in the wall to understand if our small effects are driven by the fact that the wall only partially covers the U.S.-Mexico border. We find no evidence of such nonlinearities: filling in half of the remaining gaps on the border would reduce the number of Mexican migrants by 87,000 yet increase the economic benefit to only \$0.47 per low-skill U.S. worker. Second, we consider an experiment that reduces the international trade costs between the United States and Mexico, which – by reducing the relative wage gap in the two countries – reduces the incentive of migration. We find that, like the border wall expansion, this reduction in trade costs also reduced the number of Mexican workers in the United States. For example, a trade policy that reduced the impact of distance on international trade flows one-quarter of the way toward the impact of distance on domestic trade flows would have reduced the number of Mexican workers residing in the United States by about 107,000. However, unlike the border wall expansion, reducing trade costs results in large economic benefits for both U.S. and Mexican workers by reducing the costs of goods, thereby increasing worker's purchasing power. For example, a 25% reduction in the additional international cost of distance would would yield a benefit of equivalent to a \$57.63 increase in income for each low-skill U.S. worker and even greater gains for low-skill Mexican workers and high-skill workers of both nationalities.

We should emphasize that there are several potential concerns about these results. First, our primary measure of migration comes from the Matrícula Consular database. The unique feature of the Matrícula database is that we see the origin muncipality of migrants who live in the U.S. and so can study how the wall differentially affected migrants depending on their exposure to it. This is in contrast to the ACS or Census which collects country, but not region, of birth. However, since migrants choose whether or not to apply for an

ID card, a natural concern is whether the choice to apply for an ID card is affected by the wall. To address this concern, we first show that changes in the number of consular ID cards correlate strongly with population counts of Mexican residents in both origin locations from the Mexico Census and destination locations from the United States American Community survey, and second, we show we find no evidence that the correlation between Census data and the consular ID database depends on the concentration of the migrant network. We also use alternative measures of migration to validate our finding that the wall changed migration patterns, providing direct evidence from independently collected survey data that migrants' choice of where to cross the border changed in response to the border wall expansion and that the location of border apprehensions by the U.S. Border Patrol shifted away from the newly walled portion of the border.

A second concern is at the destination level (aggregating across all affected pairs) the predicted effect of the wall on the stock of migrants is small and difficult to discern in the population data. Our estimates suggest that the median location in the U.S. should receive just 0.4% fewer migrants after the wall – a small impact relative to the large contemporaneous shock of the Great Recession. Because of this, our estimated event studies of the effect of the wall on migrant stocks have wide confidence intervals. Additionally, there is some evidence that locations most impacted by the wall may have had different population trends prior to the wall expansion. To help address concerns of potential pre-existing trends, we undertake two robustness exercises when using our instrument to estimate the structural elasticities of the model. First, we show that the estimated structural elasticities remain remarkably similar after controlling for a number of covariates possibly correlated with exposure to the Secure Fence Act including population trends, sectoral composition, distance to the border, and changes in local housing values. We then show that counterfactual results are qualitatively similar if we disregard our own structural estimates entirely and instead choose alternative parameter constellations spanning the range of estimates from the literature: regardless of the parameter values chosen, both border wall expansions and reductions in trade costs always reduce Mexico to United States migration, reducing trade costs always substantially increased the welfare of both U.S. and Mexican workers, and the border wall expansion always causes welfare declines for most labor groups. Across all parameter constellations, the average high-skill U.S. worker is never made better off from the Secure Fence Act and the economic benefits for the average low-skill U.S. worker never exceeds an equivalent of $2.32 per year.

Our paper contributes to a number of strands of several literatures spanning the fields of international trade, economic geography, and migration. First, the paper builds on the growing quantitative spatial literature (see e.g., Ahlfeldt, Redding, Sturm, and Wolf (2015);

Allen and Arkolakis (2014); Monte, Redding, and Rossi-Hansberg (2018) and the excellent reviews by Costinot and Rodríguez-Clare (2014) and Redding and Rossi-Hansberg (2017)). Relative to existing papers in this literature, we make three contributions: (1) we incorporate multiple types of imperfectly substitutable labor based on the nativity and skill level of the worker into a model with both flexible trade and migration frictions;[1] 2) we provide conditions for the existence and uniqueness of an equilibrium of a general class of spatial models with arbitrarily many locations, types of spatial frictions, and imperfectly substitutable factors of production;[2] and 3) we derive estimating equations for key structural parameters that can be implemented simply via a series of instrumental variable regressions, creating a link to the large existing immigration literature.[3] However, we should also note that to make our framework as transparent as possible, we omit several margins of possible interest: we focus on the steady state economic impacts, abstracting from the dynamics shown to be empirically important in other settings (see e.g. Dix-Carneiro (2014) and Dix-Carneiro and Kovak (2017)) which have been previously incorporated in Desmet, Nagy, and Rossi-Hansberg (2018), Caliendo, Dvorkin, and Parro (2019), and Allen and Donaldson (2018); we abstract from productivity and amenity externalities (see e.g. Allen and Arkolakis (2014) and Ahlfeldt, Redding, Sturm, and Wolf (2015)); and we abstract from differences in industrial composition (and, relatedly, input-output linkages) and across labor markets (see e.g. Caliendo and Parro (2015)).

Second, the paper contributes to the large literature examining the effect of immigration on labor markets (see e.g., Card (2001); Borjas (2003); Ottaviano and Peri (2012); Borjas, Grogger, and Hanson (2012); Llull (2017); Clemens, Lewis, and Postel (2018); and Dustmann, Schönberg, and Stuhler (2016) for a recent review). Like many papers in this literature, we estimate the local labor market effects of immigration using a shock to the relative local labor supply – the expansion of the border wall – that is plausibly uncorrelated with local fundamentals.[4] Relative to this literature, we do so in a framework that explicitly

[1]Two papers develop related models: Burstein, Hanson, Tian, and Vogel (2017) also construct a many-location general equilibrium spatial model with multiple types of labor based on nativity, but do not allow for bilateral costly migration between locations; Caliendo, Parro, Opromolla, and Sforza (2018) develop a dynamic framework with workers of different skills and nativities, but assume that workers of different nativities are perfect substitutes.

[2]This theoretical result extends those of Allen, Arkolakis, and Li (2016), who only consider frameworks where factors of production are combined with unit elasticity of substitution (i.e. Cobb-Douglas). In the context of immigration, this extension is important, as the literature estimates much higher degrees of substitutability between workers of different nativities.

[3]Typically in the spatial literature, the estimation procedure relies on a method of moments (or simulated method of moments) procedure; see e.g. Ahlfeldt, Redding, Sturm, and Wolf (2015). We leverage an inversion result (Lemma 1, below) along with the block recursive nature of the equilibrium to implement the estimation procedure through a set of instrumental variables regressions.

[4]That the border wall has an impact on migration is consistent with several papers examining the impact

incorporates general equilibrium linkages between local labor markets through the movement of both goods and factors. Reassuringly, our estimation procedure not only looks similar to prior procedures that abstract from such linkages, it also relies upon the same identifying assumptions.

Third, this paper contributes to the large literature examining how the movement of goods and the movement of people interact. Classic treatments of the topic include Mundell (1957) and Markusen (1983), while more recent papers include Tombe and Zhu (2015) and Morten and Oliveira (2018). Like these more recent papers, our framework takes no stand on whether migration and trade are complements or substitutes – instead, the response of both trade and migration to an underlying shock depends on the particulars of the underlying geography. Relative to these papers, we incorporate imperfectly substitutable workers of different types and nativities and allow their productivities and amenities to vary across labor markets, allowing for richer responses to shocks.

Finally, we note that the two recent papers Feigenberg (2017) and Caballero, Cadena, and Kovak (2018) are closely related to our paper in terms of topic and data. Like Feigenberg (2017), we estimate the impact of the Secure Fence Act on migration; however, unlike that paper, by observing bilateral migration flows, our analysis allows us to separate the impact of the border wall from other contemporaneous economic shocks in both origins and destinations (e.g. Arizona's anti-immigrant SB 1070 law, which required police to request documentation from those suspected of being in the country illegally). Like Caballero, Cadena, and Kovak (2018), we rely upon the Matrícula Consular database to observe migration flows; however, unlike that paper, we use a confidential version of the data that provides variation at a sub-state (Mexican municipality - U.S. County) level, allowing us to control for state-level shocks (such as policies) that may impact migration flows. Relative to both papers, we estimate the welfare effects of the border wall expansion and other counterfactuals by developing a new methodology of combining the "reduced form" techniques of the immigration literature with a new general equilibrium spatial model with multiple labor types and flexible trade and migration frictions.

The rest of the paper is organized as follows. We start by describing the data and the border wall expansion in Section 2. Section 3 estimates the direct impact of the border wall expansion on migration flows. Section 4 presents our general equilibrium spatial model. Section 5 derives the structural estimating equations and estimates the key model parameters. Section 6 estimates the economic impacts of the Secure Fence Act, larger (counterfactual)

of changes in immigration policy on migration patterns, including e.g., Bazzi, Burns, Hanson, Roberts, and Whitley (2018); Lessem (2018); Hanson and Spilimbergo (1999); Angelucci (2012) and Bohn and Pugatch (2015).

border wall expansions, and (counterfactual) reductions in trade costs. We briefly conclude in Section 7.

2 Empirical context and data

This section describes the border wall expansion we examine and the different data sources we use to evaluate its impact on Mexican migration to the United States.[5]

2.1 Empirical context: The Secure Fence Act of 2006

We study the effect of border wall expansion between 2007 and 2010 that occurred as a result of the Secure Fence Act signed by President George Bush on October 26, 2006. The bill authorized the construction of reinforced fencing on locations of the border in California, Arizona, New Mexico, and Texas. Between 2007 and 2010, 548 miles of wall were constructed along the 1954-mile U.S.-Mexico border, bringing the total wall to 658 miles. Of this new wall, 260 miles were "vehicular wall" and 288 miles were "primary pedestrian wall."[6] The cost of the wall construction between 2007 and 2015 was $2.3 billion (United States Government Accountability Office (2017b,a)). This number is equivalent to spending over $7 for each person in the United States.[7]

We geocode the locations of the wall along the border by digitizing an engineering report that displays all the wall locations at a 1:50,000 scale (Michael Baker Jr. Inc. (2013)). This report displays the location of all constructed walls and identifies the particular construction project each wall segment belongs. In some cases, the wall replaced legacy fence from earlier efforts to control immigration (for example, Operation Gatekeeper built six miles of fence along the San Diego portion of the U.S.-Mexico border in 1994).[8] In the majority of cases, however, the wall was built in locations that previously did not have any fence. We

[5]While the migration of other groups to the United States, particularly Central Americans, has become increasingly important over the past several years, 94% of apprehensions at the U.S.-Mexican border during 2000–2010 were of Mexican nationals, suggesting our abstraction from the impact of the border wall expansion on migration to the United States from countries other than Mexico is reasonable for our period of study.

[6]These numbers are based on analysis of GIS shape files generously shared with us by Guerrero and Castañeda (2017). These numbers differ very slightly from the official statistics, which as of 2017 are 354 miles of primary pedestrian fence and 300 miles of vehicular fence, so a total of 654 miles of fence (source). The discrepancy may be due to the treatment of fence repairs across the two data sets.

[7]This number does not account for maintanenance costs of the fence. Between 2007 and 2015, $0.45 billion was spent on maintenance. The Government Accountability Office estimated lifetime maintanenance costs of the fence to be estimated to be an additional $1 billion dollars (United States Government Accountability Office, 2017b).

[8]Other early wall sections were constructed in Arizona during Operation Safeguard in 1993 and Operation Hold-the-Line in Texas in 1993.

complement this digitized data with GIS shapefiles collected by Guerrero and Castañeda (2017) (and generously shared with us), which provides information on when each segment of the wall was constructed. Figure 1 shows the location of the new wall and legacy wall constructed on the border. Appendix Figure 1 shows two examples of the wall on the border.

To generate our analysis dataset, we start by dividing the U.S.-Mexico border into 1001 equally spaced points, approximately two miles apart. We then overlay the location of the border wall. For each point along the border, we construct a buffer of 10km around each point[9], and we define a point as affected by the wall if it intersects this buffer. By this measure, of the 1001 border points, 22% contained a wall in 2006. By 2010, 51% of the points contained a wall. Column (2) of Table 1 shows that the geography along the border strongly predicts where the wall was expanded: of the 781 border locations that were unwalled in 2006, a wall was 83% less likely to be constructed if the location had a river, 23% less likely to be constructed for every additional kilometer of elevation, and 5% less likely to be constructed for each additional temperature degree (capturing the desert area). Columns (4) and (5) add in economic variables and show that the wall was more likely to be constructed in populated areas and was also more likely to be constructed in locations that were hit harder by the Great Recession, as measured by the housing shock from Mian and Sufi (2014). Column (6) adds state fixed effects. Even controlling for geographic heterogeneity, the wall was less likely to be constructed in Texas compared with the three other border states.[10] We consider how this heterogeneity affects our estimates in Section 3

To measure the impact of the border wall expansion on a particular Mexican origin (municipality) - U.S. destination (PUMA, or public use micro-data area) pair, we calculate the distance between the pair along the least cost overland path that avoids a wall. In what follows, we refer to this distance along the least cost route avoiding a border well as "travel time."[11] Our primary measure of wall exposure will be the change in this (log) travel time

[9]We consider robustness to the size of the buffer in Section 3.

[10]This is likely due to the "Roosevelt Reservation," a proclamation by President Theodore Roosevelt in 1907 that set apart a strip of land within 60 feet of the U.S.-Mexico border with California, Arizona, and New Mexico and reserved it from entry, settlements, or operation of public land laws. The Roosevelt Reservation did not apply to Texas because Texas had retained title to all its public lands at the time of annexation in 1845. As a result, the federal government already owned much of the land adjacent to the border in California, New Mexico, and Arizona, and so legal action to acquire the land was not required before building the wall. This was not the case in Texas, where lengthy and costly eminent domain proceedings needed to occur before the start of wall construction (Congressional Research Service (2009); Miller, Collier, and Aguilar (2017)). Consistent with this, Appendix Figure 2 shows when the wall in each state was constructed: the Arizona portion of the wall was constructed first, between 2006 and 2008, whereas the Texan portion was constructed in the latter period of wall building.

[11]To do so, we calculate the least cost overland distance from each location to each point along the border without a wall and find which point minimizes the total distance. Since each point along the border is identified as having a wall if it is within 10km of the border wall, this procedure does not allow small gaps in the wall to impact the measure of exposure (as small gaps in the wall may reflect other deterrents to crossing

between 2006 and 2010 as a result of the wall expansion. Based on this measure 86% of all possible origin-destination pairs were affected by the wall. However, we predict that most migrants can avoid the wall by making small changes to their path: conditional on being affected by the wall, migrants moving between the median pair face a 1.7% increase in travel time, and those moving between the 75th(25th) percentile pair face a 2.1%(1.3%) increase. Those moving between the 95th percentile pair face a 5.0% increase in travel time.

2.2 Data

Our goal is to measure the migration flow between Mexico and the United States as well as the migration stock in each United States destination and Mexican origin. The American Community Survey (ACS) and the Census include information on Mexican migrants. However, only the country of birth, and not any further information about which part of Mexico the individual migrated from, is included, making it difficult to study the exposure of the migrant to the wall. To measure migration between origins in Mexico and destinations in the United States we use the confidential version of the Mexican government's *Matrícula Consular* database.

2.2.1 The Matrícula Consular Database

The Matrícula Consular (Consulate ID card) is a document issued by Mexican consulates in the United States to Mexican citizens residing in the United States. The Matrícula Consular is accepted as an identification document by several financial institutions and government agencies.[12] Applying for a Matrícula Consular is voluntary. To apply, individuals are required to show proof of Mexican citizenship; they do not need to provide proof of legal status in the United States. For this reason, the Matrícula Consular is a particularly valuable form of identification for unauthorized migrants living in the United States. A Matrícula Consular is valid for five years once issued, after which it may be renewed. A renewed card appears as a new entry in the database. We use the confidential version of the Matrícula Consular database which contains the Mexican municipality of birth, the U.S. county the migrant is living in at the time the card is issued, and some demographic information on gender, education, and occupation.[13]

the border). We show that our estimates are qualitatively unchanged if we use a 4km buffer instead.

[12]For example, *Bank on California*, an initiative spearheaded by Governor Arnold Schwarzenegger in 2008 to help Californians open a bank account, encourages banks to accept Consular ID cards as a form of identification. http://www.bankoncalifornia.ca.gov/files/id_requirements.pdf

[13]One shortcoming of the Matrícula data is that we do not observe any labor market outcomes. The Pew Research Center undertook a one-time survey, during 2004–2005, of Matrícula applicants in six different states when they were inside the consulate applying for the ID card. These data give us a snapshot of a

Because take-up of the Matrícula is a choice, the number of Matrículas we observe in a given year will depend on both the flow of migrants and their take-up rate. A decrease in the number of Matrículas across years could therefore reflect a decrease in the take-up rate rather than a decrease in migration. Our primary analysis will exploit the pair-level structure of the data (how many cards were issued to migrants from origin i in destination j) and thus allow us to control for destination-year fixed effects and pair fixed effects.[14] If it is the case that the take-up decision is a destination characteristic (for example, migrants in California feel comfortable applying for a Matrícula ID card, which may signal being an unauthorized migrant, but migrants in Texas do not), then the destination-year fixed effect will control for different (potentially time-varying) take-up rates, and the change in Matrícula IDs will measure the change in migration. If take-up is a time-invariant characteristic at the pair level, then the pair fixed effect will control for this. The challenge will be if take-up is an time-varying pair level characteristic, if, for example, take-up depends on both the destination and the size of one's own network. While we cannot conclusively rule out this possibility, we do not find that Matrícula issuances correlate with Herfindahl indices of migrant concentration, as would be the case if take-up were a function of network size.[15]

Columns (1) and (4) in Appendix Table 2 give summary statistics for the Matrícula database. We observe approximately 850,000 Matrículas Consulares issued per year. 96% of Matrículas are issued to individuals with a high-school education or less. This group is highly likely to be unauthorized: Passel (2007) estimates that 72% of unauthorized migrants have this level of education, compared with 45% of authorized migrants. 64% of the Matrícula ID cards are issued to men. California is the most common destination (with 38% of migrants in

sample of Matrícula applicants. We compare this database to the sample of Mexican-born individuals in the 2005 ACS. Appendix Table 6 shows that the Matrícula applicants are on average slightly younger (31 vs 37 years); slightly less educated (94% of the sample has high school or less as their highest level of completed education, compared with 86% in the ACS); earn slightly less ($334/week, compared with $451/week); and have spent less time in the United States (39% arrived less than five years ago, compared with 17% in the ACS).

[14] While we have observations that come from all 50 U.S. states, Mexico has consulates in only 23 of the 50 states. It is plausible that it is easier for a migrant to visit a consulate if there is one closer to where they are living. We will undertake robustness for this possibility in later empirical sections.

[15] There are two other complications here. The first is that migrants who have been in the U.S. for many years may also apply for a Matrícula card, and so changes in the number of ID cards could reflect a change in the take-up rate of pre-existing migrants. The second is that the Matrícula card is valid for 5 years, after which it is renewed and appears as a new entry in the database. The same identification assumption – that the take-up rate for pre-existing migrants and the renewal rate for matriculas is a destination-level characteristic (i.e. not an origin-destination characteristic) enables the change in ID cards to reflect the change in new migrants. A separate issue is that the migrant stock depends on both migrant entry as well as migrant exit. It may be the case that new migration is entirely offset by migrant exit, leading to an increase in the number of Matrículas issued but no change in the stock of migrants. We show below that the data checks are consistent whether we consider the stock of migrants or the stock of migrants who have arrived within the last five years.

2005–2006, and 31% during 2010–2012), followed by Texas (with 15% of migrants in 2006 and 23% during 2010–2012). Broadly, the Matrícula data suggest a shift away from California and Arizona and into Texas over the study period. The other columns in Appendix Table 2 show the distribution of migrants in the ACS. The same broad patterns are present, with a shift away from California and towards Texas.

The Matrícula data have been used to study migration by Massey, Rugh, and Pren (2010), Clemens (2015), and Caballero, Cadena, and Kovak (2018). These papers use a publicly available version of the data that aggregates migration flows between Mexican municipalities and U.S. states. We use a confidential version of the data that disaggregates the destination to the U.S. county, rather than the state, level. This additional level of spatial disaggregation will prove helpful in the estimation of the structural parameters below as it will allow us to exploit very localized migration networks, providing additional variation in the exposure to the wall. The state-level version of the Matrícula database has been correlated against several measures of migrant stocks in Caballero, Cadena, and Kovak (2018). Since we use the county-level version of the data, we provide checks for the county-level version of the data against Census and ACS data sets in Appendix B.5, where we find that the Matrícula database positively correlates with population counts (looking within PUMA over time) and negatively correlates with population counts when we consider a fixed cohort of individuals (looking within municipality over time) in Mexico.[16]

The highly disaggregated geographical coverage in the confidential Matrícula data allows us to recover rich patterns of migration. To illustrate these patterns, Appendix Figure 3 plots the share of Matrículas Consulares that were issued in California for each origin municipality in Mexico. The figure shows both that there is a geographic pattern to migration (74% of migrants from Baja California migrate to nearby California), but also that geography is not the only predictor of migration (71% of migrants from the Yucatán Peninsula, in the far south of Mexico, also migrate to California). Such patterns likely reflect historical migration patterns and the fact that migration networks are very persistent (Munshi (2003); Card (2001)). Panel (a) and (b) show that the migrant network also differs within California – for example, 32% of migrants from Yucatán go to the Bay Area, whereas migrants from Baja California are much more likely to migrate to Los Angeles, with only 4% moving to the Bay Area.[17] Given this rich heterogeneity in migration destinations, the same event –

[16] At the destination level, a stronger assumption is needed for the assumption for the change in matriculas to reflect the change in new migrants: the take-up rate of matriculas are homogenous across origin groups and across destinations.

[17] Appendix Figure 4 shows similar patterns for migration to Texas, with the role of geography clear through the concentration of migration to Texas from the northeastern states of Coahuila and Nuevo León, but also with a large amount of heterogeneity, especially regarding the location of those who migrate to Dallas instead of Houston.

e.g., the construction of a wall on the border – may therefore have very different effects on how it changes the migration destination of migrants from two different origin municipalities, depending on how exposed they are to the wall as well as their historical migration patterns. Empirically, we will show that accounting for these network effects improves the ability of the model to predict the effects of the wall.

2.2.2 U.S. PUMA-level economic data

We use the ACS and Census waves from 2000–2012 to analyze the impact of migration in the United States. Our unit of analysis is the PUMA (public use microdata area), adjusted to constant boundaries between 2000 and 2010. Dropping observations in Hawaii and Alaska, this yields 1066 unique markets. We follow Borjas, Grogger, and Hanson (2012) and Ottaviano and Peri (2012) in the construction of the sample. The sample includes all adults aged 18–64, who are not residing in group quarters and who have worked at least one week in the year prior to the Census. The wage is defined as the mean log average weekly wage. We omit self-employed workers both from both the computation of wages (following the argument that returns to self-employment may also include returns to non-labor inputs) and from the counts of population. We classify workers into two education groups: high education (if they have completed at least some college) and low education (if they have completed high school or less). We differ from the sample definition used in Borjas, Grogger, and Hanson (2012) in two ways. We include women as well as men and we do not drop people who worked zero hours from the population counts (because not working is likely an endogenous outcome). Our primary sample for the structural estimation and counterfactuals below is the 2000 United States Census ("pre" border wall expansion) and an average across the 2010–2012 ACS ("post" border wall expansion).

2.2.3 Mexican municipality-level economic data

We use the Mexican Census waves from 1990, 2000, 2005, 2010 and 2015. Our unit of analysis is the Mexican municipality, adjusted to consistent boundaries over time. This yields 2331 unique markets in Mexico. We follow the same definition for the variables as we did for the United States data. We compute wages as the monthly income earned adjusted by the number of hours worked. We follow the same education classification and define workers as low education if they have completed high school or less and high education if they have completed some college. We keep self-employed individuals in the income data. Our primary sample for the structural estimation and counterfactuals below is the 2000 and 2010 Censuses ("pre" and "post" border wall expansion, respectively).

2.2.4 Bilateral state-to-state trade flow data

We use the United States Commodity Flow Survey to construct the value of trade shipped from each United States state to each other United States state in the years 1997, 2002, 2007, and 2012. We combine this with the North American TransBorder Freight Database, which allows us to construct the value of trade shipped from each United States state to each Mexican state for the years 2006–2016. Our primary data set compares 2007 ("pre" border wall expansion) and 2012 ("post" border wall expansion) where we have trade flows both within the United States and from the United States to Mexico.

3 The direct impact of a border wall on migration

This section develops an identification strategy based on leveraging changes in pair-level origin-destination flows to separate the effect of the wall from origin and destination shocks.

3.1 Main results

In order to quantify how much each origin-destination pair was affected by the wall expansion, we estimate a gravity model of location decision. This gravity equation will have a structural interpretation in the model we develop in Section 4. We estimate the following equation:

$$\log N_{ijt} = \beta post_t \times \Delta \log traveltime_{ij} + \gamma_{it} + \delta_{jt} + \lambda_{ij} + \varepsilon_{ijt}, \tag{1}$$

where N_{ijt} is the number of migrants from origin i to destination j in year t, $\Delta \log traveltime_{ij}$ is the change in log travel time between origin i and destination j along the least cost overland path that avoids a wall, and γ, δ, and λ are origin-year, destination-year, and origin-destination fixed effects, respectively. That is, controlling for these fixed effects, we look to see if the construction of a wall on the least-cost path between the origin and destination reduced the relative migration flow between the origin and destination. The fixed effects included in this regression control for any destination-year specific shock (for example, the effects of the Great Recession on destination labor markets) as well as any shocks to the origin labor market (such as negative economic shocks). The destination-year fixed effects also control for any differences in take-up of the Matrícula Consular across destinations.[18]

[18]For the destination-year fixed effect to control for takeup it needs to be the case that migrants from different origins have the same takeup rate within a destination. One concern could be that migrants who have a bigger network in the destination have less need for a Matrícula Consular and so takeup for some groups is lower than others. We look at this by examining whether the correlation between Matrículas and the ACS migration counts is weaker is if the location has a higher origin-based Herfindahl index. We do not find any consistent evidence of this. Results are available on request to the authors.

The pair fixed effect absorbs any time-invariant determinants of migration, such as the bilateral distance between two locations or the existence of historical migration networks. In other words, identification comes only from the differential migration response at the pair level, holding constant all origin and destination confounds. We use Matrícula data from 2006 as the pre-period and from 2010 as the post-period. We estimate the equation using weighted least squares or weighted 2SLS, weighting by population in the pre period.[19] To account for spatial correlation in the exposure to the wall we define spatial clusters of 1 degree by 1 degree for the origin and destination, and cluster the standard errors by origin-cluster/destination-cluster.[20]

One immediate concern is that the location of the border wall expansion is endogenous. To estimate Equation 1 we need that the change in log travel time, conditional on origin-year and destination-year fixed effects, to be uncorrelated with the pair-level shock. If this were not the case – for example, the wall was built in locations where migrant flows were expected to increase the most – then OLS estimation of Equation 1 may understate the effect of the wall on migration. To address this concern we use geographic variation along the border – elevation, river, and temperature – to construct a predicted wall expansion of the same size that actually occurred (that is, we use Column (2) of Table 1 and then rescale the predicted wall to have the same length as the actual wall). We then compute the predicted change in travel time if the wall were built in our predicted locations as an instrument for the actual change in travel time. The identification assumption is that the topography at the point that one crosses the border is uncorrelated with bilateral pair specific unobserved shocks to migration, conditional on origin-year and destination-year fixed effects.

A second, related, concern is that because the wall is a shock that is inherently spatial, then characteristics of the pair (such as distance to the border) may be mechanically correlated with the exposure to the wall. Appendix Table 1 shows how the actual travel time change (Column (1)) and the predicted travel time change (Column (2)) correlate with characteristics of the origin, destination, and the pair. In addition to distance, pairs with higher baseline migration (likely because shorter distances are correlated with higher levels of migration), and origin and destination industry composition received a larger shock. These correlations are present both for the actual change in travel time as well as our predicted change in travel time. We show event studies in Appendix Figure 5 that find no evidence

[19]We weight due to heteroskedasticity. We run the diagnostic tests for heteroskedasticity suggested by Solon, Haider, and Wooldridge (2015). The results (available on request) provide evidence of heteroskedasticity. The unweighted regressions, reported in Appendix Table 8, have coefficients that are consistent with the weighted regression, albeit less precisely estimated. This is expected given the diagnostic tests.

[20]Appendix Table 9 shows that results are robust to alternative spatial and non-spatial clustering of the standard errors.

that pairs with a higher wall shock were on a differential migratory trend before the wall, which we take as reassuring evidence that our effects are not driven by characteristics of the pairs that were treated by the wall. Nonetheless, we include time trends for all origin-specific, destination-specific, and pair-specific variables in our estimating equation.[21] We find that these time trends do not affect the point estimate.

Finally, this discussion suggests that there may be important heterogenous effects – for example, if the wall has diverted migrants onto more difficult paths, or if the effect of the wall is different for pairs closer to the border – which we consider below.

The results of estimating Equation 1 are in Table 2. Columns (1) – (3) show the OLS regressions. We find a negative elasticity of migration flows to the wall, with an elasticity of 10% (considering observations where we see positive migration flows); 13% (considering the elasticity to 1 + the number of migrants, to include observations with zero observed migration); and 14% (considering the elasticity to the inverse hyperbolic sine of the number of migrants). Columns (3) – (6) report the reduced form estimates. We estimate an elasticity of between 11% and 18%. Columns (7) – (9) show the instrumental variable estimates.[22] We estimate an elasticity between 14% and 27%. The IV elasticities are larger than those estimated by OLS, consistent with the wall being built in locations that were expected to receive larger flows of migrants.

To give a sense of the magnitude of our estimates, we conduct a simple back-of-the-envelope calculation and predict the total change in migration, weighting by pre-period flows, holding constant all fixed effects in the regression. This tells us that the (partial equilibrium) *direct* effect of the Secure Fence Act is to reduce total migration from Mexico to the United States by 0.5%. Of course, such a number is fraught for two reasons: first, it ignores the possibility that the Secure Fence Act led to an overall decrease (or increase) in total migration from a particular origin; second, it ignores the possibility that the benefits of migrating to a particular destination may change as a result of the Secure Fence Act (e.g., by changing the wages or prices). (These effects are absorbed by the origin-year and destination-year fixed effects in the gravity regression, respectively). A main contribution of our paper is to estimate the total economic impacts of the Secure Fence Act (including these two indirect effects), which we do in Section 5 below by combining this estimated elasticity with a general equilibrium spatial model.

[21]In practice, this only requires an explicit time trend for the pair-level variable, baseline migration, as time trends in origin-specific and destination-specific variables are already included by the origin-year and destination-year fixed effects.

[22]We report the first-stage regressions for the IV results in Appendix Table 7.

3.2 Robustness

Several other concerns remain. Appendix Table 10 consider several possibilities. First, Column (2) shows that including a time trend in pre-migration flows does not affect the point estimate. Second, our main specification pools together the vehicular and pedestrian fences. Column (3) of Table 3 shows that the effects are larger for a pedestrian fence, which is reassuring, as internal U.S. government documents suggest that vehicular fences were not designed to prevent migrants from crossing the border on foot (United States Government Accountability Office (2017b)).[23] Third, Column (4) shows that the results are robust to using a buffer for the fence of 4km instead of 10km (the elasticity is larger, but this is offset but a much smaller increase in travel time). Fourth, although we control for a rich set of fixed effects, which help alleviate concerns about specific labor market or political shocks in the destination, it could be the case that there are time-varying shocks at the pair level that are not absorbed by the origin-year and destination-year fixed effects. For example, although the overall effect of the Great Recession is absorbed by the destination-year fixed effects, if certain origins have many migrants who work in the construction sector, these origins may have been much more affected by the Great Recession. To examine this, we include a measure of the share of migrants in the baseline who report working in the construction sector interacted with a measure of the intensity of the housing shock taken from Mian and Sufi (2014). Column (5) shows that, after allowing for these pair-level shocks, the estimated effect of the wall is almost unchanged. Column (6) of the same table shows that the elasticity is robust to controlling for Border Patrol resources along each sector, which measures the intensity of staffing along the border. Another concern is that the results may be driven by specific subgroups. We show that the estimated elasticity is stable if estimated for only the 23 states that have Mexican consuls (Column (7)), or if very large flows are dropped (Column (8)). Column (9) shows the result of nonparameterically estimating the effect of the wall by allowing the wall to have a separate effect for each quintile of the shock. The results show that, in general, locations that received a larger wall shock faced larger declines in migration, although there is a small amount of non-linearity for locations that were barely affected by the wall.

Finally, we may expect that the effects of the wall depend on the initial characteristics of the location, either at the border crossing location or at the pair level. Appendix Table 11 considers the effect of geographical characteristics at the border-crossing location itself. Appendix Table 12 considers heterogenous effects based on baseline characteristics (which

[23]The rest of the estimation is robust to creating an instrument based on the pedestrian fence only; although the point estimate is larger, only half the fence constructed was pedestrian, so the net effects we estimate are similar.

have all been transformed into standardized normal variables) of the migration pair. The effect of the wall is always negative for the median observation.

3.3 Additional evidence

Our measure of wall exposure assumes that migrants will choose to cross the border at different locations to avoid the wall. It is useful to verify if this is a reasonable modeling choice. We use a second data set, the *Encuestas sobre Migracíon en las Fronteras Norte y Sur de México* (EMIF), which surveys migrant workers in 17 border cities that are traditionally used as crossing points, to provide additional evidence that the wall did indeed change the location where people crossed the border. By design, these border cities are high-traffic locations; 60% were already fenced before the Secure Fence Act, and this increased to 90% after the Secure Fence Act.[24] We use the expansion of the wall and show in Appendix Table 13 that individuals were 3 percentage points (or 51%) less likely to report planning to cross at one of 17 high-frequency border crossing points after a wall was built at that location.

Another measure of border crossing activity is apprehensions by the U.S. Border Patrol.[25] The Southern border is divided into nine border sectors, as shown in Appendix Figure 10. To a first approximation, the wall expands in all the border sectors except for three sectors in Texas – Big Bend, Del Rio, and Laredo. We plot the apprehensions of Mexican nationals by sector in Appendix Figure 11.[26] The figure shows that annual apprehensions of Mexican nationals on the U.S.-Mexico border declined from 1.6 million in 2000 to 400,000 in 2010. While the other six sectors saw share decreases in apprehensions between 2007 and 2010 (although this decline started earlier than 2007 in some sectors) the three unwalled sectors in

[24] A detailed description of the data can be found at https://www.colef.mx/emif/eng/index.php. Some care should be taken interpreting these data; given the clandestine nature of much of the cross-border migration, it would be difficult to survey a truly representative group of migrants. The survey itself also takes place at locations which are widely considered to be common border crossing points; migrants who choose to cross at these points may differ from migrants who choose to cross at less common crossing points. It is also the case that many migrants are not successful at crossing: estimates of the apprehension rates of crossing the border fall in the range of 30%-40% (Massey, Durand, and Malone (2003)), and so a survey of those attempting to cross the border will not necessarily be representative of those who successfully cross the border. Nonetheless, the data provide rich insight into intended migration patterns and allow us to study the choice of border crossing.

[25] Apprehension data is an imperfect measure of border crossing activity as it may be that both the apprehension probability as well as the number of attempts change when a wall is built. It is also the case that people may be changing their border crossing locations due to differential labor market opportunities in different states and not because of the wall.

[26] The plot for non-Mexican nationals is included in Appendix Figure 11 for comparison. Over the period 2000—2010, 94% of apprehensions on the Southern border were Mexican nationals. This number decreases to 58% after 2010, primarily because of the 2014 crisis resulting from entry of large numbers of unauthorized Central American children. Most of these migrants turned themselves in at the Rio Grande Valley sector, and so this explains the spike in apprehensions in that sector shown on the figure.

Texas had low but stable apprehensions across the period, yielding some suggestive evidence that migrants were less likely to be apprehended in border sectors after a wall was built.[27]

Taken together, these results suggest that the wall changed relative migration patterns between Mexico and the United States, although our estimates imply that the direct impact on migration was small. However, this direct impact does not consider any possible indirect impacts the wall might have had by changing underlying returns to migration and leading to general equilibrium effects. We now turn to a framework that allows us to characterize such general equilibrium effects.

4 Theoretical framework

In this section, we present our theoretical framework. The framework embeds the labor market structure featuring imperfectly substitutable labor types differing in skill and nativity developed in the immigration literature[28] into a general equilibrium "quantitative" spatial framework[29] where outcomes are intertwined across labor markets through both the costly movement of goods (i.e. trade) and people (i.e. migration). The framework serves three purposes: first, it allows us to quantify the indirect economic impacts of the Secure Fence Act; second, it allows us to assess the welfare effects of the wall expansion on different types of labor in different locations; and third, it allows us to compare the Secure Fence Act to other large-scale counterfactual policies.

4.1 Setup

Consider a world comprising $i \in \{1, ..., N\} \equiv \mathcal{N}$ locations and inhabited by workers of two different skills s (high-skill h and low-skill l) and two different nationalities n (Mexican M and United States U), each endowed with a unit of labor which they supply inelastically. In each location $i \in \mathcal{N}$, the four types of workers combine their labor to produce a differentiated

[27] Analysis undertaken by the Congressional Research Service on an earlier period of fence building in the San Diego sector found decreases in apprehensions in that sector coinciding with Operation Gatekeeper, which built a fence along the San Diego border during 1995—1998. The analysis found increases in apprehensions in other sectors of the border, which the authors interpret as evidence that the fence shifted the crossing location for migrants (Congressional Research Service (2009)).

[28] See, for example, the works of Katz and Murphy (1992); Card (2001); Borjas (2003); Borjas and Katz (2007); Ottaviano and Peri (2012) and the excellent review article of Dustmann, Schönberg, and Stuhler (2016).

[29] See, for example, the works of Allen and Arkolakis (2014); Tombe and Zhu (2015); Burstein, Hanson, Tian, and Vogel (2017); Monte, Redding, and Rossi-Hansberg (2018); Redding (2016) and the excellent review article of Redding and Rossi-Hansberg (2017).

variety of good using a nested constant elasticity of substitution (CES) production function:

$$Q_i = \left(\sum_{s \in \{h,l\}} \left(\left(\sum_{n \in \{M,U\}} A_i^{n,s} \left(L_i^{n,s}\right)^{\frac{\rho_s - 1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s - 1}} \right)^{\frac{\rho - 1}{\rho}} \right)^{\frac{\rho}{\rho - 1}}, \tag{2}$$

where $A_i^{n,s} > 0$ is the productivity of a worker of nationality n and skill s in location i, $\rho_s \geq 1$ is the elasticity of substitution across the nationalities of workers of a skill s, and $\rho \geq 1$ is the elasticity of substitution across high-skill and low-skill workers.[30]

Production occurs under perfect competition and a worker in location i of nationality n and skill s is paid a wage $w_i^{n,s}$ equal to her marginal product:

$$w_i^{n,s} = p_i \times Q_i^{\frac{1}{\rho}} \times \left(\left(\sum_{n \in \{M,U\}} A_i^{n,s} \left(L_i^{n,s}\right)^{\frac{\rho_s - 1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s - 1}} \right)^{\left(\frac{1}{\rho_s} - \frac{1}{\rho}\right)} \times A_i^{n,s} \times \left(L_i^{n,s}\right)^{-\frac{1}{\rho_s}}, \tag{3}$$

where p_i is the equilibrium price of the differentiated variety produced in location i, which from perfect competition and the production function above can be written as:

$$p_i = \left(\sum_{s \in \{h,l\}} \left(\left(\sum_{n \in \{M,U\}} \left(A_i^{n,s}\right)^{\rho_s} \left(w_i^{n,s}\right)^{1-\rho_s} \right)^{\frac{1}{1-\rho_s}} \right)^{1-\rho} \right)^{\frac{1}{1-\rho}}.$$

The movement of goods across locations are subject to "iceberg" frictions. Let $\tau_{ij} \geq 1$ be the number of units of a good shipped from location $i \in \mathcal{N}$ in order for one unit of the good to arrive in location $j \in \mathcal{N}$; as a result, the price of a differentiated variety from location $i \in N$ in location $j \in \mathcal{N}$ is $p_{ij} = \tau_{ij} p_i$. Workers of all types in all locations have identical CES preferences over the differentiated varieties with constant elasticity of substitution $\sigma \geq 1$ so their indirect utility can be written as:

$$W_i^{n,s} = \frac{w_i^{n,s}}{P_i} u_i^{n,s},$$

[30] While our framework abstracts from capital, it is formally isomorphic to a setting where capital is perfectly mobile across locations and hence rent is equalized, see Allen and Arkolakis (2014). The model can be extended to incorporate immobile capital (i.e. a fixed factor of production) by assuming that the productivity of workers is a function of the number of workers within a labor market, thereby creating diseconomies of scale. Note, however, that even with a constant returns to scale production function in labor, because there are many labor markets varying in their levels of productivity, a reallocation of labor across labor markets can have impact aggregate output – something that is not true in frameworks that assume a single national production function (see e.g. Ottaviano and Peri (2012)).

where $P_i \equiv \left(\sum_{j\in\mathcal{N}} \left(\tau_{ji} p_j\right)^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$ is the Dixit-Stiglitz price index and $u_j^{n,s}$ is a type-specific amenity for each location.

The movement of people across locations are also subject to "iceberg" frictions. For simplicity, we take the initial distribution of different types of labor across locations $\left\{L_{i,0}^{n,s}\right\}$ as exogenous and treat the migration decision as static. In particular, we suppose that for each type of labor in each initial location, there is a continuum of heterogeneous workers $\nu \in \left[0, L_{i,0}^{n,s}\right]$ who chooses where to live in order to maximize her welfare:

$$U_i^{n,s}(\nu) = \max_{j\in\mathcal{N}} \frac{W_j^{n,s}}{\mu_{ij}^{n,s}} \varepsilon_{ij}^{n,s}(\nu), \tag{4}$$

where , $\mu_{ij}^{n,s} \geq 1$ is a migration friction common to all workers moving from $i \in \mathcal{N}$ to $j \in \mathcal{N}$ of type $\{n, s\}$, and $\varepsilon_{ij}^{n,s}(\nu)$ is an migration friction idiosyncratic to worker ν drawn from an extreme value (Fréchet) distribution with shape parameter $\theta^{n,s} \geq 0$.

Some terminology is helpful in what follows. We refer to the set of $(5N^2)$ parameters $\left\{\tau_{ij}, \mu_{ij}^{n,s}\right\}_{i,j,\in\mathcal{N}\times\mathcal{N}}^{n\in\{U,M\},s\in\{h,l\}}$ as the *bilateral frictions* and the set of $(8N)$ parameters $\left\{A_i^{n,s}, u_i^{n,s}\right\}_{i\in\mathcal{N}}^{n\in\{U,M\},s\in\{h,l\}}$ as the *location fundamentals*; together, they comprise the *geography* of the world. The seven parameters $\{\rho, \rho^s, \sigma, \theta^{n,s}\}_{n\in\{U,M\},s\in\{h,l\}}$ we refer to as the *model elasticities*. Finally, we refer to the $(8N)$ endogenous outcomes $\left\{w_i^{n,s}, L_i^{n,s}\right\}_{i\in\mathcal{N}}^{n\in\{U,M\},s\in\{h,l\}}$ as the *location observables*.

4.2 Migration and Trade Gravity Equations

Given the initial distribution of the population and a set of wages and prices, the assumed Fréchet distribution yields the following gravity migration equation for the bilateral flow of workers of nationality n and skill s from location i to location j:

$$L_{ij}^{n,s} = \left(\mu_{ij}^{n,s}\right)^{-\theta^{n,s}} \left(\frac{w_j^{n,s}}{P_j} u_j^{n,s}\right)^{\theta^{n,s}} \left(\Pi_i^{n,s}\right)^{-\theta^{n,s}} L_{i,0}^{n,s}, \tag{5}$$

where $\Pi_i^{n,s} \equiv \left(\sum_{j\in\mathcal{N}} \left(\mu_{ij}^{n,s}\right)^{-\theta^{n,s}} \left(\frac{w_j^{n,s}}{P_j} u_j^{n,s}\right)^{\theta^{n,s}}\right)^{\frac{1}{\theta^{n,s}}}$ is a migration "price-index" that is (proportional to) the expected welfare of workers of nationality n and skill s initially residing in location i.

Similarly, given the assumed perfect competition and iceberg trade costs, consumer preferences over the differentiated varieties yield the following gravity trade equation of the value of trade flows from location i to location j:

$$X_{ij} = \tau_{ij}^{1-\sigma} p_i^{1-\sigma} P_j^{\sigma-1} E_j, \tag{6}$$

where E_j is the total expenditure of all agents residing in location j.

4.3 Equilibrium

Given a geography of the world, the model elasticities, and the initial distribution of population $\left\{L_{i,0}^{n,s}\right\}$, the equilibrium of the model is defined by a set of location observables such that:

1. Given wages and the price index, the number of workers of each type in each location is equal to the total flows of workers to that location:

$$L_i^{n,s} = \sum_{j \in \mathcal{N}} \left(\mu_{ji}^{n,s}\right)^{-\theta^{n,s}} \left(\frac{w_i^{n,s}}{P_i} u_i^{n,s}\right)^{\theta^{n,s}} \left(\Pi_j^{n,s}\right)^{-\theta^{n,s}} L_{j,0}^{n,s} \tag{7}$$

2. Given the number of workers in each location, the quantity produced of the differentiated variety in each location is given by the production function from Equation (2).

3. Given the number of workers in each location, the equilibrium price of the differentiated variety, and the quantity produced of the differentiated variety, the equilibrium wage of each type of worker in each location is equal to its marginal product given by Equation (3).

4. Given the equilibrium quantity produced of the differentiated variety in each location, equilibrium prices are determined by the income and expenditure of a location being equal to its total sales (i.e. market clearing):

$$p_i Q_i = \sum_{j \in \mathcal{N}} \tau_{ij}^{1-\sigma} p_i^{1-\sigma} P_j^{\sigma-1} p_j Q_j \tag{8}$$

In what follows, we focus on the steady state equilibrium where the initial spatial distribution of labor of each type is equal to the equilibrium spatial distribution of labor of each type, i.e. $L_i^{n,s} = L_{i,0}^{n,s}$ for all $i \in \mathcal{N}$, $n \in \{M, U\}$, and $s \in \{h, l\}$.

Despite the many locations, multiple types of workers, and flexible bilateral frictions and location fundamentals, we are able derive sufficient conditions for the existence and uniqueness of the equilibrium. We first state a more general theorem that encompasses a large class of spatial gravity models before deriving the sufficient conditions for existence and uniqueness of our model as a corollary. While previous work has provided such conditions for systems of log-linear equilibrium equations arising from gravity models with multiple factors of production combined in Cobb-Douglas production functions,[31] to our knowledge, the following theorem is the first to allow for multiple factors of production combining with non-unit elasticities of substitution:

Theorem 1. *Consider any $N \times K$ system of Equations $F : \mathbb{R}_{++}^{N\times K} \to \mathbb{R}_{++}^{N\times K}$:*

$$F(\mathbf{x})_{ik} \equiv \sum_j K_{ij,k} \prod_{l=1}^{K} (x_{j,l})^{\alpha_{k,l}} \prod_{l=1}^{K} (x_{i,l})^{\lambda_{k,l}} \prod_{m=1}^{M} P_m(\mathbf{x}_j)^{\gamma_{k,m}} \prod_{m=1}^{M} P_m(\mathbf{x}_i)^{\chi_{k,m}},$$

where $Q_m(\cdot)$ are nested CES aggregating functions:

$$P_m(\mathbf{x}_j) \equiv \left(\sum_{l \in S_m} \frac{1}{|S_m|} \left(\left(\sum_{n \in T_l} \frac{1}{|T_n|} (x_{j,n})^{\delta_{m,l}} \right)^{\frac{1}{\delta_{m,l}}} \right)^{\beta_m} \right)^{\frac{1}{\beta_m}},$$

where $\delta_{m,l} > 0$ and $\beta_m > 0$ for all m and l, $\{K_{ij,k}, U_l, T_{j,n}\}$ are all strictly positive parameter values; S_m and $T_{l,m}$ are (weak) subsets of $\{1, ..., K\}$; and $\{\alpha_{k,l}, \lambda_{k,l}, \gamma_{k,m}, \chi_{k,p}\}$ are all real-valued.

If $\max_{k\in\{1,...,K\}} \left(\sum_{m=1}^{M} |\gamma_{k,m}| + \sum_{l=1}^{K} |\alpha_{k,l}| + \sum_{m=1}^{M} |\lambda_{k,m}| + \sum_{m=1}^{M} |\chi_{k,m}| \right) < 1$, then there exists a unique fixed point $F(\mathbf{x}^*) = \mathbf{x}^*$.

Proof. See Appendix A.1. □

It is straightforward to see how the system of equilibrium conditions in our framework falls into the framework considered by Theorem 1 (see Appendix A.2 for details). As a result, the following corollary follows immediately:

Corollary 1. *Given any geography with symmetric trade costs and migration costs, there exists a unique strictly positive set of location observables if the trade elasticity and migration elasticity are sufficiently small. In particular, $\theta^{n,s} < \frac{1}{2}\left(\frac{\sigma-1}{4\sigma-3}\right)$ $\forall n \in \{M, U\}, s \in \{h, l\}$ and $\sigma < \frac{5}{4}$.*

Proof. See Appendix A.2. □

Unfortunately, Corollary 1 does not directly apply to the empirical setting we consider below for two reasons: first, we allow for asymmetric migration costs (as the border wall affects the cost of migrating from Mexico to the United States but not vice versa); second, it

[31] See e.g. Karlin and Nirenberg (1967); Zabreiko (1975); Kennan (2001) for existence and uniqueness conditions of systems of non-linear operators, Allen and Arkolakis (2014) for the application of such theorems to log-linear spatial models with many locations and a single spatial linkage, and Allen, Arkolakis, and Li (2016) for the generalization to log-linear spatial models with many locations and many spatial linkages.

turns out that the trade and migration elasticities we ultimately estimate do not satisfy the conditions provided by Corollary 1. Still, we present the theoretical results in the hope they will prove helpful future spatial models that move beyond log-linear equilibrium relationships.

5 Estimation

In this section, we estimate the structural parameters from the model presented in Section 4. To do so, we derive a series of straightforward estimating equations that can be implemented using an instrumental variables regression strategy using the construction of portions of the U.S.-Mexico border wall discussed in Section 3 for identifying variation. We first derive the estimating equations for each of the model elasticities (i.e. the elasticities of substitution between different types of labor in the production function (i.e. ρ_l, ρ_h, ρ); the migration elasticity of each type of worker $\{\theta^{n,s}\}$ for $n \in \{M, U\}$ and $s \in \{h, l\}$; and the elasticity of substitution σ which governs the trade elasticity). We then show how the location fundamentals (i.e. the productivity $A_i^{n,s}$ and amenity $u_i^{n,s}$ for $n \in \{M, U\}$ and $s \in \{h, l\}$ in each location in each location $i \in \{1, ..., N\}$) can be uniquely identified to rationalize the observed data given the estimated parameters.

Our estimation strategy exploits the nested CES framework that has been extensively used to study the impact of immigration on wages (see, e.g. Katz and Murphy (1992); Card and Lemieux (2001); Borjas (2003); Borjas and Katz (2007); Ottaviano and Peri (2012)Katz and Murphy (1992); Card and Lemieux (2001); Borjas (2003); Borjas and Katz (2007); Ottaviano and Peri (2012)).[32] By showing that these estimation approaches pioneered in the immigration literature can be applied in a general equilibrium context where labor markets are linked through trade and migration, the paper helps bridge the gap between the large immigration literature and the growing "quantitative spatial" literature.

5.1 Estimating elasticities of substitution between worker types

We first estimate the elasticity of substitution of U.S. and Mexican workers within a skill group. Taking ratios of Equation (3) across the two worker types, then taking logs and

[32]The literature has identified several empirical issues with this methodology. One concern is whether migrants face occupational downgrading, where they work in occupations lower than their level of education would predict. This issue may be particularly important for recently-arrived migrants, who e.g. may not yet be certified to work in their area of training, and may lead to under-estimates of the substitutability of native and non-native workers (see, e.g, the discussion in Dustmann, Schönberg, and Stuhler (2016)). Another concern with the approach is that it ignores labor supply decisions of native workers, assuming that labor supply shocks come only from immigration (see also the discussion in Dustmann, Schönberg, and Stuhler (2016), and recent extensions by Llull (2018); Piyapromdee (2019)).

first-differencing yields the following expression:

$$\Delta \ln \left(\frac{w_i^{M,s}}{w_i^{U,s}} \right) = -\frac{1}{\rho_s} \Delta \ln \left(\frac{L_i^{M,s}}{L_i^{U,s}} \right) + \Delta \ln \frac{A_i^{M,s}}{A_i^{U,s}} \; \forall s \in \{h, l\}, \tag{9}$$

where Δ indicates a first-difference (i.e. $\Delta x_i = x_{i,t+1} - x_{i,t}$). Hence, if one can find an instrument for the change in the relative supply of labor in a location that is orthogonal to the change in relative productivity, we can use Equation (9) to estimate the elasticity of substitution between worker nationalities, ρ_s. We discuss such an instrument below.

Given estimates of ρ_l and ρ_h, we can proceed similarly to estimate the elasticity of substitution between the high and low skilled labor. Define $\tilde{p}_i^s \equiv \left(\left(\frac{w_i^{M,s}}{w_i^{U,s}} \right) \left(\frac{L_i^{M,s}}{L_i^{U,s}} \right) \left(w_i^{M,s} \right)^{1-\rho_s} + \left(w_i^{U,s} \right)^{1-\rho_s} \right)^{\frac{1}{1-\rho_s}}$ and $\tilde{Q}_i^s \equiv \left(\left(\left(\frac{w_i^{M,s}}{w_i^{U,s}} \right) \left(\frac{L_i^{M,s}}{L_i^{U,s}} \right)^{\frac{1}{\rho_s}} \right) \left(L_i^{M,s} \right)^{\frac{\rho_s - 1}{\rho_s}} + \left(L_i^{U,s} \right)^{\frac{\rho_s - 1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s - 1}}$ to be combinations of observables that are closely related to the composite price and quantity of skill group s. It can be shown that the elasticity of substitution between high and low-skill labor relates the relative price and quantity of the high and low-skill composites in a location:

$$\Delta \ln \frac{\tilde{p}_i^h}{\tilde{p}_i^l} = -\frac{1}{\rho} \Delta \ln \frac{\tilde{Q}_i^h}{\tilde{Q}_i^l} + \Delta \ln \varepsilon_i, \tag{10}$$

where $\Delta \ln \varepsilon_i \equiv \left(1 - \frac{1}{\rho} \right) \Delta \ln \frac{\left(A_i^{U,h} \right)^{\frac{\rho_h}{\rho_h - 1}}}{\left(A_i^{U,l} \right)^{\frac{\rho_l}{\rho_l - 1}}}$. As above, if we can also find an instrument for the change in the relative composite quantities, we can use Equation (10) to recover the elasticity of substitution ρ.

5.2 Estimating trade and migration bilateral frictions

We next estimate the bilateral frictions. To do so, we use the gravity equation for the flow of people and the flow of goods.

Consider first the estimation of bilateral migration frictions.Taking logs of the migration gravity equation (5) and adding a time subscript yields:

$$\ln \frac{L_{ijt}^{n,s}}{L_{it,0}^{n,s}} = \ln \left(\left(\mu_{ijt}^{n,s} \right)^{-\theta^{n,s}} \right) + \ln \gamma_{it}^{n,s} + \ln \delta_{jt}^{n,s},$$

where $\ln \gamma_{it}^{n,s} \equiv \left(\Pi_{it}^{n,s} \right)^{-\theta^{n,s}}$ is the *push factor* and $\ln \delta_{jt}^{n,s} \equiv \left(W_{jt}^{n,s} \right)^{\theta^{n,s}}$ is the *pull factor* of the migration gravity equation. This equation is equivalent to Regression 1 in Section 3, although here we also include data on migration flows between locations within the United

States and between locations within Mexico in order to estimate migration frictions within countries.[33] To estimate the migration frictions (raised to the migration elasticity), we then use the estimated origin-destination pair fixed effect and for Mexican workers (but not U.S. workers), we increase the migration cost according to the estimated impact of the wall variables:

$$\widehat{\left(\mu_{ijt}^{n,s}\right)^{-\theta^{n,s}}} = \exp\left(\hat{\beta}\log traveltime_{ijt} \times \mathbf{1}\left\{n = M\right\} + \hat{\lambda}_{ij}\right).$$

We pursue a similar strategy for the estimation of the bilateral trade frictions, taking into account that trade flows are observed at the more aggregate state-to-state level.

We take the mean across all locations (i.e. all pairs of municipalities in Mexico and PUMAS in the United States that are within the origin-state-destination-state pair ij) of the *traveltime* variable. Taking logs of the trade gravity equation (6), adding a time subscript, and normalizing the trade flows by own origin trade flows (which, along with an assumption of costless trade within state, allows us to recover the constant in the gravity regression) yielding the following regression:

$$\log\frac{X_{ijt}}{X_{iit}} = \beta\ln traveltime_{ijt} - \delta_{it} + \delta_{jt} + \lambda_{ij} + \varepsilon_{ijt}. \tag{11}$$

Appendix Table 14 presents the results. We find that in the absence of the origin-destination fixed effect and including least cost overland distance rather than travel time avoiding walls, trade flows decline strongly with distance, with an elasticity of -1.25 for domestic trade flows, and an elasticity of -1.81 for international trade flows. (We return to these estimates in Section 6, where we examine what would happen if the international distance elasticity were to decline in magnitude closer to the intra-national distance elasticity). However, with the inclusion of the origin-destination fixed effect and the travel time measure avoiding walls (so that the coefficient on travel time is only identified based on the border wall expansion), we find no evidence that there was a direct impact of the border wall expansion on trade flows.

As we found no evidence that the border wall affected trade flows, we construct a measure of trade costs at the location-pair level (where locations are Mexican municipalities and United States PUMAs), by taking the estimated coefficients on distance from the state-to-state flows using the location-pair distances and allowing distance to have a different

[33]Given that observed migration flows are over one year for the Mexico-United States flows and the within-United States migration flows and over five years for the within-Mexico flows, we scale the number of migrants by ten and two, respectively, to get a measure of the number of people migrating over the ten year period of study (2000 to 2010).

elasticity for domestic and international pairs:

$$\hat{\tau_{ijt}^{1-\sigma}} = \exp\left(\hat{\beta}_0 + \hat{\beta}_1 \ln dist_{ij} + \hat{\beta}_2 \ln dist_{ij} \times \mathbf{1}\left\{intl_{ij}\right\}\right).$$

5.3 Estimating trade and migration elasticities

Given our estimates of the elasticities of substitution in the production function, i.e. $\left\{\rho^h, \rho^l, \rho\right\}$ and the estimates for the bilateral frictions $\left(\mu_{ij}^{n,s}\right)^{\theta^{n,s}}$ and $\tau_{ij}^{1-\sigma}$ along with location observables (i.e. $\{w_i^{n,s}, L_i^{n,s}\}_{i\in\mathcal{N}}^{n\in\{U,M\},s\in\{h,l\}}$), we proceed by estimating the trade and migration elasticities. To do so, define the welfare of worker of type $\{n,s\}$ in location i $W_i^{n,s} \equiv \frac{w_i^{n,s}}{P_i} u_i^{n,s}$. We then rely on the following Lemma:

Lemma 1. *For any set of bilateral frictions (i.e.* $\left\{\tau_{ij}^{1-\sigma}, \left(\mu_{ij}^{n,s}\right)^{\theta^{n,s}}\right\}_{i,j,\in\mathcal{N}\times\mathcal{N}}^{n\in\{U,M\},s\in\{h,l\}}$*) and location observables (i.e.* $\{w_i^{n,s}, L_i^{n,s}\}_{i\in\mathcal{N}}^{n\in\{U,M\},s\in\{h,l\}}$*), there exists a unique (to-scale) set* $\left\{p_i^{1-\sigma}, P_i^{\sigma-1}\right\}_{i\in\mathcal{N}}$ *and a unique (to-scale) set* $\left\{\left(\Pi_i^{n,s}\right)^{-\theta^{n,s}}, \left(W_i^{n,s}\right)^{\theta^{n,s}}\right\}_{i\in\mathcal{N}}^{n\in\{U,M\},s\in\{h,l\}}$.

Proof. See Appendix A.3. □

Applying Lemma 1, we recover the unique (to-scale) push and pull factors of the migration gravity equation (i.e. $\left\{\left(\Pi_i^{n,s}\right)^{-\theta^{n,s}}, \left(W_i^{n,s}\right)^{\theta^{n,s}}\right\}_{i\in\mathcal{N}}^{n\in\{U,M\},s\in\{h,l\}}$) and origin and destination fixed effects of the trade gravity equation (i.e. $\left\{p_i^{1-\sigma}, P_i^{\sigma-1}\right\}_{i\in\mathcal{N}}$). Define $\tilde{p}_i \equiv \left(\left(\tilde{p}_i^h\right)^{1-\rho} + \left(\frac{\tilde{p}_i^h\left(\tilde{Q}_i^h\right)^{\frac{1}{\rho}}}{\tilde{p}_i^l\left(\tilde{Q}_i^l\right)^{\frac{1}{\rho}}}\right)^{-\rho}\left(\tilde{p}_i^l\right)^{1-\rho}\right)^{\frac{1}{1-\rho}}$ to be combinations of the observed composite price of the two different skill groups. Then we can regress the origin fixed effect of the gravity trade Equation (recovered from the market clearing conditions) onto this observed composite price as follows:

$$\Delta \ln\left(p_i^{1-\sigma}\right) = (1-\sigma)\Delta \ln \tilde{p}_i + (\sigma - 1)\left(\frac{\rho_h}{\rho_h - 1}\right)\Delta \ln A_i^{U,h}. \tag{12}$$

If we have an appropriate instrument for the change in the composite price in location i that is uncorrelated with the change in local productivities, we can recover the trade elasticity from Equation (12). Intuitively, the extent to which exports decline as the local price rises identifies consumer's elasticity of substitution across goods produced in different locations.

Finally, estimating the migration elasticities is reasonably straightforward. Recall that welfare $W_i^{n,s} \equiv \frac{w_i^{n,s}}{P_i} u_i^{n,s}$, so that we have:

$$\Delta \ln \left(W_i^{n,s}\right)^{\theta^{n,s}} = \theta^{n,s} \Delta \ln \frac{w_i^{n,s}}{P_i} + \theta^{n,s} \Delta \ln u_i^{n,s}. \tag{13}$$

Hence, if we have an appropriate instrument for the change in the nominal wage of labor group $\{n,s\}$ and the price index that is uncorrelated with the change in the local amenity, we can identify the migration elasticity of that group from Equation (13) (along with the trade elasticity). Intuitively, we recover the pull factor in each destination using the labor market clearing condition and regress the change in this pull factor after the construction of the wall on the change in the local real wage to recover the migration elasticity of each labor group.

5.4 Estimating location fundamentals

Once we have estimated all the model elasticities, the following proposition shows that it is possible to recover all location fundamentals from observed data:

Proposition 1. *For any set of model elasticities, bilateral friction , and location observables, there exists a unique (to-scale) set of location fundamentals (i.e. $\{A_i^{n,s}, u_i^{n,s}\}_{i\in\mathcal{N}}^{n\in\{U,M\},s\in\{h,l\}}$).*

Proof. See Appendix A.4. □

Intuitively, the productivity and amenity of each labor type in each location can be chosen so that the observed populations and wages are exactly consistent with the model equilibrium given trade and migration frictions; this result is not particularly surprising, as the location fundamentals play the role of structural residuals in the estimating equations above.

5.5 Using the border wall expansion as an instrument

As is evident from above, to estimate the model elasticities, we need to find instruments for the change in relative United States and Mexican labor of the same skill (i.e. $\Delta \ln \left(\frac{L_i^{M,s}}{L_i^{U,s}}\right)$), the change in the relative supply of high and low-skill labor (i.e. $\Delta \ln \frac{\tilde{Q}_i^h}{\tilde{Q}_i^l}$), the change in good price (i.e. $\Delta \ln \tilde{p}_i$), and the change in the real wage of each labor group, (i.e. $\Delta \ln \frac{w_i^{n,s}}{P_i}$). These instruments must be uncorrelated with changes in the local productivities (i.e. $\Delta \ln A_i^{n,s}$) and amenities (i.e. $\Delta \ln u_i^{n,s}$). We use the border wall expansion due to the Secure Fence Act to construct such an instrument.[34]

[34]The assumed orthogonality of the instrument with each of the four local productivities and four local amenities is why the eight model elasticities can be identified with a single instrument. Moreover, the recursive nature of the model allows us to estimate the model parameters using a sequential series of linear instrumental regressions (rather than having to implement the estimation procedure using GMM), which greatly increases the transparency of the estimation procedure (albeit with a loss of efficiency).

5.5.1 Constructing the border wall exposure instrument

We begin by noting that the model implies that the change in the number of Mexican migrants arriving in a destination (i.e. a U.S. location) j, $\hat{M}_j^{US}$, can be written as:

$$\hat{M}_j^{US} = \hat{\delta}_j \times \left(\sum_{i \in Mex} \left(\frac{L_{ij0}}{M_{i0}} \right) \hat{\kappa}_{ij} \hat{M}_i^{MEX} \times \left(\sum_l \left(\frac{L_{il0}}{\sum_k L_{kl}} \right) \hat{\kappa}_{il} \hat{\delta}_l \right)^{-1} \right)$$

where the "exact hat" notation denotes the ratio of a variable before and after the border wall expansion (i.e., $\hat{x}_i \equiv \frac{x_{i1}}{x_{i0}}$) , $\hat{\kappa}_{ij} \equiv \hat{\mu}_{ij}^{-\theta}$ is the impact of the border wall expansion on migration costs (to the power of the migration elasticity), and we assume a single skill type for simplicity. Intuitively, the first component, $\hat{\delta}_j$ is the direct change in the attractiveness of the destination (for example, through the wage). The second term, $\left(\frac{L_{ij0}}{\sum_k L_{ik}} \right) \hat{\kappa}_{ij} \hat{M}_i$, measures the effect of the wall, weighted by the lagged share of migrants from that origin in the destination population. The third piece accounts for the fact that migrants from origin i make a decision about going to destination j based on how attractive j has become relative to every other possible destination (this is very similar to the concept of multilateral resistance in the trade literature (Anderson and van Wincoop (2003)).) Similarly, the change in the number of migrants departing an origin i (i.e. a Mexican location), $\hat{M}_i^{MEX}$, can be written as $\hat{M}_i^{MEX} = \hat{\gamma}_i \times \left(\sum_{j \in US} \left(\frac{L_{ij0}}{M_{j0}} \right) \hat{\kappa}_{ij} \hat{M}_j^{US} \times \left(\sum_k \left(\frac{L_{kj0}}{M_{j0}} \right) \hat{\kappa}_{kj} \hat{\gamma}_k \right)^{-1} \right)$.

We derive three different measures of the exposure of a location to the border wall expansion that move from the simplest measure of wall exposure toward this expression:

1. Simple wall exposure: We approximate $\hat{M}_j^{US} \approx \sum_{i \in Mex} \hat{\kappa}_{ij}$ and $\hat{M}_i^{MEX} \approx \sum_{j \in US} \hat{\kappa}_{ij}$. This is an unweighted average of the change in travel time (across all origins for a destination in the United States,and, conversely, across all destinations for an origin in Mexico.).

2. Network wall exposure: We approximate $\hat{M}_j^{US} \approx \sum_{i \in Mex} \left(\frac{L_{ij0}}{M_{i0}} \right) \hat{\kappa}_{ij}$ and $\hat{M}_i^{MEX} \approx \sum_{j \in US} \left(\frac{L_{ij0}}{M_{j0}} \right) \hat{\kappa}_{ij}$. This calculates a weighted average in the change in travel time, where the weights are the initial migrant shares. This incorporates for the possibility that different origins have different migration costs to a particular destination (e.g. due to differences in existing migration networks).

3. General equilibrium wall exposure: $\hat{M}_j^{US} \approx \sum_{i \in Mex} \frac{\left(\frac{L_{ij0}}{M_{i0}} \right) \hat{\kappa}_{ij}}{\sum_l \left(\frac{L_{il0}}{\sum_k L_{kl}} \right) \hat{\kappa}_{il}}$ and $\hat{M}_i^{MEX} \approx \sum_{j \in US} \frac{\left(\frac{L_{ij0}}{M_{j0}} \right) \hat{\kappa}_{ij}}{\sum_k \left(\frac{L_{kj0}}{M_{j0}} \right) \hat{\kappa}_{kj}}$. Unlike the network wall exposure, this instrument additionally accounts for the possibility that the wall expansion altered the cost of migrating to other possible destinations

from a given origin (or to a given destination), thereby changing the relative benefit of migrating to a particular destination.

Appendix Figure 6 shows the spatial patterns of the three exposure measures. The more sophisticated instruments have the potential to provide additional identification power, both because they take advantage of the observed rich heterogeneity in pre-expansion bilateral migration flows and because they are closer approximations to the model-consistent expression (to the extent the model is an accurate reflection of reality). However, note that even the last measure of wall exposure fails to account for the direct change in the attractiveness of a destination (or origin), as the gravity regression above cannot separate the change in the push factors $\hat{\delta}_i$ and pull factors $\hat{\delta}_j$ because of the border wall expansion from other economic changes. To calculate such impacts, we turn to a full general equilibrium spatial model below.

5.5.2 Assessing the validity of the wall exposure instrument

Before turning to the results, we briefly assess the validity of the instrument. Our exclusion restriction is that exposure to the Secure Fence Act is uncorrelated with changes in a location's productivities or amenities of any worker type. Note that this is a stronger identification assumption that that required for the gravity regressions where, because we had pair-level data, we only required that the wall was exogenous conditional on origin-year and destination-year fixed effects.

One concern with such an assumption is that the location of the wall expansion may have been built in response to time-varying characteristics of the destination (for example, a location that elects anti-immigrant politicians may both build a wall and have a less-friendly labor market for immigrants). To address this concern, we use the geographical prediction of where the wall was constructed (from Section 3) and related predicted change in travel time to generate a predicted change in migrants. As a result, the identification assumption becomes that the geographical variables that we use to predict the location of the wall expansion are uncorrelated with changes in a location's productivities or amenities.

Due to the spatial nature of the shock, one concern with such an assumption is that the exposure to the border wall construction will be correlated with geographic variables (like the distance to the border), which may be correlated with pre-existing trends in productivities or amenities unrelated to the border wall expansion. Indeed, Appendix Table 15 shows that the predicted change in migration is larger for border states, locations closer to the border, areas with a larger baseline share of the workforce in agriculture, and areas with a smaller baseline share of the workforce in manufacturing, although after controlling for state fixed effects (which we will include in our specification) only distance to border (and the housing shock, for one of the three instruments) remains significant.

To check for the possible presence of pre-existing trends, we estimate event studies of the estimated impact of our measure of border wall exposure for low-skilled Mexico and U.S. populations before, during, and after the border wall expansion. Appendix Panel (i) of Figure 8 depicts the results in the United States (for our preferred general equilibrium network instrument). While the confidence intervals are wide, there is suggestive evidence that the predicted change in migration correlates more strongly with the change in actual migration in the post-wall period. However, there is also some evidence that that once the regression is weighted by the baseline population (panel (c)), locations that receive a larger predicted migration shock in fact see migration falling before the wall. Panel (ii) of Figure 8 considers locations in Mexico. If migrants do not leave, then we expect to see population increase in Mexico, and so again expect to see a positive coefficient. We again find no clear evidence that population increased in Mexico, although the confidence intervals are even wider.

What do we make of these results? Given the small estimated impact of the border wall expansion (and the inconvenient timing concurrent to the Great Recession), it is difficult to ascertain to assert confidently that migration fell most in locations most impacted by the border wall.[35] However, the confidence intervals are wide, and we cannot reject that the wall reduced migration by the amount estimated using the Matrícula bilateral flow data in Section 3. To address concerns of possible pre-existing trends in what follows we will pursue two strategies: first, we will show that our estimation of the structural elasticities are remarkably robust to the inclusion of a large number of controls (including observed pre-trends) and across alternative specifications; second, we will show that our key conclusions regarding the effect of the wall are robust to using parameter values at each extreme range in the literature instead of our own estimates.

5.6 Results

We first consider the estimation of the elasticity of substitution between different workers estimated using Equation (9) and (10). Appendix Table 18 presents the first-stage estimates

[35] We investigate this finding in other datasets. For example, Feigenberg (2017) uses Mexican labor force (ENOE) data to study the time-varying impact of the wall. His study exploits the time variation of when the wall is constructed and finds a large decrease in migration from border municipalities immediately after a wall is constructed. In Appendix C we use the ENOE data to look the change in migration between 2006 and 2010 across all municipalities and do not find any evidence that, over this longer time period, migration rates differentially fell between highly affected locations and less affected locations across the country, consistent with the evidence presented above for the ACS/Census data.

of the three measures of border wall exposure used as instruments; as expected, all three instruments are positively correlated with both relative changes in the ratio of Mexican to U.S. workers within a skill group and negatively correlated with relative high- to low-skill workers. (Recall the instruments are predicted changes in Mexican migrants). However, we should note that the identifying variation is arising almost entirely from locations within the United States. This seems reasonable, as the impact of the border wall on the stock of Mexican workers within Mexico was likely quite small (as we found in the proceeding section, and as the counterfactuals confirm below).

Table 3 reports the second stage results of Regression (9) and (10). Using our preferred "general equilibrium network" instrument, we estimate an elasticity of substitution between United States and Mexican low-skill workers (ρ_l) of 4.5 (with a standard error of 1.5), high-skill workers (ρ_h) of 8.6 (with a standard error of 10.9), and an elasticity between low and high-skill workers (ρ) of 2.0 (with a standard error of 0.6).[36] We will also undertake robustness over very large and very small values of these elasticities.

We next turn to the direct estimate of the trade elasticity using regression (12). Table 4 presents the results. The first column shows the first stage of a regression of the observed change in the price of a good (measured as a CES composite of observed wages for each labor type) on the predicted change in the stock of Mexican workers from the border wall expansion. As expected, for all three instruments, we find that a decrease in the stock of Mexican workers increased the price of the good relative to other less-affected locations, an effect which is strongly significant for the "network" and "GE network" measures and of similar magnitude in both the United States and Mexico. The second column presents the second stage regression of the change in the "exporter fixed effect" recovered from the inversion of market clearing conditions $\Delta \ln p_i^{1-\sigma}$ on the predicted change in the price of goods. We find that the predicted increase in the price of goods is indeed associated with a fall in exports, with an implied elasticity of substitution of $\sigma = 3.1$ (with a standard error of 0.8).[37] We take both the first- and second-stage results as strong evidence of the importance of incorporating spatial linkages through the flow of goods in order to analyze the economic impacts of the wall expansion.

[36] Our estimate of the elasticity between Mexican and U.S. workers are slightly lower than those estimated in the literature: Burstein, Hanson, Tian, and Vogel (2017) estimate a (within occupation) elasticity of 5.6, Ottaviano and Peri (2012) find an elasticity of 12.5, while Piyapromdee (2019) finds an estimate of 18. For the elasticity between high-skill United States and Mexican workers, our estimate is very close to Piyapromdee (2019)'s estimate of 6.9. Our estimate of the elasticity of substitution between low and high-skill workers of 2.1 is very close to the values estimated in Ottaviano and Peri (2012) and Piyapromdee (2019) of 2 and 2.2, respectively.

[37] This estimate implies a trade elasticity of 2.1, which is lower than (but statistically indistinguishable from) the value of 4 typically found in the international trade literature, see e.g. Simonovska and Waugh (2014).

Finally, we estimate the migration elasticities. Appendix Table 19 reports the first stage regression of the change in real wages of each skill group on border wall exposure (where the change in price index $\hat{P}_i$, is recovered using the Lemma (1) and our estimate of σ). While we do find evidence that locations which faced declines in Mexican-born population due to border wall exposure saw declines in real wages for Mexican low-skill workers, we do not find strong evidence of real wages changing for any other labor group (although there is some evidence that real wages of United States high-skill workers increase). Perhaps because of the weakness of the instrument, our estimates of the migration elasticities in the second stage – as presented in Table 5 – are imprecise for all labor types except low-skilled Mexican workers, for whom we actually estimate a marginally statistically significant negative elasticity. Taken together, we interpret these results as suggesting limited re-sorting of labor as a result of general equilibrium changes in labor markets due to the border wall expansion. The literature has found a migration elasticity in the range of 2-4 (Bryan and Morten (2018); Morten and Oliveira (2018); Diamond (2016); Tombe and Zhu (2015); Monte, Redding, and Rossi-Hansberg (2018)); we will use an estimate of 3 for our baseline estimate and then undertake robustness around this value.

Finally, Table 22 implements a number of robustness tests on the full set of structural estimates for the general equilibrium network instrument. Column (1) replicates the estimates from Tables 3, 4, and 5. Because of concerns of possible pre-trends in locations differentially impacted by wall (see Section 5.5.2), Columns (2)-(6) sequentially control for 1990-2000 population growth rates for each labor group; the 2000-2005 population growth rates for each labor group (i.e. controlling for pre-trends directly); (log) distance to the border; the year 2000 agriculture, industry, and manufacturing employment shares in each location; and the United States housing shock as measured by Mian and Sufi (2014). As is evident, the low-skill elasticity of substitution ρ_l, the high-low skill elasticity of substitution, and the trade elasticity σ estimates remain stable across all controls, although the standard errors do increase when all controls are included (in Column (7)). Columns (8)-(10) show how the results change for different specifications. Regardless if the first stage is restricted to have the same effect in both countries (column (8)), or if we use instruments based on the actual location of the wall expansion (column (9)) (instead of the geographic predict wall expansion) or if we restrict the sample to only U.S. locations, we again find similar structural estimates for the structural parameters.[38] While we believe these results are evidence that the structural parameters are robust to a variety of specifications, in the counterfactuals that

[38] Another concern is about whether the selection of immigrants changed after the wall. We estimate a very similiar elasticity of substitution between Mexican and U.S. workers if we use Mincerian residuals instead of wages. This controls for (observable) characteristics of the labor force (results available upon request from the authors).

follow we also consider how altering the parameters to either low or high extremes change our conclusions.

6 The total economic impact of a border wall

In this section, we estimate the steady state economic impact of the Secure Fence Act and then compare it to two alternative policies: one in which the border wall is expanded even further and one in which, instead of a border wall, international trade costs are reduced.

6.1 The Secure Fence Act of 2006

Given our estimated parameter values above, we proceed to estimated the economic impact of the Secure Fence Act. To do so, we first rely on Proposition 1 to identify the underlying geography consistent with the observed data and our model estimates in the year 2000 prior to the Secure Fence Act. We then calculate a new steady state equilibrium in which we adjust the bilateral migration costs to account for Secure Fence Act using the estimates from Section 3, holding constant the underlying geography at its year 2000 level. This allows us to answer the question: What would the impacts of the Secure Fence Act have been on the welfare of each type of worker in every location in the United States and Mexico if nothing else had changed between 2000 and 2010?

Because workers of the same type living in different locations will be impacted differently, we summarize the change in aggregate welfare of a particular group from a policy shock as a weighted geometric mean of the change in expected welfare across all location pairs, where the weights are the pre-period group-specific population shares, i.e. $\log \hat{W}^{n,s} \equiv \sum_{i,j} \left(\frac{L_{ij,0}^{n,s}}{\bar{L}^{n,s}} \right) \log \hat{W}_{ij}^{n,s}$, where $\hat{W}_{ij}^{n,s} \equiv E\left(\widehat{U_i^{n,s}} (\nu) \right) = \frac{\left(\hat{w}_j^{n,s} / \hat{P}_j \right) \hat{u}_j^{n,s}}{\hat{\mu}_{ij}^{n,s}} \left(\frac{\hat{L}_{ij}^{n,s}}{\hat{L}_i^{n,s}} \right)^{-\frac{1}{\theta_{n,s}}}$ is the expected utility of an worker of nationality n and skill s born in location $i \in N$ (see equation (4)). This aggregate welfare function allows for the following convenient decomposition of the impact of the Secure Fence Act on the log difference in welfare of workers:

$$\log \hat{W}^{n,s} = \sum_j \left(\frac{L^{n,s}_{j,0}}{\bar{L}^{n,s}}\right) \left(\underbrace{\log \frac{\hat{p}_j}{\hat{P}_j}}_{\text{“terms of trade”}} - \underbrace{\frac{1}{\rho} \log \left(\frac{\hat{Q}^s_j}{\hat{Q}_j}\right)}_{\text{“relative skill supply”}} - \underbrace{\frac{1}{\rho_s} \log \left(\frac{\hat{L}^{n,s}_j}{\hat{Q}^s_j}\right)}_{\text{“relative nationality supply”}} \right)$$
$$- \sum_{i,j} \left(\frac{L^{n,s}_{ij,0}}{\bar{L}^{n,s}}\right) \left(\underbrace{\log \hat{\mu}_{ij}}_{\text{“direct effect”}} + \underbrace{\frac{1}{\theta_{n,s}} \log \left(\frac{\hat{L}^{n,s}_{ij}}{\hat{L}^{n,s}_i}\right)}_{\text{“idio. preferences”}} \right),$$

where $\hat{x}_i \equiv \frac{x_{i1}}{x_{i0}}$.

The Secure Fence Act (or a policy shock more generally) can affect welfare of a worker group in five ways: (1) it can affect the terms of trade by changing the relative price of the production good (p_j) to the consumption bundle (P_j); (2) it can change the relative scarcity of skill group s (thereby affecting wages); (3) it can change relative scarcity of the nationality n within skill group (also affecting wages); (4) it can directly affect the cost of migrating; and (5) it can affect the expected idiosyncratic preferences of workers by changing patterns of sorting.

Column 1 of Table 6 summarizes the impact of the Secure Fence Act on each labor group, where we convert from percentage changes in welfare to equivalent variation changes in per capita annual real income using U.S. and Mexican real GDP and total population figures from the year 2000.[39] Consider, for example, low-skill U.S. workers. By reducing the number of low-skill Mexican workers in the United States, the Secure Fence Act increased the scarcity of low-skill workers (the “relative skill supply”), increasing the wages of U.S. low-skill workers by \$1.70. However, this effect was almost wholly offset by the fact that there were now more relatively more U.S. low-skill workers than Mexican low-skill workers (the “relative nationality supply”), which decreased wages of U.S. low-skill workers by \$1.46. All told, the benefit of the Secure Fence Act for U.S. low-skill workers was tiny: an equivalent variation annual per capita income increase of \$0.28.

This paltry effect turns out to be the largest positive benefit of the Secure Fence Act, as all other groups of workers were harmed. For Mexican low- and high-skill workers, small increases in their wages due to their increased scarcity in the United States (the “relative

[39] We calculate a year 2000 per capita real income of \$11,549 for Mexican low-skill workers, \$28,789 for Mexican high-skill workers, \$37,504 for U.S. low-skill workers, and \$61,081 for U.S. high-skill workers, all measured in 2012 chained U.S. dollars. Note that the population figures are for the total population, so individuals outside the workforce (e.g. children) are proportioned across skill groups according to the fraction of the workforce each worker type comprises.

nationality supply") were insufficient to offset the direct increased costs of migration due to the wall expansion, with low-skill Mexican workers losing an equivalent of \$0.81 and high-skill Mexican workers losing an equivalent of \$1.82. U.S. high-skill workers were the worst impacted, losing an equivalent of \$2.73, as they became both less scarce as a nationality (the "relative nationality supply") and less scarce as a skill group (the "relative skill supply"). Note that none of these effects account for the direct costs of wall construction, estimated to be \$7 for each person in the United States (see Section 2.1).

What about the aggregate economic impacts? Column (1) of Table 7 summarizes the results. Because the wall expansion resulted in fewer Mexican workers residing in the United States, economic activity was redistributed toward Mexico, increasing real GDP in Mexico by \$0.7 billion and causing real GDP in the United States to fall by \$1.5 billion. In total, we estimate the Secure Fence Act reduced the aggregate Mexican population living in the United States by 0.39%, equivalent to a reduction of 49,956 people. Note that this 0.39% *total* (general equilibrium) decline in migration is smaller than the (0.5%) *direct* (partial equilibrium) decline calculated in Section 3, indicating the importance of accounting for the general equilibrium forces when calculating aggregate impacts. Intuitively, the wall expansion increased the relative scarcity of Mexican workers in the United States, which increased the incentive to migrate, thereby mitigating the direct impact of the increased migration costs. Taken together, this suggests that for each fewer migrant in the United States as a result of the Secure Fence Act, GDP declined by \$30,000 (in addition to the direct costs of wall construction).

How robust are these estimated effects? The top panel of Table 23 reports how the impact of the Secure Fence Act changes as we vary each of the structural elasticities – i.e. the elasticity of substitution across nationalities, the trade elasticity, or the migration elasticities – to values at either the lower or upper end of the range found in the literature. While the aggregate impacts differ quantitatively across parameter constellations, they are qualitatively similar, with a decline in migration of Mexican workers to the United States between 917 (for very low migration elasticities) and 68,173 (for very high elasticities of substitution between U.S. and Mexican workers). Moreover, across all parameter constellations the welfare effects are qualitatively consistent and quantitatively modest: U.S. low-skill workers never benefit more than an equivalent of \$2.32 and may even lose (for very low elasticities of substitution between U.S. and Mexican workers); U.S. high-skill workers are always made no better off; and Mexican low-skill workers are always made worse off. Mexican high-skill workers are usually made worse off, although with a low elasticity of substitution between U.S. and Mexican workers, it is possible for them to benefit (as the positive "relative nationality supply" dominates the negative "relative skill supply"). That the results remain small across all parameter constellations is not particularly surprising, as we are calibrating the model to match the modest changes in migration flows we observe in Section 3.

These aggregate effects belie a substantial amount of heterogeneity across space. The top panel of Figure 2 depicts the change in population of each labor type across space. As is evident, the Secure Fence Act reduced the number of Mexican workers in United States locations most affected by the border wall expansion, causing a redistribution of U.S. workers to these areas. The bottom panel of Figure 2 depicts the change in real wages of each labor type (i.e. $\left(\hat{w}_j^{n,s}/\hat{P}_j\right)$, expressed in equivalent variation changes in per capita real income) across space, which is negatively correlated with the change in population; intuitively, Mexican workers and low-skill U.S. workers residing in locations most affected by the border wall expansion benefit from their relative scarcity. However, the effects of the Secure Fence Act are small in all locations, especially for U.S. workers: no U.S. worker in any location benefits by more than an equivalent increase in annual income of \$5.52.

6.2 Counterfactual #1: Additional border wall

What would happen if the United States had pursued an even greater expansion of the border wall than the Secure Fence Act? To answer this question, we use the geography along the border to predict the locations of a border wall expansion beyond that of the Secure Fence Act. We then construct two counterfactuals, illustrated in Appendix Figure 2, expanding the border wall beyond the Secure Fence Act locations to cover either 25% or 50% of the remaining border with a wall. In each case, we then calculate the expected increase in travel time to avoid a border wall and recalculate the equilibrium, assuming that the impact of the border wall on migration costs through increased travel time is the same as estimated for the Secure Fence Act in Section 3. Because the increase in travel time to avoid the border wall becomes an increasingly large fraction of the total trip as a greater proportion of the border is fenced, such counterfactuals are helpful in assessing whether there are non-linearities in the impact of a border wall.[40]

Columns (2) and (3) of Table 6 summarize the impact of the 25% and 50% wall expansion, respectively, on the welfare of each labor group. We estimate that a more expansive border wall would have qualitatively similar welfare impacts on each labor group that are quantitatively larger (but still small in absolute magnitude). For example, U.S. low-skill workers would on average benefit by \$0.43 by a 25% additional expansion and \$0.47 by a

[40]In the limit where a wall is constructed along the entirety of the border, our measure of travel time becomes infinite. In such a situation, it is possible that potential migrants would find alternative methods of migrating. As a result, we limit our analysis to more modest counterfactual border wall expansions – such as those recently proposed in the U.S. Senate – where extrapolating from the estimated impacts of the Secure Fence Act is more plausible.

50% additional expansion, while all other groups would be made worse off (e.g. U.S. high-skill workers would on average lose \$4.11 by a 25% additional expansion and \$4.78 by a 50% additional expansion). This does not include the direct costs of the construction of additional wall.

Columns (2) and (3) of Table 7 summarize the impacts of a 25% and 50% wall expansion, respectively, on aggregate real output of each country and total migration flows. While larger border walls would have larger impacts on migration from Mexico to the United States, they would also result in greater reallocation of economic activity to Mexico; for example, a wall expansion that builds along half the remaining uncovered border would result in 87,392 fewer Mexican workers residing in the United States, causing the United States real GDP to decline by \$2.6 billion, or approximately \$29,750 in lost economic output for each migrant prevented, which is very similar to the cost per migrant of the Secure Fence Act. As a result, we do not find any evidence that a larger border wall expansion would have substantively different impacts from the Secure Fence Act.

Panels 2 and 3 of Table 23 report how these impacts of a border wall expansion vary across different parameter constellations; across all parameter constellations, the positive impact of a wall expansion on low-skill U.S. workers is always less than \$4.15 and is always exceeded by the negative impact on high-skill U.S. workers.

Figure 3 depicts the change in population (top panel) of each labor type and equivalent variation in real wages (bottom panel) across space as a result of a 25% expansion in the border wall beyond that of the Secure Fence Act. As with the aggregate effects, the spatial distributions of the impact of greater wall expansions are similar to those of the Secure Fence Act.

6.3 Counterfactual #2: Reducing international trade costs

Suppose instead of constructing a border wall to increase migration costs, the United States and Mexico engaged in a policy that reduced international trade costs. In particular, recall in Section 5 we estimated that international trade flows declined more with distance than domestic trade flows. What would be the impact of a policy that reduced the cost of international trade in a way that the caused the relationship between international trade flows and distance to approach the domestic relationship? In particular, we consider two variants in which the additional decline with distance for international trade flows is reduced by 25% or 50%. As with the previous analysis, for both of these variations on reducing international trade costs, we calculate the equilibrium effect of the policy holding constant the geography at its year 2000 level.[41]

Columns (4) and (5) of Table 6 summarize the impact of reducing trade costs on each labor type. Unlike a border wall expansion, all labor groups benefit from a reduction of trade costs. Moreover, the benefits are much larger than the impact of a border wall: for example, we estimate that a reduction in trade costs that moves the international trade costs of distance 25% closer to the domestic cost would increase welfare for low-skill U.S. workers by an amount equivalent to increasing their income by \$57.63. The effects are even larger for U.S. high-skill workers (\$78.27), Mexican low-skill workers (\$100.12), and Mexican high-skill workers (\$244.95). Perhaps not surprisingly, this positive impact is driven almost entirely by improvements in terms of trade, i.e., as trade costs fall, the cost of goods workers consume become less expensive relative to the price of the goods the workers produce.

Columns (4) and (5) of Table 7 summarize the aggregate impact of reducing trade costs. Regardless of the size of the trade cost reduction, we estimate that the number of Mexican workers residing in the United States would decline and the real GDP of both countries would increase. That trade and migration are substitutes it arises from the fact that as a smaller economy, Mexico's terms of trade improve relatively more than the U.S., thereby reducing the incentive of Mexican workers to migrate to the U.S.[42] Indeed, a 25% reduction in trade costs would result in more than twice as large a decline in migration from Mexico to the United States (107,030) than the Secure Fence Act achieved. However, unlike a border wall – which causes real GDP in the United States to fall – a reduction in trade costs would result in increased United States economic output and increased Mexican economic output. For example, a 25% reduction in trade costs would increase real United States GDP by \$7.2 billion, or for each fewer migrant, a benefit (rather than a cost) of about \$67,000. The bottom two panels of Table 23 report how these aggregate impacts of a reduction in trade costs vary across different parameter constellations. While the aggregate impacts differ quantitatively across parameter constellations (especially depending on the assumed trade elasticity), they are qualitatively similar, with a decline in migration of Mexican workers to the United States and an increase in welfare of all labor types.

Figure 4 depicts the change in population (top panel) of each labor type and equivalent variation in welfare (bottom panel) across space as a result of a 25% reduction in trade

[41] While our framework allows for rich patterns for how the gains from trade are distributed across space and worker types, our single-sector model abstracts from the possible unequal gains from trade across occupations and industries, which are likely important margins as well. An interesting avenue for future research would be to extend our framework to incorporate such margins using e.g. the tools developed by Caliendo and Parro (2015), Lee (2018), and Burstein, Hanson, Tian, and Vogel (2017).

[42] It is straightforward to construct alternative geographies for which our framework implies that reductions in trade costs increases migration – hence, in our framework, the degree of substitutability between trade and migration depends on the particular context considered.

costs. As is evident, reducing international trade costs would result in a redistribution of population (and economic activity) closer to the border between the two countries. As a result, the welfare impacts – while positive everywhere – are larger for both U.S. workers and Mexican workers residing near the U.S.-Mexico border, the same locations that are disproportionately impacted by the border wall. Hence, even if the policy objective of the border wall is to benefit low-skill U.S. workers residing along the border, these results suggest that such an objective is better achieved by a reduction in trade costs.

7 Conclusion

In this paper, we provide three contributions to the debate on the economic impact of border walls. First, we combine confidential data on detailed sub-national bilateral migration flows with geographic variation in the 2007-2010 expansion of the United States Mexico border wall. We document that migration flows fell differentially for origin-destination pairs most impacted by the border wall expansion. Second, we develop a general equilibrium spatial model incorporating multiple types of labor and flexible spatial linkages in the flow of people and goods and estimate the key structural parameters of the model using the border wall expansion. Third, we compare the estimated economic impacts of the border wall expansion to a counterfactual policy reducing international trade costs. We find while both reduce the number of Mexican workers to the United States, the reduction in international trade costs is also associated with substantial welfare gains for all labor types, while the border wall expansion is not.

While this paper contributes to a growing literature emphasizing the need to incorporate general equilibrium effects when evaluating the impact of spatial policy in general and immigration policy in particular, we should emphasize that there are likely additional economic forces absent from the model that may be important in reality, e.g. productivity and amenity spillovers across and within labor groups. We look forward to future research incorporating such forces.

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Table 1: Predicting where the wall expansion occurs

	(1) b/se	(2) b/se	(3) b/se	(4) b/se	(5) b/se
River	-0.675	-0.833	-0.867	-0.469	-0.350
	0.035***	0.037***	0.037***	0.052***	0.059***
Elevation		-0.228	-0.213	-0.003	-0.430
		0.033***	0.032***	0.037	0.062***
Temperature		-0.053	-0.051	-0.087	-0.138
		0.007***	0.006***	0.007***	0.008***
Populated			0.198	0.188	0.173
			0.035***	0.033***	0.031***
Housing Shock				3.734	2.283
				0.367***	0.452***
CA					0.719
					0.128***
AZ					0.794
					0.083***
NM					0.498
					0.055***
Mean dep. var	0.365	0.365	0.365	0.365	0.365
N	781	781	781	781	781
r2	0.327	0.401	0.424	0.492	0.559

Notes: The table shows OLS regressions. Dependent variable is having a wall in 2010. An observation is one of the 781 points (out of a total 1001 points) along the border without a baseline wall in 2006. Omitted border state is Texas.

Table 2: Gravity equations: Matrícula data

	OLS			RF			IV		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	log(x)	log(1+x)	asinh(x)	log(x)	log(1+x)	asinh(x)	log(x)	log(1+x)	asinh(x)
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Post x change log traveltime	-0.104	-0.131	-0.142				-0.269	-0.142	-0.160
	0.034***	0.024***	0.026***				0.075***	0.047***	0.050***
Post x change log travel time (pred)				-0.176	-0.113	-0.127			
				0.049***	0.039***	0.042***			
N	451074	4969692	4969692	451074	4969692	4969692	451074	4969692	4969692
First-stage F stat							153.14	276.29	276.29
Mean change travel time var.	0.036	0.018	0.018	0.017	0.018	0.018	0.036	0.018	0.018
Destination-year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Origin-year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Pair FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Est. method	WLS	WLS	WLS	WLS	WLS	WLS	W2SLS	W2SLS	W2SLS
SE clustered at:	spatial	spatial	spatial	spatial	spatial	spatial	spatial	spatial	spatial
Pre-mig trend	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Data: 2006 and 2010 Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. PUMA) pair. Log change travel time is the log change in travel time for the least-cost path between the origin and destination pair. Log change travel time (pred) is the change in travel time for the predicted wall expansion. Standard errors are reported in parentheses. Spatial cluster is origin-cluster (1 degree x 1 degree) x destination cluster (1 degree x 1 degree). If weighted, weighted by migration flow. Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Table 3: Estimation of production function elasticities

	Mex./U.S.: Low skill (1)	Mex./U.S.: High skill (2)	High/low skill (3)
Simple average wall exposure			
Labor ratio	-0.271***	-0.042	-0.590***
	(0.061)	(0.428)	(0.144)
EoS	3.693***	23.897	1.695***
	(0.827)	(244.508)	(0.415)
First-stage F-statistic	1.796	0.773	3.147
Network wall exposure			
Labor ratio	-0.223***	-0.114	-0.518***
	(0.075)	(0.154)	(0.142)
EoS	4.490***	8.784	1.930***
	(1.513)	(11.861)	(0.528)
First-stage F-statistic	4.873	4.512	9.019
GE network wall exposure			
Labor ratio	-0.221***	-0.117	-0.491***
	(0.074)	(0.147)	(0.150)
EoS	4.533***	8.581	2.036***
	(1.521)	(10.852)	(0.624)
First-stage F-statistic	4.835	6.138	5.979
Controls	None	None	None
Fixed Effects	State	State	State
Standard Errors	State clusters	State clusters	State clusters
Weighting	Pre-pop.	Pre-pop.	Pre-pop.
Sample	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.
Observations	3392	3392	3392

Notes: Two stage least squares. Each observation is a (log) difference in a U.S. or Mexico location pre- and post- the SFA. Pre- and post- data come from the 2000 and 2010 censuses in Mexico, respectively; pre- data in the U.S. comes from the 2000 census and post-data come from an average of the 2010-2012 ACS. The dependent variable is the change in relative payments to the two labor types between 2000 to 2010-2012. The independent variable is the change in relative population shares. The construction of each instrument is discussed in the text and briefly summarized in the previous first-stage table. Standard errors are reported in parentheses. Stars indicate statistical significance: * p<.10 ** p<.05 *** p<.01.

Table 4: Estimation of trade elasticity

	(1) First stage	(2) Second stage
Simple average wall exposure		
Simple average wall exposure	-5.243	
	(4.585)	
...X Mexico	197.699*	
	(108.132)	
Change in total payments to labor		-0.377
		(0.387)
EoS b/t goods in different locations (σ)		1.377***
		(0.387)
First-stage F-statistic	2.241	
Network wall exposure		
Network wall exposure	-2.471***	
	(0.806)	
...X Mexico	2.844	
	(5.536)	
Change in total payments to labor		-1.975***
		(0.420)
EoS b/t goods in different locations (σ)		2.975***
		(0.420)
First-stage F-statistic	4.709	
GE network wall exposure		
GE network wall exposure	-2.333**	
	(0.945)	
...X Mexico	3.163	
	(6.164)	
Change in total payments to labor		-2.141***
		(0.756)
EoS b/t goods in different locations (σ)		3.141***
		(0.756)
First-stage F-statistic	3.055	
Controls	None	None
Fixed Effects	State	State
Standard Errors	State clusters	State clusters
Weighting	Pre-pop.	Pre-pop.
Sample	U.S. and Mex.	U.S. and Mex.
Observations	3392	3392

Notes: Two stage least squares. Each observation is a (log) difference in a U.S. or Mexico location prior to the SFA in 2000 to after the SFA in 2010 (in Mexico) or an average across 2010-2012 (in the U.S.). The dependent variable is the change in the origin fixed effect of the trade gravity equation recovered from the goods market clearing condition. The independent variable is the change in the composite goods price calculated from observed wages of each labor group and the estimated elasticities of substitution between groups. The independent variable (the instrument) is either a *simple average fence exposure* which is the unweighted average fence exposure across all origins; a *network wall exposure* which is a weighted average fence exposure across all origins, where the weights are the pre-period migration flows; or a *GE network wall exposure* which in addition to weighting flows by pre-period mirgation flows also accounts for substitution in migration across different destinations by correcting for each orgin's market access; see the text for details. Standard errors are reported in parentheses. Stars indicate statistical significance: * p<.10 ** p<.05 *** p<.01.

Table 5: Estimation of migration elasticities

	(1) Mex Low Skill	(2) Mex High Skill	(3) U.S. Low Skill	(4) U.S. High Skill	(5) Pooled
Simple average wall exposure					
Migration elasticity	-1.007*	0.991	0.171	0.147	0.036
	(0.593)	(1.158)	(0.971)	(0.935)	(0.596)
First-stage F-statistic	8.581	0.679	1.126	2.200	0.538
Network wall exposure					
Migration elasticity	-1.114**	1.178	1.188	-11.684	-0.397
	(0.518)	(1.786)	(1.827)	(22.411)	(0.511)
First-stage F-statistic	22.413	0.748	0.767	0.265	4.112
GE network wall exposure					
Migration elasticity	-1.543*	1.273	1.724	-6.090	-1.130
	(0.856)	(3.277)	(4.459)	(5.102)	(1.101)
First-stage F-statistic	25.258	0.568	0.197	0.664	1.496
Controls	None	None	None	None	None
Fixed Effects	State	State	State	State	State*Type
Standard Errors	State clusters	State clusters	State clusters	State clusters	State clusters
Weighting	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.
Sample	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.
Observations	3392	3392	3392	3392	13568

Notes: Two stage least squares. Each observation is a (log) difference in a U.S. or Mexico location pre- and post- the SFA. Pre- and post- data come from the 2000 and 2010 censuses in Mexico, respectively; pre-data in the U.S. comes from the 2000 census and post-data come from an average of the 2010-2012 ACS. The dependent variable is the (log) change in the labor type specific migration destination fixed effect. The independent variable is the (log) change in the real wage, where the nominal wages are observed and the price indices are calculated from the trade destination fixed effect and the estimated trade elasticity. The construction of each instrument is discussed in the text and briefly summarized in the previous first-stage table. Standard errors are reported in parentheses. Stars indicate statistical significance: * p<.10 ** p<.05 *** p<.01.

Table 6: Counterfactual Results: Welfare

	Secure Fence Act	Additional Border Wall Expansion		Reducing International Trade Costs	
		25% expansion	50% expansion	25% reduction	50% reduction
		Mex. Low Skill (per capita 2012 USD)			
Terms of trade	0.26	0.39	0.45	95.09	318.50
Relative skill supply	0.18	0.26	0.28	1.43	5.32
Relative nationality supply	0.64	0.96	1.15	2.80	9.77
Direct effect	-1.94	-2.93	-3.41	0.00	0.00
Idiosyncratic preferences	0.05	0.10	0.10	0.81	6.42
Total welfare impact	-0.81	-1.22	-1.43	100.12	340.01
		Mex. High Skill (per capita 2012 USD)			
Terms of trade	-0.15	-0.23	-0.26	238.20	792.47
Relative skill supply	-0.18	-0.25	-0.22	-5.96	-23.16
Relative nationality supply	2.60	3.90	4.54	10.76	37.41
Direct effect	-4.22	-6.36	-7.37	0.00	0.00
Idiosyncratic preferences	0.13	0.24	0.25	1.95	15.37
Total welfare impact	-1.82	-2.70	-3.06	244.95	822.09
		U.S. Low Skill (per capita 2012 USD)			
Terms of trade	0.04	0.06	0.07	56.13	188.04
Relative skill supply	1.70	2.57	3.03	7.73	27.23
Relative nationality supply	-1.46	-2.20	-2.64	-6.50	-22.37
Direct effect	0.00	0.00	0.00	0.00	0.00
Idiosyncratic preferences	0.00	0.00	0.00	0.27	2.21
Total welfare impact	0.28	0.43	0.47	57.63	195.11
		U.S. High Skill (per capita 2012 USD)			
Terms of trade	-0.15	-0.22	-0.25	88.97	297.19
Relative skill supply	-2.07	-3.12	-3.63	-9.00	-31.64
Relative nationality supply	-0.51	-0.76	-0.89	-2.06	-7.04
Direct effect	0.00	0.00	0.00	0.00	0.00
Idiosyncratic preferences	0.00	0.00	0.00	0.36	2.87
Total welfare impact	-2.73	-4.11	-4.78	78.27	261.37

Notes: The Secure Fence Act counterfactual calculates the equilibrium effect of the estimated increase in migration costs for Mexican born workers due to the construction of additional segments of border wall. The reducing trade costs counterfactual reduces the additional estimated distance elasticity for international trade over and above the distance elasticity of domestic trade flows by a given percentage. The change in welfare is the change in the population-weighted gemoetric mean of expected welfare across all locations, where the welfare includes real wages, amenities, and idiosyncratic preferences.

Table 7: Counterfactual Results: Aggregate impact

	Secure Fence Act	Additional Border Wall Expansion		Reducing International Trade Costs	
		25% expansion	50% expansion	25% reduction	50% reduction
		Change in Mex. to U.S. migration			
% change	-0.390	-0.584	-0.681	-0.835	-3.195
Absolute change (persons)	-49956	-74937	-87392	-107030	-409761
		Change in U.S. real GDP			
% change	-0.012	-0.018	-0.020	0.056	0.187
Absolute change ($b)	$-1.5	$-2.3	$-2.6	$7.2	$24.1
		Change in Mex. real GDP			
% change	0.048	0.071	0.083	0.840	2.933
Absolute change ($b)	$0.7	$1.0	$1.2	$12.3	$42.8

Notes: The Secure Fence Act counterfactual calculates the equilibrium effect of the estimated increase in migration costs for Mexican born workers due to the construction of additional segments of border wall. The reducing trade costs counterfactual reduces the additional estimated distance elasticity for international trade over and above the distance elasticity of domestic trade flows by a given percentage. Absolute changes in real GDP calculated by scaling the model estimated baseline GDP by year 2000 real GDP for U.S. and Mexico, respectively.

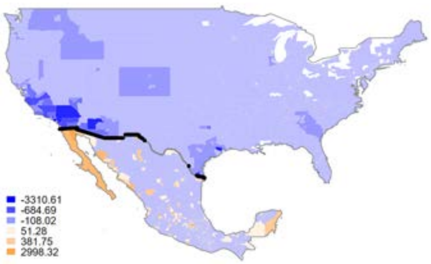
Figure 1: The location of old and new walls on the United States-Mexico border

Notes: Data digitized from Michael Baker Jr. Inc. (2013).

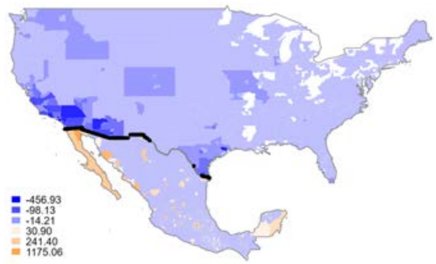
Figure 2: Effect of the Secure Fence Act

Panel (i): Population

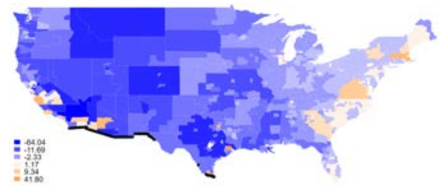
(a) Mex. low-skill



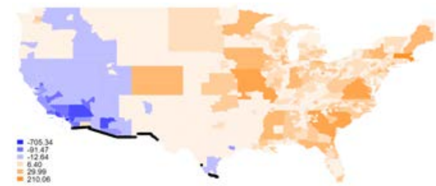
(b) Mex. high-skill



(c) United States low-skill

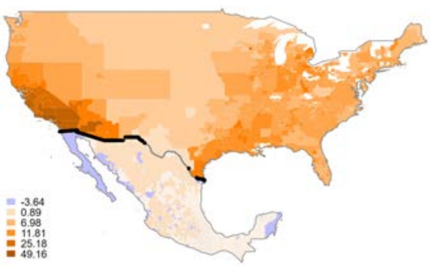


(d) United States high-skill

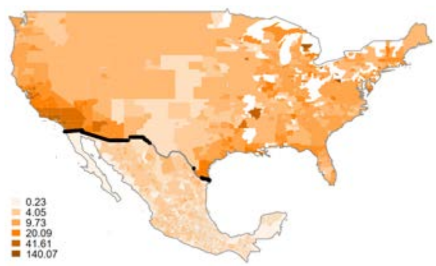


Panel (ii): Real Wages

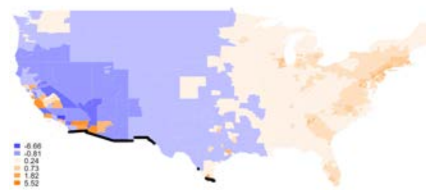
(e) Mex. low-skill



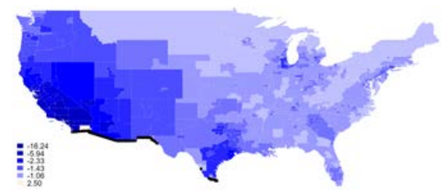
(f) Mex. high-skill



(g) United States low-skill



(h) United States high-skill

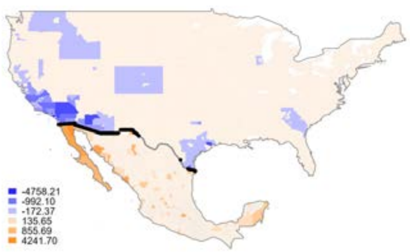


Notes: These figures show effect of the Secure Fence Act (Secure Fence Act) on the spatial distribution of population of each labor type (top panel) and the real wage impact of each labor type (bottom panel). Changes in real wages (i.e. $\left(\hat{w}_j^{n,s}/\hat{P}_j\right)$ are expressed in equivalent variation changes in per capita annual real income, measured in chained 2012 USD.

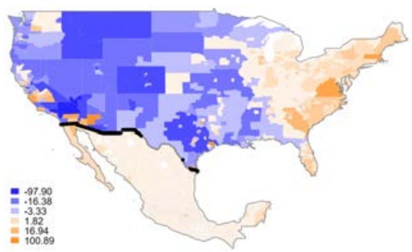
Figure 3: Effect of additional border wall

Panel (i): Population

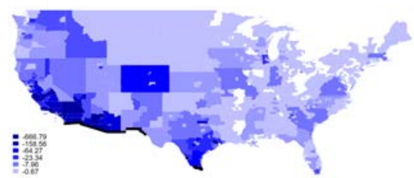
(a) Mex. Low Skill



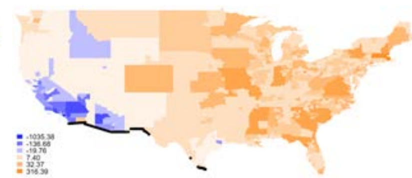
(b) Mex. High Skill



(c) United States Low Skill

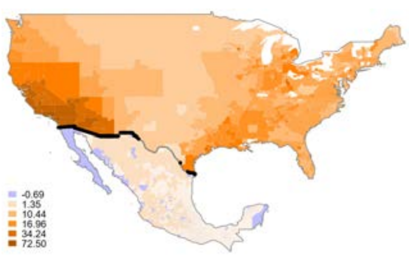


(d) United States High Skill

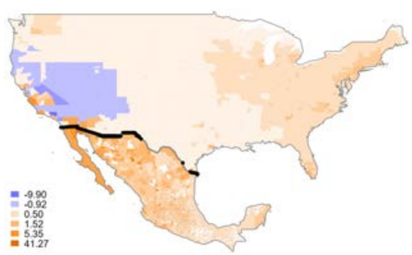


Panel (ii): Real Wages

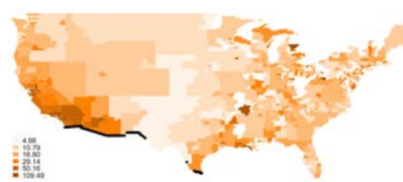
(e) Mex. Low Skill



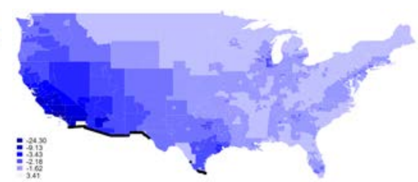
(f) Mex. High Skill



(g) United States Low Skill



(h) United States High Skill

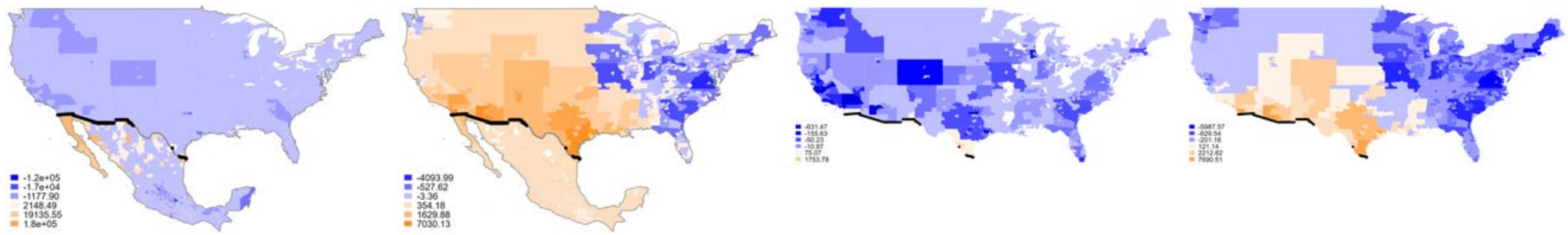


Notes: These figures show effect of a 25% additional expansion in the border wall on the spatial distribution of population of each labor type (top panel) and the real wage impact of each labor type (bottom panel). Changes in real wages (i.e. $\left(\hat{w}_j^{n,s}/\hat{P}_j\right)$ are expressed in equivalent variation changes in per capita annual real income, measured in chained 2012 USD.

Figure 4: Effect of reducing trade costs

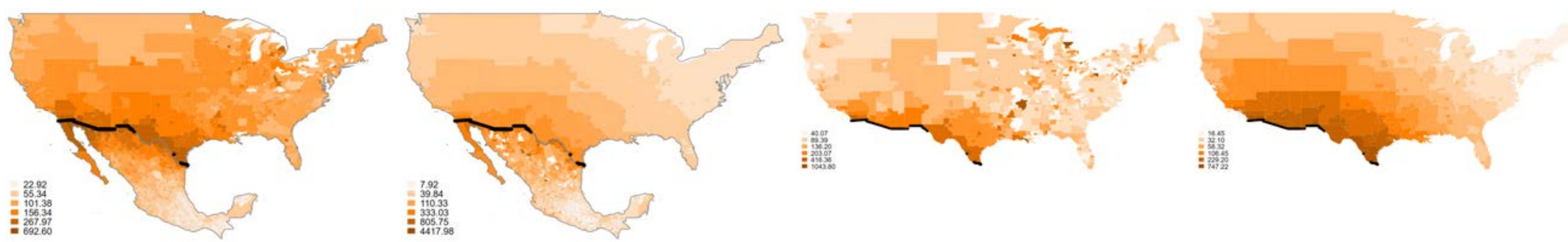
Panel (i): Population

(a) Mex. Low Skill (b) Mex. High Skill (c) United States Low Skill (d) United States High Skill



Panel (ii): Real Wages

(e) Mex. Low Skill (f) Mex. High Skill (g) United States Low Skill (h) United States High Skill



Notes: These figures show effect of a 25% reduction in international trade costs on the spatial distribution of population of each labor type (top panel) and the real wage impact of each labor type (bottom panel). Changes in real wages (i.e. $\left(\hat{w}_j^{n,s}/\hat{P}_j\right)$ are expressed in equivalent variation changes in per capita annual real income, measured in chained 2012 USD.

Online Appendix (not for publication)

A Proofs

In this section, we provide proofs of Theorem 1, Corollary 1, Lemma 1, and Proposition 1.

A.1 Proof of Theorem 1

In this section, we prove Theorem 1 using the contraction mapping theorem. Recall that the system of Equations $F : \mathbb{R}_{++}^{N\times K} \to \mathbb{R}_{++}^{N\times K}$ are written as:

$$F(\mathbf{x})_{ik} \equiv \sum_j K_{ij,k} \prod_{l=1}^{K} (x_{j,l})^{\alpha_{k,l}} \prod_{l=1}^{K} (x_{i,l})^{\lambda_{k,l}} \prod_{m=1}^{M} P_m(\mathbf{x}_j)^{\gamma_{k,m}} \prod_{m=1}^{M} P_m(\mathbf{x}_i)^{\chi_{k,m}},$$

where $Q_m(\cdot)$ are nested CES aggregating functions:

$$P_m(\mathbf{x}_j) \equiv \left(\sum_{l\in S_m} \frac{1}{|S_m|} \left(\left(\sum_{n\in T_l} \frac{1}{|T_n|} (x_{j,n})^{\delta_{m,l}} \right)^{\frac{1}{\delta_{m,l}}} \right)^{\beta_m} \right)^{\frac{1}{\beta_m}},$$

where $\delta_{m,l} > 0$ and $\beta_m > 0$ for all m and l, $\{K_{ij,k}, U_l, T_{j,n}\}$ are all strictly positive parameter values; S_m and $T_{l,m}$ are (weak) subsets of $\{1,...,K\}$; and $\{\alpha_{k,l}, \lambda_{k,l}, \gamma_{k,m}, \chi_{k,p}\}$ are all real-valued.

It proves helpful to instead consider an equivalent function $G : \mathbb{R}^{N\times K} \to \mathbb{R}^{N\times K}$:

$$G(\mathbf{x}) \equiv \log \sum_j K_{ij,k} \prod_{l=1}^{K} (\exp x_{j,l})^{\alpha_{k,l}} \prod_{l=1}^{K} (\exp x_{i,l})^{\lambda_{k,l}} \prod_{m=1}^{M} \exp Q_m(\mathbf{x}_j)^{\gamma_{k,m}} \prod_{m=1}^{M} \exp Q_m(\mathbf{x}_i)^{\chi_{k,m}},$$

where:

$$Q_m(\mathbf{x}_j) \equiv \log \left(\sum_{l\in S_m} \frac{1}{|S_m|} \left(\left(\sum_{n\in T_l} \frac{1}{|T_n|} (\exp x_{j,n})^{\delta_{m,l}} \right)^{\frac{1}{\delta_{m,l}}} \right)^{\beta_m} \right)^{\frac{1}{\beta_m}}.$$

Clearly if there is any fixed point $\tilde{\mathbf{x}}^* \in \mathbb{R}^{N\times K}$ such that $G(\tilde{\mathbf{x}}^*) = \tilde{\mathbf{x}}^*$implies that $\mathbf{x}^* \equiv \exp(\tilde{\mathbf{x}}^*) \in \mathbb{R}_{++}^{N\times K}$ is a fixed point for F, i.e. $F(\mathbf{x}^*) = \mathbf{x}^*$ (where it is understood that the exponential function is element by element).

For any $\mathbf{x}$ and $\mathbf{y}$ in $\mathbb{R}^{N\times K}$, consider the "max" metric $d(\mathbf{x},\mathbf{y}) = \max_{i,k} |x_{i,k} - y_{i,k}|$. Then $\left(\mathbb{R}^{N\times K}, d\right)$ is a complete metric space so that by the contraction mapping theorem, there exists a unique $\tilde{\mathbf{x}}^* \in \mathbb{R}^{N\times K}$ such that $G(\tilde{\mathbf{x}}^*) = \tilde{\mathbf{x}}^*$ (and hence there exists a unique $\mathbf{x}^* \in \mathbb{R}_{++}^{N\times K}$) if there exists a $\rho \in [0,1)$ such that for all $\mathbf{x}$ and $\mathbf{y}$ in $\mathbb{R}^{N\times K}$ we have $d(G(\mathbf{x}), G(\mathbf{y})) \leq \rho \times d(\mathbf{x},\mathbf{y})$. We define $\rho \equiv \max_{k\in\{1,\dots,K\}} \left(\sum_{m=1}^{M} |\gamma_{k,m}| + \sum_{l=1}^{K} |\alpha_{k,l}| + \sum_{m=1}^{M} |\lambda_{k,m}| + \sum_{m=1}^{M} |\chi_{k,m}| \right)$, and show in the following that $d(G(\mathbf{x}), G(\mathbf{y})) \leq \rho \times d(\mathbf{x},\mathbf{y})$, as required.

First, choose any two $\mathbf{x}$ and $\mathbf{y}$ in $\mathbb{R}^{N\times K}$. We then can calculate the metric of $G(\mathbf{x})$ and

$G(\mathbf{y})$:

$$d\left(G\left(\mathbf{x}\right),G\left(\mathbf{y}\right)\right)=\max_{i,k}|\log\sum_{j}K_{ij,k}\exp\left(\sum_{l=1}^{K}\alpha_{k,l}x_{j,l}+\sum_{m=1}^{M}\gamma_{k,m}Q_{j,m}\left(\mathbf{x}_{j}\right)+\sum_{m=1}^{M}\chi_{k,m}Q_{j,m}\left(\mathbf{x}_{i}\right)\right)\iff$$
$$-\log\sum_{j}K_{ij,k}\exp\left(\sum_{l=1}^{K}\alpha_{k,l}y_{j,l}+\sum_{m=1}^{M}\gamma_{k,m}Q_{j,m}\left(\mathbf{y}_{j}\right)+\sum_{m=1}^{M}\chi_{k,m}Q_{j,m}\left(\mathbf{y}_{i}\right)\right)|$$
$$=\max_{i,k}\left|\log\frac{\sum_{j}K_{ij,k}\exp\left(\sum_{l=1}^{K}\alpha_{k,l}x_{j,l}+\sum_{m=1}^{M}\gamma_{k,m}Q_{j,m}\left(\mathbf{x}_{j}\right)+\sum_{m=1}^{M}\chi_{k,m}Q_{j,m}\left(\mathbf{x}_{i}\right)\right)}{\sum_{j}K_{ij,k}\exp\left(\sum_{l=1}^{K}\alpha_{k,l}y_{j,l}+\sum_{m=1}^{M}\gamma_{k,m}Q_{j,m}\left(\mathbf{y}_{j}\right)+\sum_{m=1}^{M}\chi_{k,m}Q_{j,m}\left(\mathbf{y}_{i}\right)\right)}\right|\iff$$
$$=\max_{i,k}\left|\log\sum_{j}C_{ij,k}\left(\exp\left(\begin{array}{c}\sum_{l=1}^{K}\alpha_{k,l}\left(x_{j,l}-y_{j,l}\right)+\\ \sum_{m=1}^{M}\gamma_{k,m}\left(Q_{j,m}\left(\mathbf{x}_{j}\right)-Q_{j,m}\left(\mathbf{y}_{j}\right)\right)+\\ \sum_{m=1}^{M}\chi_{k,m}\left(Q_{j,m}\left(\mathbf{x}_{i}\right)-Q_{j,m}\left(\mathbf{y}_{i}\right)\right)\end{array}\right)\right)\right|, \tag{14}$$

where $C_{ij,k}\equiv\sum_{j}\frac{K_{ij,k}\exp\left(\sum_{l=1}^{K}\alpha_{k,l}y_{j,l}+\sum_{m=1}^{M}\gamma_{k,m}Q_{j,m}(\mathbf{y}_{j})+\sum_{m=1}^{M}\chi_{k,m}Q_{j,m}(\mathbf{y}_{i})\right)}{\sum_{j}K_{ij,k}\exp\left(\sum_{l=1}^{K}\alpha_{k,l}y_{j,l}+\sum_{m=1}^{M}\gamma_{k,m}Q_{j,m}(\mathbf{y}_{j})++\sum_{m=1}^{M}\chi_{k,m}Q_{j,m}(\mathbf{y}_{i})\right)}$. Note that $\sum_{j}C_{ij,k}=1$ for all i and k.

Second, note that we can bound the difference in the CES aggregate functions $Q_{m}(\cdot)$ as follows:

$$\left|Q_{j,m}\left(\mathbf{x}_{j}\right)-Q_{j,m}\left(\mathbf{y}_{j}\right)\right|=|\log\left(\sum_{l\in S_{m}}\frac{1}{|S_{m}|}\left(\left(\sum_{n\in T_{l}}\frac{1}{|T_{n}|}\left(\exp\left(x_{j,n}\right)\right)^{\delta_{m,l}}\right)^{\frac{1}{\delta_{m,l}}}\right)^{\beta_{m}}\right)^{\frac{1}{\beta_{m}}}\iff$$
$$-\log\left(\sum_{l\in S_{m}}\frac{1}{|S_{m}|}\left(\left(\sum_{n\in T_{l}}\frac{1}{|T_{n}|}\left(\exp\left(y_{j,n}\right)\right)^{\delta_{m,l}}\right)^{\frac{1}{\delta_{m,l}}}\right)^{\beta_{m}}\right)^{\frac{1}{\beta_{m}}}|$$
$$=\left|\frac{1}{\beta_{m}}\log\left(\frac{\sum_{l\in S_{m}}\left(\left(\sum_{n\in T_{l}}\frac{1}{|T_{n}|}\left(\exp\left(x_{j,n}\right)\right)^{\delta_{m,l}}\right)^{\frac{1}{\delta_{m,l}}}\right)^{\beta_{m}}}{\sum_{l\in S_{m}}\left(\left(\sum_{n\in T_{l}}\frac{1}{|T_{n}|}\left(\exp\left(y_{j,n}\right)\right)^{\delta_{m,l}}\right)^{\frac{1}{\delta_{m,l}}}\right)^{\beta_{m}}}\right)\right|\iff$$
$$=\left|\frac{1}{\beta_{m}}\log\left(\sum_{l\in S_{m}}\left(\lambda_{l}\left(\sum_{n\in T_{l}}\omega_{n,l}\exp\left(\delta_{m,l}\left(x_{j,n}-y_{j,n}\right)\right)\right)^{\frac{1}{\delta_{m,l}}}\right)^{\beta_{m}}\right)\right|,$$

where $\omega_{n,l}\equiv\frac{(\exp(y_{j,n}))^{\delta_{m,l}}}{\sum_{n\in T_{l}}(\exp(y_{j,n}))^{\delta_{m,l}}}$ and $\lambda_{l}\equiv\frac{\left(\left(\frac{1}{|T_{n}|}\sum_{n\in T_{l}}(\exp(y_{j,n}))^{\delta_{m,l}}\right)^{\frac{1}{\delta_{m,l}}}\right)^{\beta_{m}}}{\sum_{l\in S_{m}}\left(\left(\sum_{n\in T_{l}}\frac{1}{|T_{n}|}(\exp(y_{j,n}))^{\delta_{m,l}}\right)^{\frac{1}{\delta_{m,l}}}\right)^{\beta_{m}}}$. Note that $\omega_{n,l}\geq 0$ and $\sum_{n\in T_{l}}\omega_{n,l}=1$ and, similarly, $\lambda_{l}\geq 0$ and $\sum_{l\in S_{m}}\lambda_{l}=1$, i.e. both $\omega_{n,l}$ and λ_{l}

are weights. As a result we have:

$$|Q_{j,m}(\mathbf{x}_j) - Q_{j,m}(\mathbf{y}_j)| = \left| \frac{1}{\beta_m} \log \left(\sum_{l \in S_m} \left(\lambda_l \left(\sum_{n \in T_l} \omega_{n,l} \exp\left(\delta_{m,l}\left(x_{j,n} - y_{j,n}\right)\right) \right)^{\frac{1}{\delta_{m,l}}} \right)^{\beta_m} \right) \right| \Longrightarrow$$

$$|Q_{j,m}(\mathbf{x}_j) - Q_{j,m}(\mathbf{y}_j)| \leq \frac{1}{\beta_m} \log \left(\sum_{l \in S_m} \left(\left(\sum_{n \in T_l} \omega_{n,l} \exp\left(\delta_{m,l}\left(\max_{i,k} |x_{i,k} - y_{i,k}|\right)\right) \right)^{\frac{1}{\delta_{m,l}}} \right)^{\beta_m} \times \lambda_l \right) \Longleftrightarrow$$

$$|Q_{j,m}(\mathbf{x}_j) - Q_{j,m}(\mathbf{y}_j)| \leq \max_{i,k} |x_{i,k} - y_{i,k}| \tag{15}$$

Third, we apply Equation (15) and the fact that $\sum_j C_{ij,k} = 1$ to derive the following bound:

$$\begin{aligned} \sum_j C_{ij,k} \left(\exp \left(\begin{array}{c} \sum_{l=1}^{K} \alpha_{k,l}\left(x_{j,l} - y_{j,l}\right) + \\ \sum_{m=1}^{M} \gamma_{k,m}\left(Q_{j,m}(\mathbf{x}_j) - Q_{j,m}(\mathbf{y}_j)\right) + \\ \sum_{m=1}^{M} \chi_{k,m}\left(Q_{j,m}(\mathbf{x}_i) - Q_{j,m}(\mathbf{y}_i)\right) \end{array} \right) \right) &\leq \sum_j C_{ij,k} \left(\exp \left(\begin{array}{c} \sum_{l=1}^{K} |\alpha_{k,l}| \, |x_{j,l} - y_{j,l}| + \\ \sum_{m=1}^{M} |\gamma_{k,m}| \, |(Q_{j,m}(\mathbf{x}_j) - Q_{j,m}(\mathbf{y}_j))| + \\ \sum_{m=1}^{M} |\chi_{k,m}| \, |Q_{j,m}(\mathbf{x}_i) - Q_{j,m}(\mathbf{y}_i)| \end{array} \right) \right) \\ &\leq \exp\left(\sum_{l=1}^{K} |\alpha_{k,l}| + \sum_{m=1}^{M} |\gamma_{k,m}| + \sum_{m=1}^{M} |\chi_{k,m}| \right) \max_{i,k} |x_{i,k} - y_{i,k}| \, . \end{aligned} \tag{16}$$

Finally, applying Equation (16) to Equation (14) yields:

$$d\left(G(\mathbf{x}), G(\mathbf{y})\right) \leq \rho \times d(\mathbf{x}, \mathbf{y}),$$

as required.

A.2 Proof of Corollary 1

We first derive two equilibrium equations from the four conditions defining the equilibrium presented in Section 4.3. We then apply Theorem 1 to this system of equations.

Suppose migration costs are symmetric. Recall the first equilibrium condition requires both:

$$L_i^{n,s} \left(\frac{w_i^{n,s}}{P_i} u_i^{n,s} \right)^{-\theta^{n,s}} = \sum_{j \in \mathcal{N}} \left(\mu_{ji}^{n,s}\right)^{-\theta^{n,s}} \left(\Pi_j^{n,s}\right)^{-\theta^{n,s}} L_j^{n,s}$$

$$\left(\Pi_i^{n,s}\right)^{\theta^{n,s}} \equiv \sum_{j \in \mathcal{N}} \left(\mu_{ij}^{n,s}\right)^{-\theta^{n,s}} \left(\frac{w_j^{n,s}}{P_j} u_j^{n,s} \right)^{\theta^{n,s}}$$

It turns out that this set of two equations can be simplified to a single equation when migration costs are symmetric. To see this, suppose that the following relationship holds true for some scalar $\kappa^{n,s} > 0$:

$$L_i^{n,s} \left(\frac{w_i^{n,s}}{P_i} u_i^{n,s} \right)^{-\theta^{n,s}} = \kappa^{n,s} \left(\Pi_i^{n,s}\right)^{\theta^{n,s}}$$

Then the first equation becomes:

$$
\begin{aligned}
L_i^{n,s}\left(\frac{w_i^{n,s}}{P_i}u_i^{n,s}\right)^{-\theta^{n,s}} &= \sum_{j\in\mathcal{N}}\left(\mu_{ji}^{n,s}\right)^{-\theta^{n,s}}\left(\Pi_j^{n,s}\right)^{-\theta^{n,s}}L_j^{n,s} \iff \\
\kappa\left(\Pi_i^{n,s}\right)^{\theta^{n,s}} &= \sum_{j\in\mathcal{N}}\left(\mu_{ji}^{n,s}\right)^{-\theta^{n,s}}\left(\frac{w_j^{n,s}}{P_j}u_j^{n,s}\right)^{\theta^{n,s}}\kappa \iff \\
\left(\Pi_i^{n,s}\right)^{\theta^{n,s}} &= \sum_{j\in\mathcal{N}}\left(\mu_{ij}^{n,s}\right)^{-\theta^{n,s}}\left(\frac{w_j^{n,s}}{P_j}u_j^{n,s}\right)^{\theta^{n,s}},
\end{aligned}
$$

where the last line imposed symmetry. Hence both equations in the system are identical given the above relationship. This allows us to consider a single non-linear equation:

$$
L_i^{n,s} = \kappa^{n,s}\sum_{j\in\mathcal{N}}\left(\mu_{ji}^{n,s}\right)^{-\theta^{n,s}}\left(\frac{w_i^{n,s}}{P_i}u_i^{n,s}\right)^{\theta^{n,s}}\left(\frac{w_j^{n,s}}{P_j}u_j^{n,s}\right)^{\theta^{n,s}}. \tag{17}
$$

Similarly, suppose trade costs are symmetric. Recall the fourth equilibrium condition requires that both:

$$
\begin{aligned}
Y_i^{\sigma}Q_i^{1-\sigma} &= \sum_{j\in\mathcal{N}}\tau_{ij}^{1-\sigma}P_j^{\sigma-1}Y_j \\
P_i^{1-\sigma} &\equiv \sum_{j\in\mathcal{N}}\tau_{ji}^{1-\sigma}Y_i^{1-\sigma}Q_i^{\sigma-1}
\end{aligned}
$$

Suppose that the following relationship holds true for some scalar $\kappa > 0$:

$$
\begin{aligned}
Y_i^{\sigma}Q_i^{1-\sigma} &= \kappa P_i^{1-\sigma} \iff \\
P_i &= \kappa^{\frac{1}{\sigma-1}}Y_i^{-\frac{\sigma}{\sigma-1}}Q_i
\end{aligned} \tag{18}
$$

then the first equation becomes:

$$
\begin{aligned}
Y_i^{\sigma}Q_i^{1-\sigma} &= \sum_{j\in\mathcal{N}}\tau_{ij}^{1-\sigma}P_j^{\sigma-1}Y_j \iff \\
\kappa P_i^{1-\sigma} &= \sum_{j\in\mathcal{N}}\tau_{ij}^{1-\sigma}\left(\kappa Y_j^{-\sigma}Q_j^{\sigma-1}\right)Y_j \iff \\
P_i^{1-\sigma} &= \sum_{j\in\mathcal{N}}\tau_{ji}^{1-\sigma}Y_j^{1-\sigma}Q_j^{\sigma-1}
\end{aligned}
$$

where the last line imposed symmetry of trade costs. Hence the two equations are identical.

This allows us to consider a single non-linear equation:

$$
\begin{aligned}
Y_i^{\sigma} Q_i^{1-\sigma} &= \kappa \sum_{j \in \mathcal{N}} \tau_{ij}^{1-\sigma} Y_j^{1-\sigma} Q_j^{\sigma-1} \iff \\
Y_i &= \kappa \sum_{j \in \mathcal{N}} \tau_{ij}^{1-\sigma} \left(Y_i^{1-\sigma} Q_i^{\sigma-1}\right) \left(Y_j^{1-\sigma} Q_j^{\sigma-1}\right).
\end{aligned} \tag{19}
$$

Substituting the price index equation (18) into the migration equation (17) yields:

$$
\begin{aligned}
L_i^{n,s} &= \kappa^{n,s} \sum_{j \in \mathcal{N}} \left(\mu_{ji}^{n,s}\right)^{-\theta^{n,s}} \left(\frac{w_i^{n,s}}{P_i} u_i^{n,s}\right)^{\theta^{n,s}} \left(\frac{w_j^{n,s}}{P_j} u_j^{n,s}\right)^{\theta^{n,s}} \iff \\
L_i^{n,s} &= \frac{\kappa^{n,s}}{\kappa^{\frac{2\theta^{n,s}}{\sigma-1}}} \sum_{j \in \mathcal{N}} \left(\mu_{ji}^{n,s}\right)^{-\theta^{n,s}} \left(\frac{w_i^{n,s}}{Y_i^{-\frac{\sigma}{\sigma-1}} Q_i} u_i^{n,s}\right)^{\theta^{n,s}} \left(\frac{w_j^{n,s}}{Y_j^{-\frac{\sigma}{\sigma-1}} Q_j} u_j^{n,s}\right)^{\theta^{n,s}}
\end{aligned}
$$

Moreover, using the equilibrium equation (3) for wages from the first order conditions of the producer (the third equilibrium condition):

$$
w_i^{n,s} = A_i^{n,s} Y_i Q_i^{\frac{1-\rho}{\rho}} \left(Q_i^s\right)^{\left(\frac{1}{\rho_s} - \frac{1}{\rho}\right)} \left(L_i^{n,s}\right)^{-\frac{1}{\rho_s}}
$$

we have:

$$
\begin{aligned}
L_i^{n,s} =& \frac{\kappa^{n,s}}{\kappa^{\frac{2\theta^{n,s}}{\sigma-1}}} \sum_{j \in \mathcal{N}} \left(\mu_{ji}^{n,s}\right)^{-\theta^{n,s}} \left(\frac{w_i^{n,s}}{Y_i^{-\frac{\sigma}{\sigma-1}} Q_i} u_i^{n,s}\right)^{\theta^{n,s}} \left(\frac{w_j^{n,s}}{Y_j^{-\frac{\sigma}{\sigma-1}} Q_j} u_j^{n,s}\right)^{\theta^{n,s}} \iff \\
L_i^{n,s} =& \tilde{\kappa}^{n,s} \sum_{j \in \mathcal{N}} \left(\frac{A_i^{n,s} u_i^{n,s} A_j^{n,s} u_j^{n,s}}{\mu_{ij}^{n,s}}\right)^{\theta^{n,s}} \left(Y_i^{\frac{2\sigma-1}{\sigma-1}} Q_i^{-\frac{2\rho-1}{\rho}} \left(Q_i^s\right)^{\left(\frac{1}{\rho_s} - \frac{1}{\rho}\right)} \left(L_i^{n,s}\right)^{-\frac{1}{\rho_s}}\right)^{\theta^{n,s}} \\
& \times \left(Y_j^{\frac{2\sigma-1}{\sigma-1}} Q_j^{-\frac{2\rho-1}{\rho}} \left(Q_j^s\right)^{\left(\frac{1}{\rho_s} - \frac{1}{\rho}\right)} \left(L_j^{n,s}\right)^{-\frac{1}{\rho_s}}\right)^{\theta^{n,s}}.
\end{aligned} \tag{20}
$$

We apply Theorem 1 to the system of equations (19) and (20). Note that the second equilibrium condition defines how Q_i and Q_s are functions of the $\{L_i^{n,s}\}_{n \in \{M,U\}}^{s \in \{h,l\}}$. Recall that Theorem 1 applies to any system of Equations $F : \mathbb{R}_{++}^{N \times K} \to \mathbb{R}_{++}^{N \times K}$ are written as:

$$
F(\mathbf{x})_{ik} \equiv \sum_j K_{ij,k} \prod_{l=1}^{K} \left(x_{j,l}\right)^{\alpha_{k,l}} \prod_{l=1}^{K} \left(x_{i,l}\right)^{\lambda_{k,l}} \prod_{m=1}^{M} Q_m\left(\mathbf{x}_j\right)^{\gamma_{k,m}} \prod_{m=1}^{M} Q_m\left(\mathbf{x}_i\right)^{\chi_{k,m}},
$$

where $Q_m(\cdot)$ are nested CES aggregating functions:

$$
Q_m\left(\mathbf{x}_j\right) \equiv \left(\sum_{l \in S_m} U_l \left(\left(\sum_{n \in T_{l,m}} T_{j,n} \left(x_{j,n}\right)^{\delta_{m,n}}\right)^{\frac{1}{\delta_{m,n}}}\right)^{\beta_m}\right)^{\frac{1}{\beta_m}},
$$

$\{K_{ij,k}, U_l, T_{j,n}\}$ are all strictly positive parameter values; S_m and $T_{l,m}$ are (weak) subsets of $\{1, ..., K\}$; and $\{\alpha_{k,l}, \lambda_{k,l}, \gamma_{k,m}, \chi_{k,p}\}$ are all real-valued.

Equations (19) and (20) are one such system where N is the number of locations, $K = 5$ is the number of endogenous variables in each location (corresponding to the four types of labor $L_i^{h,M}, L_i^{h,U}, L_i^{l,M}, L_i^{l,U}$ and the income in each location Y_i, using the production function – equilibrium condition), and $M = 3$ (one CES aggregate for high-skill labor Q^h, one CES for low-skill labor Q^l, and one nested CES aggregate across both high and low-skill labor Q). Under the assumptions that $\rho_s > \rho$ for $s \in \{h, l\}$, $\rho > \frac{1}{2}$ and $\sigma > 1$, Theorem 1 provides the following sufficient conditions for uniqueness:

$$\theta^{n,s} < \frac{1}{2}\left(\frac{\sigma - 1}{4\sigma - 3}\right) \ \forall n \in \{M, U\}, s \in \{h, l\}$$

$$\sigma < \frac{5}{4},$$

as claimed.

A.3 Proof of Lemma 1

First, note that we can immediately construct the total income of a location from the location observables as follows: $Y_i = \sum_{n\in\{U,M\},s\in\{h,l\}} w_i^{n,s} L_i^{n,s}$. Noting that $Y_i = p_i Q_i$ as well and rearranging Equation (8), we have:

$$p_i^{\sigma-1} = \sum_{j=1}^{N} \tau_{ij}^{1-\sigma} P_j^{\sigma-1}\left(\frac{Y_j}{Y_i}\right)$$

$$P_i^{1-\sigma} = \sum_{j=1}^{N} \tau_{ji}^{1-\sigma} p_j^{1-\sigma}$$

An immediate application of Theorem 3 of Allen, Arkolakis, and Li (2016) tells us that there exists a unique (to-scale) set of $p_i^{1-\sigma}$ and $P_i^{1-\sigma}$ consistent with observed trade costs $\left\{\tau_{ij}^{1-\sigma}\right\}$ and incomes $\{Y_i\}$.

Identifying amenities proceeds in a similar way. Define $W_i^{n,s} \equiv \frac{w_i^{n,s}}{P_i} u_i^{n,s}$ as the welfare of worker of type $\{n, s\}$ in location i. Rearranging equation (7) then yields:

$$\left(W_i^{n,s}\right)^{-\theta^{n,s}} = \sum_{j\in\mathcal{N}} \left(\mu_{ji}^{n,s}\right)^{-\theta^{n,s}} \left(\Pi_j^{n,s}\right)^{-\theta^{n,s}} \frac{L_{j,0}^{n,s}}{L_i^{n,s}}$$

$$\left(\Pi_i^{n,s}\right)^{\theta^{n,s}} = \sum_{j\in\mathcal{N}} \left(\mu_{ij}^{n,s}\right)^{-\theta^{n,s}} \left(W_j^{n,s}\right)^{\theta^{n,s}}$$

Again, an immediate application of Theorem 3 of Allen, Arkolakis, and Li (2016) tells us that there exists a unique (to-scale) set of $\left(W_i^{n,s}\right)^{\theta^{n,s}}$ and $\left(\Pi_i^{n,s}\right)^{\theta^{n,s}}$ consistent with observed migration costs $\left\{\left(\mu_{ij}^{n,s}\right)^{-\theta^{n,s}}\right\}$ and populations $\left\{\frac{L_{j,0}^{n,s}}{L_i^{n,s}}\right\}$.

A.4 Proof of Proposition 1

We express the (unobserved) productivities of each type of labor as a function of the local factor price (which from above can be recovered from the data using the market clearing condition). First, taking ratios of United States and Mexican born workers, Equation (3) implies:

$$\frac{A_i^{M,s}}{A_i^{U,s}} = \left(\frac{w_i^{M,s}}{w_i^{U,s}}\right)\left(\frac{L_i^{M,s}}{L_i^{U,s}}\right)^{\frac{1}{\rho_s}} \quad \forall s \in \{h, l\},$$

so that given observed relative wages and populations (along with the known elasticity of substitution ρ_s), relative productivities of United States to Mexican workers of the same skill group within location are observed. Hence, once the productivity of U.S. workers of a skill group is recovered, we can immediately deduce the productivity of Mexican workers in that skill group.

We proceed by identifying the price and quantity of skilled workers within a location (an identical derivation holds for low-skilled workers). Using the CES aggregate of the price of high-skill workers, we have:

$$\begin{aligned}
\left(p_i^h\right)^{1-\rho_h} &= \left(A_i^{M,h}\right)^{\rho_h}\left(w_i^{M,h}\right)^{1-\rho_h} + \left(A_i^{U,h}\right)^{\rho_h}\left(w_i^{U,h}\right)^{1-\rho_h} \iff \\
\left(p_i^h\right)^{1-\rho_h} &= \left(A_i^{U,h}\right)^{\rho_h}\left(\left(\frac{A_i^{M,h}}{A_i^{U,h}}\right)^{\rho_h}\left(w_i^{M,h}\right)^{1-\rho_h} + \left(w_i^{U,h}\right)^{1-\rho_h}\right) \iff \\
p_i^h &= \left(A_i^{U,h}\right)^{-\frac{\rho_h}{\rho_h-1}}\left(\left(\frac{A_i^{M,h}}{A_i^{U,h}}\right)^{\rho_h}\left(w_i^{M,h}\right)^{1-\rho_h} + \left(w_i^{U,h}\right)^{1-\rho_h}\right)^{\frac{1}{1-\rho_h}} \iff \\
p_i^h &= \left(A_i^{U,h}\right)^{-\frac{\rho_h}{\rho_h-1}}\tilde{p}_i^h,
\end{aligned}$$

where $\tilde{p}_i^h \equiv \left(\left(\frac{A_i^{M,h}}{A_i^{U,h}}\right)^{\rho_h}\left(w_i^{M,h}\right)^{1-\rho_h} + \left(w_i^{U,h}\right)^{1-\rho_h}\right)^{\frac{1}{1-\rho_h}}$ can be recovered from observed data. That is, the high-skill price is identified up to the United States high skilled productivity in a location.

Similarly, using the CES aggregate of the quantity of high-skill, we have:

$$\begin{aligned}
Q_i^h &= \left(A_i^{U,h}\right)^{\frac{\rho_h}{\rho_h-1}}\left(\frac{A_i^{M,h}}{A_i^{U,h}}\left(L_i^{M,h}\right)^{\frac{\rho_h-1}{\rho_h}} + \left(L_i^{U,h}\right)^{\frac{\rho_h-1}{\rho_h}}\right)^{\frac{\rho_h}{\rho_h-1}} \iff \\
Q_i^h &= \left(A_i^{U,h}\right)^{\frac{\rho_h}{\rho_h-1}}\tilde{Q}_i^h,
\end{aligned}$$

where $\tilde{Q}_i^h \equiv \left(\frac{A_i^{M,h}}{A_i^{U,h}}\left(L_i^{M,h}\right)^{\frac{\rho_h-1}{\rho_h}} + \left(L_i^{U,h}\right)^{\frac{\rho_h-1}{\rho_h}}\right)^{\frac{\rho_h}{\rho_h-1}}$ can be recovered from observed data. Combining the above expressions for prices and quantity yields:

$$
\begin{aligned}
p_i^h \left(Q_i^h\right)^{\frac{1}{\rho}} &= \tilde{p}_i^h \left(A_i^{U,h}\right)^{\frac{\rho_h}{-\rho_h-1}} \times \left(\left(A_i^{U,h}\right)^{\frac{\rho_h}{\rho_h-1}} \tilde{Q}_i^h\right)^{\frac{1}{\rho}} \iff \\
p_i^h \left(Q_i^h\right)^{\frac{1}{\rho}} &= \tilde{p}_i^h \left(\tilde{Q}_i^h\right)^{\frac{1}{\rho}} \left(A_i^{U,h}\right)^{\left(\frac{\rho_h}{\rho_h-1}\right)\left(\frac{1}{\rho}-1\right)}
\end{aligned}
$$

Since the same expression holds for low-skill workers, we can combine these results with the first order condition $p_i^h \left(Q_i^h\right)^{\frac{1}{\rho}} = p_i^l \left(Q_i^l\right)^{\frac{1}{\rho}}$ to yield:

$$
\begin{aligned}
\tilde{p}_i^h \left(\tilde{Q}_i^h\right)^{\frac{1}{\rho}} \left(A_i^{U,h}\right)^{\left(\frac{\rho_h}{\rho_h-1}\right)\left(\frac{1}{\rho}-1\right)} &= \tilde{p}_i^l \left(\tilde{Q}_i^l\right)^{\frac{1}{\rho}} \left(A_i^{U,l}\right)^{\left(\frac{\rho_l}{\rho_l-1}\right)\left(\frac{1}{\rho}-1\right)} \iff \\
\frac{\left(A_i^{U,h}\right)^{\left(\frac{\rho_h}{\rho_h-1}\right)\left(1-\frac{1}{\rho}\right)}}{\left(A_i^{U,l}\right)^{\left(\frac{\rho_l}{\rho_l-1}\right)\left(1-\frac{1}{\rho}\right)}} &= \frac{\tilde{p}_i^h \left(\tilde{Q}_i^h\right)^{\frac{1}{\rho}}}{\tilde{p}_i^l \left(\tilde{Q}_i^l\right)^{\frac{1}{\rho}}}
\end{aligned}
$$

Finally, we define $x_i \equiv \frac{\left(A_i^{U,h}\right)^{\left(\frac{\rho_h}{\rho_h-1}\right)\left(1-\frac{1}{\rho}\right)}}{\left(A_i^{U,l}\right)^{\left(\frac{\rho_l}{\rho_l-1}\right)\left(1-\frac{1}{\rho}\right)}} = \left(\frac{\left(A_i^{U,h}\right)^{\left(\frac{\rho_h}{\rho_h-1}\right)}}{\left(A_i^{U,l}\right)^{\left(\frac{\rho_l}{\rho_l-1}\right)}}\right)^{-(1-\rho)\frac{1}{\rho}}$ (which can be recovered from data using the above expression) and use the CES aggregate expression for prices to derive an expression for the United States high skilled workers:

$$
\begin{aligned}
p_i^{1-\rho} &= \left(p_i^h\right)^{1-\rho} + \left(p_i^l\right)^{1-\rho} \iff \\
p_i^{1-\rho} &= \left(\left(A_i^{U,h}\right)^{-\frac{\rho_h}{\rho_h-1}} \times \tilde{p}_i^h\right)^{1-\rho} + \left(\left(A_i^{U,l}\right)^{-\frac{\rho_l}{\rho_l-1}} \times p_i^l\right)^{1-\rho} \iff \\
p_i^{1-\rho} &= \left(\left(A_i^{U,h}\right)^{-\frac{\rho_h}{\rho_h-1}} \times \tilde{p}_i^h\right)^{1-\rho} + \left(\left(A_i^{U,l}\right)^{-\frac{\rho_l}{\rho_l-1}} \times p_i^l\right)^{1-\rho} \iff \\
p_i^{1-\rho} &= \left(A_i^{U,h}\right)^{-\frac{\rho_h}{\rho_h-1}(1-\rho)} \left(\left(\tilde{p}_i^h\right)^{1-\rho} + \left(\frac{\left(A_i^{U,h}\right)^{\frac{\rho_h}{\rho_h-1}}}{\left(A_i^{U,l}\right)^{\frac{\rho_l}{\rho_l-1}}}\right)^{(1-\rho)} \left(p_i^l\right)^{1-\rho}\right) \iff \\
p_i^{1-\rho} &= \left(A_i^{U,h}\right)^{-\frac{\rho_h}{\rho_h-1}(1-\rho)} \left(\left(\tilde{p}_i^h\right)^{1-\rho} + x_i^{-\rho} \left(\tilde{p}_i^l\right)^{1-\rho}\right) \iff \\
A_i^{U,h} &= \left(\left(\left(\left(\tilde{p}_i^h\right)^{1-\rho} + x_i^{-\rho} \left(\tilde{p}_i^l\right)^{1-\rho}\right)^{\frac{1}{1-\rho}}\right) / p_i\right)^{\frac{\rho_h-1}{\rho_h}}
\end{aligned}
$$

Finally, we recover $A_i^{U,l}$ in all locations:

$$\left(\frac{\left(A_i^{U,h}\right)^{\left(\frac{\rho_h}{\rho_h-1}\right)\left(1-\frac{1}{\rho}\right)}}{x_i}\right)^{\frac{1}{\left(\frac{\rho_l}{\rho_l-1}\right)\left(1-\frac{1}{\rho}\right)}} = \left(A_i^{U,l}\right).$$

As a result, we have recovered the productivity of all labor types solely as a function of observables and model elasticities. Note that because the factor price is only recovered up to scale (see Lemma 1), each productivity is only recovered up to scale.

Identifying amenities is simpler. Recall that $W_i^{n,s} \equiv \frac{w_i^{n,s}}{P_i} u_i^{n,s}$ is the welfare of worker of type $\{n, s\}$ in location i. From Lemma 1, there exists a unique (to-scale) set of $\left(W_i^{n,s}\right)^{\theta^{n,s}}$ consistent with observed migration costs $\left\{\left(\mu_{ij}^{n,s}\right)^{-\theta^{n,s}}\right\}$ and populations $\left\{\frac{L_{j,0}^{n,s}}{L_i^{n,s}}\right\}$. Since $w_i^{n,s}$ is observable in the data and P_i is uniquely (to-scale) recovered from the data (see Lemma 1), the amenity of each type of worker is immediately recovered from the following expression:

$$u_i^{n,s} = W_i^{n,s} / \left(\frac{w_i^{n,s}}{P_i}\right),$$

as required.

B Data appendix

B.1 United States Data

We follow the replication files provided by Ottaviano and Peri (2012) and Borjas, Grogger, and Hanson (2012) and define our sample variables in the same way:

- Our primary sample is all individuals aged 18-64 (inclusive).
- We drop people in group quarters (**inlist(gq,0,3,4)**)
- We define education as low education if the person has complete high school or less (educ variable less than or equal to category 6). We define education as high education if the person has completed some college (educ variable greater than or equal to category 7).
- We define experience as age minus first time worked, where we assume first time worked is 17 for workers with no HS degree, 19 for HS graduates, 21 for workers with some college, and 23 for college graduates. We then drop if **experience <1 | experience > 40**.
- We use the CPI - U variable to deflate the wage variables into constant year 2000 dollars
- We calculate the usual hours of work per week. Before 1980 and from 2008, we use the midpoint of the aggregated variable wkswork2. For the other years, we use the value reported in the variable hrswork2.
- We sum the variable PERWT to get the total counts of individuals.

Further sample selection rules

- We include both males and females in the analysis. Ottaviano and Peri (2012)and Borjas, Grogger, and Hanson (2012) consider only males
- For computing population counts, we drop self-employed people (**classwkrd<20 | classwkrd>28**). We keep people who did not work the last week (this is in contrast to B/OP who drop this. We are interested in employment as an outcome)
- For computing average wages, we drop self-employed people, those with zero wage income, and those who with 0 hours of regular work. Average income is weighted by the number of hours worked.

B.2 Mexican data

We follow the same definitions as above as closely as possible to define analgous variables in the Mexican Census.

B.3 Geographic concordances

We are restricted to using geographical variables that are available in the public use files. The primary variable is the PUMA (public use microdata areas). PUMAS are redefined after each Census year. We use the IPUMS variable cpuma0010, which provides consistent groupings of PUMAS from 2000-2015 for our primary analysis.

B.4 Matrícula Database

One of the data sets used in this study was constructed from the administrative records of the Mexican Matrícula Consular. The original source did not provide numeric identifiers for place of birth or residency, but the names of these locations. In this appendix we describe how we constructed our data set from this records. We will do so in two parts: first merging places of residency to PUMAs in the United States and then merging place of birth to GEOLEV2 locations in Mexico[43]

Place of residency in the United States

The raw data gives us two pieces of information regarding place of residency, "Current State" and "Current Municipality". The field "Current Municipality" is vague and was interpreted by applicants in different ways, some providing a county, others a city. Furthermore, it is common to use unofficial names, e.g. "LA" for "Los Angeles". To match theses localities to PUMAs, we made use of a crosswalk provided by the Missouri Census Data Center.[44] It contains the names of all counties, minor civil divisions, cities, villages, towns, etc. in the United States We matched these with the Matrícula data set using the Stata function *reclink*. After this, we hand-coded the unmatched localities with the highest numbers of Matrículas cards. One example of such location is "LA", which the algorithm could not recognize as being "Los Angeles". This procedure yields the following results: 92% of the Matrículas Consulares were matched to a PUMA, 7% did not have place of residency in the raw data and 1% were not matched.

Place of birth in Mexico

The raw data gives us two pieces of information regarding place of birth, "State of Birth" and "Municipality of Birth". Again, the field "Municipality of Birth" was interpreted by applicants in different ways. To match these to Municipality codes, we used a list of all geographical divisions of Mexico provided by the *Instituto Nacional de Estadistica y Geografia*[45] and the Stata function *reclink*. As above, we hand-coded the unmatched localities with the highest numbers of Matrículas cards. Finally we used the dictionaries provides by IPUMS to aggregate municipalities to GEOLEV2 areas. This procedure yields the following results:

[43] PUMAs and GEOLEV2 are time-invariant geographical divisions provided by IPUMS, which are comparable to counties, but usually larger. More details in https://usa.ipums.org/usa/

[44] http://mcdc.missouri.edu/websas/geocorr2k.html

[45] See "Catálogo de Claves de Entidades Federativas y Municipios" in http://www.inegi.org.mx/default.aspx.

86% of the Matrículas Consularess were matched to a GEOLEV2, 7% did not have place of birth in the data and 7% were not matched.

B.5 Verification of Matrícula database

First, we show that the Matrícula counts correlate with measures of migrants from the ACS. Because the stock of migrants at a point in time depends on both the inflows of new migrants and the outflows of pre-existing migrants, we consider three different measures, shown in Appendix Table 3. The first panel considers the elasticity of migrant stocks in the ACS to the number of Matrículas Consulares. We find an elasticity of 6.1 (across all migrants) and an elasticity of 7.7 (for low-educated migrants in the ACS). We then do the same exercise considering a fixed cohort of individuals, born between 1940-1987, to hold constant population growth. We find similar elasticities of 4.6 and 6.1. The second panel considers the correlation between the stock of migrants in levels and the number of Matrículas in levels. We find that each additional Matrícula is associated with an increase of between 0.4 migrants in the ACS[46] and 0.42 for the stock of lower-educated migrants. Considering only male migrants and Matrículas issued to males, we find a point estimate of 0.60. The point estimates using the fixed cohort are larger, at 0.48, 0.52, and 0.77 respectively. The third panel considers the change in the stock of migrants and the level of Matrículas. We find that each additional Matrícula is associated with a net change in the stock of between 0.03-0.07 migrants, although the point estimates are smaller for the fixed cohort estimates.

Next, we repeat the same exercise using Mexican Census data. The population growth rate in Mexico is about twice that of the United States and so we focus on the fixed cohort numbers, although both are included in the table for completeness. Appendix Table 5 shows that the number of Matrículas Consulares correlates negatively with population stocks in the Mexican Census. This is the expected direction because migrants are people who are not living in Mexico. We find that each additional Matrícula is associated with between 14-24 fewer working age people (Panel b) and a change in the stock of Mexican working-age population of between 0.6-1.5 (Panel c) in an Mexican municipality.

The above tables were constructed considering all Mexican immigrants. If we instead use only recently-arrived Mexican immigrants, then the results, shown in Appendix Table 4, look similar.

C Alternative measures of migration

We run our analysis using several other datasets. In Appendix Table 16 using the 2000 and 2010 Mexican Censuses, we find no difference between the number of migrants a household reports having in the United States at the time of the Census. We also do not see any evidence of differential changes in migration from Mexico's National Labor Force Survey (ENOE) as shown in Appendix Figure (12) and Appendix Table 17. This finding suggests that either (1) total migration was unchanged because of the wall (perhaps the effect of the wall changed the destination rather than the decision to leave), or (2) since potential

[46] We should expect this value to be less than one: demographers estimate that the ACS and the Census under-count unauthorized migration by 8-13% Passel and Cohn (2016).

migrants are a small share of the total Mexican population, this effect is just too small to pick up.

Finally, we also look for evidence of whether the wall reduced return migration from the United States to Mexico, perhaps because of concerns that re-entering the United States would be more difficult in the future (Massey, Durand, and Malone (2003); Angelucci (2012); Lessem (2018)). We do not find any evidence of this, in either the 2010 Census, as shown in Appendix Table 16 or in the ENOE data, as shown in Appendix Table 17.

Appendix Table 1: Correlates of change in travel time (pair level)

	(1)	(2)
Dep. var: Change in log travel time	Actual change	Predicted change
Origin: log distance to border	0.001	0.007
	0.000***	0.000***
Origin: share ag	0.001	0.008
	0.000***	0.000***
Origin: share construction	-0.001	0.006
	0.001	0.001***
Origin: share manufact	-0.002	-0.003
	0.001**	0.001***
Dest: log distance to border	-0.008	-0.001
	0.000***	0.000***
Dest: share ag	-0.029	-0.096
	0.005***	0.004***
Dest: share construction	-0.113	0.098
	0.006***	0.006***
Dest: share manufact	0.028	-0.003
	0.001***	0.002*
Dest: housing shock	-0.056	0.017
	0.001***	0.001***
Pair: baseline migration	0.000	0.000
	0.000***	0.000***
N	2483780	2483780
r2	0.168	0.066
Est. method	OLS	OLS

Notes: An observation is an origin-destination pair. Standard errors in parentheses. Standard errors clustered at the spatial-pair cluster level.

Appendix Table 2: Geographical location of migrants: ACS and Matrícula

	2005/2006			2010-2012		
	Matricula	ACS	ACS: recent	Matricula	ACS	ACS: recent
Demographics						
Female	0.362	0.332	0.263	0.395	0.358	0.288
High education	0.035	0.000	0.000	0.039	0.000	0.000
Destinations						
California	0.379	0.374	0.251	0.313	0.355	0.249
Texas	0.154	0.181	0.162	0.216	0.186	0.188
Illinois	0.093	0.068	0.050	0.075	0.068	0.052
Arizona	0.036	0.049	0.061	0.030	0.037	0.025
Nevada	0.029	0.021	0.023	0.021	0.021	0.014
Georgia	0.027	0.028	0.049	0.030	0.027	0.038
Florida	0.025	0.030	0.050	0.028	0.026	0.031
Colorado	0.022	0.023	0.027	0.024	0.022	0.021
North Carolina	0.022	0.025	0.042	0.037	0.027	0.040
Washington	0.021	0.021	0.025	0.011	0.024	0.026
New Mexico	0.012	0.010	0.009	0.013	0.011	0.008
All other states	0.182	0.170	0.250	0.203	0.196	0.309
N (average per year)	887,564	5,928,770	1,291,722	841,503	5,627,935	573,386

Notes: Table shows share of migrants in each state. Data source: Matrícula Consular database, 2005, 2006, 2010; ACS 2005-2012. Only migrants with high-school education or lower included from ACS.

Appendix Table 3: Comparing Matrículas and ACS Mexican-born

		All			Fixed cohort (born 1940-1987)	
	(1)	(2)	(3)	(4)	(5)	(6)
	All ACS	Low-ed ACS	Male ACS	All ACS	Low-ed ACS	Male ACS
Panel (a): Log-Log						
Log num matr	0.061	0.077		0.046	0.061	
	0.021**	0.022***		0.021*	0.022**	
Log num male matr			0.030			0.021
			0.020			0.020
N	8287	7856	8057	8251	7802	8005
yearFE	yes	yes	yes	yes	yes	yes
cpumaFE	yes	yes	yes	yes	yes	yes
Panel (b): Level-Level						
Num matr	0.402	0.419		0.482	0.517	
	0.017***	0.017***		0.021***	0.022***	
Num male matr			0.598			0.766
			0.024***			0.030***
N	11858	11858	11858	11858	11858	11858
yearFE	yes	yes	yes	yes	yes	yes
cpumaFE	yes	yes	yes	yes	yes	yes
Panel (c): First diff-level						
Num matr	0.053	0.031		0.008	-0.021	
	0.018**	0.017		0.018	0.017	
Num male matr			0.069			0.004
			0.024**			0.024
N	10780	10780	10780	10780	10780	10780
yearFE	yes	yes	yes	yes	yes	yes
cpumaFE	yes	yes	yes	yes	yes	yes

Notes: An observation is an U.S. cpuma. Data compares Matrículas and Mexican-born population in the ACS. Period: 2005-2015 (except 2011/2012).

Appendix Table 4: Comparing Matrículas and ACS Mexican-born (migrants in U.S. 0-5 years)

	All			Fixed cohort (born 1940-1987)		
	(1)	(2)	(3)	(4)	(5)	(6)
	All ACS	Low-ed ACS	Male ACS	All ACS	Low-ed ACS	Male ACS
Panel (a): Log-Log						
Log num matr	0.145	0.163		0.131	0.142	
	0.037***	0.039***		0.039***	0.041***	
Log num male matr			0.114			0.115
			0.037**			0.039**
N	5661	5179	5086	5353	4843	4761
yearFE	yes	yes	yes	yes	yes	yes
cpumaFE	yes	yes	yes	yes	yes	yes
Panel (b): Level-Level						
Num matr	0.220	0.199		0.300	0.275	
	0.011***	0.010***		0.012***	0.011***	
Num male matr			0.283			0.401
			0.014***			0.016***
N	11858	11858	11858	11858	11858	11858
yearFE	yes	yes	yes	yes	yes	yes
cpumaFE	yes	yes	yes	yes	yes	yes
Panel (c): First diff-level						
Num matr	0.048	0.041		0.006	-0.000	
	0.008***	0.007***		0.008	0.007	
Num male matr			0.049			-0.005
			0.011***			0.011
N	10780	10780	10780	10780	10780	10780
yearFE	yes	yes	yes	yes	yes	yes
cpumaFE	yes	yes	yes	yes	yes	yes

Notes: An observation is an U.S. cpuma. Data compares Matrículas and Mexican-born population in the ACS. Period: 2005-2015 (except 2011/2012).

Appendix Table 5: Comparing Matrículas and Mexican census

		All		Fixed cohort (born 1940-1987)		
	(1)	(2)	(3)	(4)	(5)	(6)
	All	Male	Low-ed	All	Male	Low-ed
Panel (a): Log-Log						
Log num matr	0.017	0.026		-0.009	-0.004	
	0.008*	0.008**		0.009	0.008	
Log num male matr			0.002			-0.017
			0.007			0.007*
N	6046	6046	6371	6012	6012	6353
yearFE	yes	yes	yes	yes	yes	yes
geolev2FE	yes	yes	yes	yes	yes	yes
Panel (b): Level-Level						
Num matr	17.442	0.607		-18.126	-22.878	
	0.624***	0.447		0.627***	0.685***	
Num male matr			13.776			-14.472
			0.507***			0.594***
N	6054	6046	6379	6020	6012	6361
yearFE	yes	yes	yes	yes	yes	yes
geolev2FE	yes	yes	yes	yes	yes	yes
Panel (c): First diff-sum of level						
5-year sum matr	-0.188	-0.194		-0.614	-1.374	
	0.034***	0.035***		0.035***	0.037***	
5-year sum male matr			-0.299			-0.587
			0.033***			0.032***
N	4662	4644	4662	4662	4644	4662
yearFE	yes	yes	yes	yes	yes	yes
geolev2FE	yes	yes	yes	yes	yes	yes

Notes: An observation is a Mexican (time-comparable) municipality. Data compares Matrículas and population in Mexican Census. Mexican Census data from 2005 and 2010. Matrícula data from 2005-2010.

Appendix Table 6: Comparison: Pew Matrícula applicants vs ACS Mexican-born

	Pew	2005 ACS (all)	2005 ACS (6 states)
Share male	0.59	0.54	0.52
Age	31.29	36.26	36.96
High school educ or less	0.94	0.87	0.86
Married	0.46		
In U.S. for less than 5 years	0.39	0.21	0.17
Avg weekly earnings	334.51	441.71	451.07
No. obs (unweighted)	4836	62871	45683

Notes: Data source: Pew Matrícula survey. Pew survey conducted in CA, NY, IL, GA, TX, NC, between July 2004-Jan 2005.

Appendix Table 7: First stage for gravity equations: Matrícula data

Dep var: Post x change log travel time	(1) log(x) b/se	(2) log($x+1$) b/se	(3) asinh(x) b/se
Post x change log travel time (pred)	0.656	0.796	0.796
	0.034***	0.027***	0.027***
N	451074	4969692	4969692
First-stage F stat	377.426	853.549	853.549
Mean change travel time var.	0.017	0.018	0.018
Destination-year FE	yes	yes	yes
Origin-year FE	yes	yes	yes
Pair FE	yes	yes	yes
Est. method	WLS	WLS	WLS
SE clustered at:	pair	pair	pair
Pre-mig trend	yes	yes	yes

Notes: Data: 2006 and 2010 Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. PUMA) pair. Log change travel time is the log change in traveltime for the least-cost path between the origin and destination pair. Log change travel time (pred) is the change in travel time for the predicted wall expansion. Standard errors are reported in parentheses. Spatial cluster is origin-cluster (1 degree x 1 degree) x destination cluster (1 degree x 1 degree). If weighted, weighted by migration flow. Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Appendix Table 8: Gravity equations: Matrícula data (robustness: unweighted)

	OLS			RF			IV		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	log(x)	log(1+x)	asinh(x)	log(x)	log(1+x)	asinh(x)	log(x)	log(1+x)	asinh(x)
	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Post x change log traveltime	-0.048	-0.208	-0.254				-0.372	-0.354	-0.442
	0.076	0.023***	0.029***				0.240	0.041***	0.051***
Post x change log travel time (pred)				-0.254	-0.282	-0.353			
				0.161	0.037***	0.046***			
N	451074	4969692	4969692	451074	4969692	4969692	451074	4969692	4969692
First-stage F stat							81.69	400.44	400.44
Mean change travel time var.	0.036	0.018	0.018	0.017	0.018	0.018	0.036	0.018	0.018
Destination-year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Origin-year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Pair FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Est. method	OLS	OLS	OLS	OLS	OLS	OLS	2SLS	2SLS	2SLS
SE clustered at:	spatial	spatial	spatial	spatial	spatial	spatial	spatial	spatial	spatial
Pre-mig trend	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Data: 2006 and 2010 Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. PUMA) pair. Log change travel time is the log change in travel time for the least-cost path between the origin and destination pair. Log change travel time (pred) is the change in travel time for the predicted wall expansion. Standard errors are reported in parentheses. Spatial cluster is origin-cluster (1 degree x 1 degree) x destination cluster (1 degree x 1 degree). If weighted, weighted by migration flow. Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Appendix Table 9: Gravity equation: standard errors

Dep var: log(1+x)	(1) b/se	(2) b/se	(3) b/se	(4) b/se	(5) b/se	(6) b/se
Post x change log traveltime	-0.354	-0.354	-0.354	-0.354	-0.354	-0.354
	0.041***	0.029***	0.082***	0.152**	0.023***	0.185*
N	4969692	4969692	4969692	4969692	4969692	4969692
First-stage F stat	400.44	1138.18	107.60	23.66	4985.41	16.03
Mean change travel time var.	0.009	0.009	0.009	0.009	0.009	0.009
Destination-year FE	yes	yes	yes	yes	yes	yes
Origin-year FE	yes	yes	yes	yes	yes	yes
Pair FE	yes	yes	yes	yes	yes	yes
Est. method	W2SLS	W2SLS	W2SLS	W2SLS	W2SLS	W2SLS
SE clustered at:	spatial pair (1x1)	spatial pair (0.5x0.5)	spatial pair (2x2)	two-way spatial (1x1)	pair	state-pair-yr
Pre-mig trend	yes	yes	yes	yes	yes	yes

Notes: Data: 2006 and 2010 Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. PUMA) pair. Log change travel time is the log change in traveltime for the least-cost path between the origin and destination pair. Log change travel time (pred) is the change in travel time for the predicted wall expansion. Cols (1)-(3) present pair spatially-clustered standard errors (origin-cluster x destination-cluster), where each cluster is noted in the table. Col (4) presents two-way clustering (origin-cluster and destination-cluster). Col (5) presents clustering at the origin-destination pair level. Col (6) presents state-pair clusters. If weighted, weighted by migration flow.

Appendix Table 10: Robustness checks of the gravity equations: Matrícula data

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Baseline	No trend	Pedestrian fence	4km buffer	Housing shock	Border patrol	Consul states	No outliers	Quintile
Dep var: $log(1+x)$	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Post x change log traveltime	-0.142	-0.138			-0.138	-0.146	-0.162	-0.322	
	0.047***	0.046***			0.047***	0.048***	0.049***	0.050***	
Post x change log traveltime (ped)			-1.606						
			0.233***						
Post x change log traveltime				-1.440					
				0.499***					
Post X construction X housing shock					-0.462				
					0.080***				
Post X border patrol staff						0.002			
						0.003			
Post x 2 quintile									0.010
									0.002***
Post x 3 quintile									-0.035
									0.004***
Post x 4 quintile									-0.066
									0.008***
Post x 5 quintile									-0.040
									0.006***
N	4969692	4969692	4969692	4969692	4969692	4969692	3375288	4906624	4969692
First stage F stat	276.29	279.79	144.28	50.15	275.89	253.48	310.14	387.09	96.29
Mean change travel time var.	0.018	0.018	0.011	0.002	0.018	0.018	0.019	0.017	0.018
Destination-year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Origin-year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Pair FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Est. method	W2SLS	W2SLS	W2SLS	W2SLS	W2SLS	W2SLS	W2SLS	W2SLS	
SE clustered at:	spatial	spatial	spatial	spatial	spatial	spatial	spatial	spatial	spatial
Pre-mig trend	yes	no	yes	yes	yes	yes	yes	yes	yes

Notes: Data: 2006 and 2010 Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. PUMA) pair. Log change travel time is the log change in travel time for the least-cost path between the origin and destination pair. Log change travel time (pred) is the change in travel time for the predicted wall expansion. Standard errors are reported in parentheses. Spatial cluster is origin-cluster (1 degree x 1 degree) x destination cluster (1 degree x 1 degree). If weighted, weighted by migration flow. Omitted category for quintile regressions is quintile 1 (smallest exposure to wall). Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Appendix Table 11: Heterogenous effects of the border crossing point

	OLS		RF		IV	
	(1)	(2)	(3)	(4)	(5)	(6)
	Log(x)	Log(1+x)	Log(x)	Log(1+x)	Log(x)	Log(1+x)
	b/se	b/se	b/se	b/se	b/se	b/se
Post x change log travel time	0.065	-0.194			-0.354	-0.375
	0.100	0.027***			0.337	0.061***
border elevation	-0.029	-0.009			0.005	0.009
	0.031	0.002***			0.045	0.004**
border river dummy	-0.175	0.003			-0.519	-0.025
	0.217	0.006			0.458	0.014*
Post x change log travel time (pred)			-0.229	-0.292		
			0.228	0.051***		
border elevation			-0.001	0.002		
			0.018	0.001		
border river dummy			-0.182	0.005		
			0.192	0.005		
N	97104	993938	97104	993938	97104	993938
First-stage F stat					26.16	195.14
Mean change travel time var.	0.035	0.018	0.017	0.018	0.035	0.018
Destination-year FE	yes	yes	yes	yes	yes	yes
Origin-year FE	yes	yes	yes	yes	yes	yes
Pair FE	yes	yes	yes	yes	yes	yes
Est. method	W2SLS	W2SLS	W2SLS	W2SLS	W2SLS	W2SLS
SE clustered at:	spatial	spatial	spatial	spatial	spatial	spatial
Pre-mig trend	yes	yes	yes	yes	yes	yes

Notes: Data: 2006 and 2010 Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. PUMA) pair. Log change travel time is the log change in travel time for the least-cost path between the origin and destination pair. Log change travel time (pred) is the change in travel time for the predicted wall expansion. Border elevation and border river are, respectivelly, the elevataion of and an indicator for a major river at the the border crossing point on the least cost path between the origin and destination. Elevation is in standard deviations. Standard errors in parentheses. Spatial cluster is origin-cluster (1 degree x 1 degree) x destination cluster (1 degree x 1 degree). If weighted, weighted by migration flows.

Appendix Table 12: Heterogenous effects of the wall: Matrícula data

Dep var: $log(1+x)$	(1) b/se	(2) b/se	(3) b/se	(4) b/se	(5) b/se	(6) b/se	(7) b/se	(8) b/se	(9) b/se
Post x change log traveltime	-0.142	-0.163	-1.230	-0.769	-0.228	-0.600	-0.139	-0.499	-1.578
	0.047***	0.049***	0.133***	0.115***	0.061***	0.080***	0.044***	0.066***	0.131***
X nummatr2005		0.001							-0.002
		0.001							0.001*
X logorigdistborder			-0.456						-0.407
			0.051***						0.062***
X logdestdistborder				-0.190					-0.075
				0.031***					0.040*
X housingShock					-0.072				-0.018
					0.023***				0.023
X origshareag						-0.407			-0.122
						0.051***			0.057**
X destshareag							-0.053		-0.057
							0.023**		0.031*
X shareConstruction								-0.713	-0.212
								0.087***	0.083**
N	4969692	4969692	4969692	4969692	4969692	4967560	4969692	4969692	4967560
First-stage F stat	276.29	131.19	161.05	188.27	21.07	93.72	113.93	443.25	81.80
Mean change travel time var.	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018
Destination-year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Origin-year FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Pair FE	yes	yes	yes	yes	yes	yes	yes	yes	yes
Est. method	W2SLS	Wgt 2SLS	Wgt 2SLS	Wgt 2SLS	Wgt 2SLS	Wgt 2SLS	Wgt 2SLS	Wgt 2SLS	Wgt 2SLS
SE clustered at:	spatial	spatial	spatial	spatial	spatial	spatial	spatial	spatial	spatial
Pre-mig trend	yes	yes	yes	yes	yes	yes	yes	yes	yes

Notes: Data: 2006 and 2010 Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. PUMA) pair. Log change travel time is the log change in travel time for the least-cost path between the origin and destination pair. Log change travel time (pred) is the change in travel time for the predicted wall expansion. Interaction variables are standardized normal variables. Spatial cluster is origin-cluster (1 degree x 1 degree) x destination cluster (1 degree x 1 degree). If weighted, weighted by migration flows.

Appendix Table 13: Fence expansion and choice of crossing location (EMIF data)

	(1)
Indicator crossing location	b/se
Log distance to destination	-0.046
	0.022**
Log distance to origin	-0.014
	0.015
Fence Expansion	-0.030
	0.017*
Origin-destination FE	568378
Crossing location FE	0.059
IndividualFE	Yes
CrossLocFE	Yes

Notes: This table estimates a choice model at the individual level (holding constant the origin and destination) of which of the 17 EMIF border crossing points to chose. The standard errors are multi-way clustered in each of the included fixed effects.

Appendix Table 14: Gravity equations: Trade data

	(1)	(2)
Post x change log traveltime	0.171 (0.673)	
Log overland distance		-1.249*** (0.032)
Log overland distance * international		-0.564*** (0.153)
Constant		3.922*** (0.207)
Origin-year FE	Yes	Yes
Destination-year FE	Yes	Yes
Origin-destination FE	Yes	No
R-squared	0.978	0.968
Observations	6422	7011

Notes: Each observations is a U.S. state to U.S./Mexico state pair in either 2007 or 2012. The dependent variable is the log value of trade flows in column 1 and the log value of trade flows normalized by own trade flows in column 2. (The normalized trade flows imply the origin-year and destination-year fixed effects are the same and allow the recovery of the constant). Overland distance is the distance along the shortest overland route between origin and destination. Traveltime is the distance along the shortest overland route that avoids a border wall. Both overland distance and traveltime are averaged across all locations (Mexican municipalities and U.S. PUMAs) within the state-year pair. Standard errors clustered by origin-destination pair. Stars indicate statistical significance: * p<.10 ** p<.05 *** p<.01.

Appendix Table 15: Correlates of change in predicted migration (origin and destination level)

	Unwgt inst.		Wgt inst.		GE inst.	
	(1)	(2)	(3)	(4)	(5)	(6)
Panel (a): US						
Dum border state	0.00057		0.0010		0.00098	
	0.00012***		0.00027***		0.00025***	
Log dist. border	0.00026	0.00026	0.00076	0.00071	0.00069	0.00063
	0.000041***	0.00013*	0.000094***	0.00027**	0.000084***	0.00026**
Share in ag	0.0073	0.00098	0.011	-0.00028	0.011	0.00029
	0.0012***	0.00087	0.0029***	0.0011	0.0026***	0.0012
Share in manufacturing	0.00043	-0.000025	0.0012	-0.000033	0.0010	-0.00016
	0.00039	0.00038	0.00090	0.00073	0.00080	0.00066
Share in construction	-0.0057	-0.0023	-0.0088	-0.0031	-0.0083	-0.0028
	0.0015***	0.0023	0.0035**	0.0039	0.0032***	0.0036
Share immigrants	0.00037	-0.00027	0.00074	-0.00066	0.00074	-0.00055
	0.00021*	0.00024	0.00048	0.00059	0.00043*	0.00047
Housing shock	-0.00067	-0.00024	-0.00085	-0.00055	-0.00071	-0.00040
	0.00033**	0.00026	0.00076	0.00032*	0.00068	0.00030
Growth 1990-2000	-0.0000017	-0.000029	0.000061	-0.0000033	0.000036	-0.000019
	0.000053	0.000042	0.00012	0.000069	0.00011	0.000064
N	1066	1063	1066	1063	1066	1063
stateFE	no	yes	no	yes	no	yes
Panel (b): Mexico						
Dum border state	-0.000080		0.00100		0.00065	
	0.000024***		0.00018***		0.00015***	
Log dist. border	0.00018	0.00000058	0.00041	-0.00080	0.00045	-0.00074
	0.000016***	0.000054	0.00012***	0.00047*	0.00010***	0.00043*
Share in ag	0.00031	0.000025	0.00027	-0.00059	0.00063	-0.00022
	0.000031***	0.000014*	0.00024	0.00046	0.00019***	0.00035
Share in manufacturing	-0.00019	-0.000071	-0.0019	-0.0013	-0.0012	-0.00074
	0.000096*	0.000066	0.00072***	0.00064**	0.00059*	0.00048
Share in construction	0.00016	0.000011	-0.00037	-0.000039	0.00019	0.00020
	0.000058***	0.000033	0.00044	0.00052	0.00036	0.00037
Growth 1990-2000	0.00014	0.0000086	0.00081	0.00036	0.00071	0.00030
	0.000026***	0.000016	0.00020***	0.00031	0.00016***	0.00025
N	2069	2067	2069	2067	2069	2067
stateFE	no	yes	no	yes	no	yes

Notes: Table shows the result of multivariate OLS regression. An observation is either a cpuma0010 (U.S.) or geolev2 (Mexico). OLS regression. Table correlates instrument (predicted change in immigrants) with local characteristics. All characteristics defined in pre-period. Standard errors clustered by state.

Appendix Table 16: Predicting pop change in Mexico: three measures (rf)

Dep var: $log(N_{dt}/N_{dt-1})$	(1) b/se	(2) b/se	(3) b/se
Low-educ pop			
Simple	-6.732		
	46.964		
Network		0.877	
		1.928	
GE Network			1.952
			2.828
F (inst)	0.021	0.207	0.477
No. of migrants in US			
Simple	239.688		
	500.225		
Network		-5.005	
		12.878	
GE Network			11.569
			19.360
F (inst)	0.230	0.151	0.357
Return migrants			
Simple	477.429		
	499.008		
Network		-17.282	
		8.324**	
GE Network			-7.282
			15.549
F (inst)	0.915	4.310	0.219
N	2328	2328	2328
State FE	yes	yes	yes
controls	Pop growth	Pop growth	Pop growth
whatSE	State	State	State
WLS	yes	yes	yes

Notes: Standard errors clustered at the state level. Sample is 2000 and 2010 Mexican Censuses.

Appendix Table 17: Migration rate: ENOE data

	No state FE			State FE			Add distance trends		
	Out	In	Net	Out	In	Net	Out	In	Net
Dep var: rate per 10,000	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se	b/se
Post X predicted change in low-skill Mex	0.494	0.565	-0.071	0.260	0.177	0.084	0.319	0.165	0.154
	0.291*	0.192***	0.252	0.264	0.197	0.097	0.264	0.196	0.103
Post X log dist border							0.003	-0.001	0.004
							0.002	0.002	0.001***
N	4941	4941	4941	4931	4931	4931	4931	4931	4931
clusterSE	state	state	state	state	state	state	state	state	state
stateYrFE	no	no	no	yes	yes	yes	yes	yes	yes

Notes: An observation is a (time-consistent) Mexican municipality. Data: 2005/2006 (pre) and 2010-2012 (post) ENOE household data. Measure of wall shock is the network instrument. Migration rates computed from the ENOE following the Mexican Statistical Agency methodological guidelines (INEGI (2012)). The instrument is the predicted change in low-skill Mexicans (which is more positive for places that are more affected by the wall). We expect the instrument to be negatively correlated with out-migration. If migrants do not want to return to locations that are more affected by the wall, then inflows would be negatively correlated with the instrument. The net effect on migration could therefore be either negative or positive.

Appendix Table 18: Estimation of production function elasticities: First stage

	Mex./U.S.: Low skill (1)	Mex./U.S.: High skill (2)	High/low skill (3)
Simple average wall exposure			
Simple average wall exposure	32.833*	15.078	-17.975**
	(18.042)	(15.397)	(7.470)
...X Mexico	-141.009	-224.299	-112.954
	(205.093)	(273.744)	(184.595)
F-statistic	1.796	0.773	3.147
Network wall exposure			
Network wall exposure	14.960**	7.712*	-8.649***
	(5.742)	(4.226)	(2.142)
...X Mexico	-29.151***	-28.969***	-7.078
	(10.051)	(9.859)	(12.107)
F-statistic	4.873	4.512	9.019
GE network wall exposure			
GE network wall exposure	19.035**	9.713	-10.636***
	(8.314)	(6.546)	(3.228)
...X Mexico	-39.665***	-39.204***	-0.492
	(12.854)	(11.366)	(11.097)
F-statistic	4.835	6.138	5.979
Controls	None	None	None
Fixed Effects	State	State	State
Standard Errors	State clusters	State clusters	State clusters
Weighting	Pre-pop.	Pre-pop.	Pre-pop.
Sample	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.
Observations	3392	3392	3392

Notes: Ordinary least squares. Each observation is a (log) difference in a U.S. or Mexico location pre- and post- the SFA. Pre- and post- data come from the 2000 and 2010 censuses in Mexico, respectively; pre- data in the U.S. comes from the 2000 census and post-data come from an average of the 2010-2012 ACS. The dependent variable is the change in the relative population shares. The independent variable (the instrument) is either a *simple average fence exposure* which is the unweighted average fence exposure across all origins; a *network wall exposure* which is a weighted average fence exposure across all origins, where the weights are the pre-period migration flows; or a *GE network wall exposure* which in addition to weighting flows by pre-period mirgation flows also accounts for substitution in migration across different destinations by correcting for each orgin's market access; see the text for details. Standard errors are reported in parentheses. Stars indicate statistical significance: * p<.10 ** p<.05 *** p<.01.

Appendix Table 19: Estimation of migration elasticities: First stage

	(1) Mex Low Skill	(2) Mex High Skill	(3) U.S. Low Skill	(4) U.S. High Skill	(5) Pooled
Simple average wall exposure					
Simple average wall exposure	-22.749***	-12.115	-3.506	0.011	-4.809
	(5.502)	(12.491)	(4.088)	(5.736)	(4.816)
...X Mexico	2.611	-46.856	179.619	287.455**	-16.814
	(79.836)	(92.073)	(143.112)	(137.155)	(77.542)
F-statistic	8.581	0.679	1.126	2.200	0.538
Network wall exposure					
Network wall exposure	-7.605***	-2.844	-1.739	0.363	-1.816**
	(1.158)	(2.745)	(1.408)	(0.932)	(0.694)
...X Mexico	4.277	-0.194	0.773	2.458	-1.440
	(2.831)	(5.421)	(10.237)	(4.690)	(2.857)
F-statistic	22.413	0.748	0.767	0.265	4.112
GE network wall exposure					
GE network wall exposure	-9.019***	-3.215	-1.144	1.058	-1.378
	(1.285)	(3.090)	(1.825)	(0.946)	(0.943)
...X Mexico	5.331	1.731	1.634	0.459	-1.967
	(3.536)	(7.142)	(12.082)	(5.527)	(3.741)
F-statistic	25.258	0.568	0.197	0.664	1.496
Controls	None	None	None	None	None
Fixed Effects	State	State	State	State	State*Type
Standard Errors	State clusters	State clusters	State clusters	State clusters	State clusters
Weighting	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.
Sample	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.
Observations	3392	3392	3392	3392	13568

Notes: Ordinary least squares. Each observation is a (log) difference in a U.S. or Mexico location pre- and post- the SFA. Pre- and post- data come from the 2000 and 2010 censuses in Mexico, respectively; pre- data in the U.S. comes from the 2000 census and post-data come from an average of the 2010-2012 ACS. The dependent variable is the (log) change in the real wage, where the nominal wages are observed and the price indices are calculated from the trade destination fixed effect and the estimated trade elasticity. The independent variable (the instrument) is either a *simple average fence exposure* which is the unweighted average fence exposure across all origins; a *network wall exposure* which is a weighted average fence exposure across all origins, where the weights are the pre-period migration flows; or a *GE network wall exposure* which in addition to weighting flows by pre-period mirgation flows also accounts for substitution in migration across different destinations by correcting for each orgin's market access; see the text for details. Standard errors are reported in parentheses. Stars indicate statistical significance: * p<.10 ** p<.05 *** p<.01.

Appendix Table 20: Robustness of estimated structural parameters: Simple instrument

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EoS between Mex. and	3.693***	3.490***	3.103***	3.875	3.715***	3.780***	4.635	3.204***	3.930***	3.308***
U.S. low skill (ρ_l)	(0.827)	(1.211)	(1.017)	(4.523)	(0.913)	(1.055)	(10.039)	(0.625)	(0.845)	(0.617)
EoS between Mex. and	23.897	-5.462	-6.741	-2.855	8.331	197.073	-1.511	2.277***	7.672	2.470***
U.S. high skill (ρ_h)	(244.508)	(21.459)	(33.847)	(5.407)	(23.040)	(1.9e+04)	(2.386)	(0.382)	(13.780)	(0.579)
EoS between high and	1.695***	1.185***	1.580*	1.568***	1.701***	1.583***	0.958**	1.540***	1.990***	1.557***
low skill (ρ)	(0.415)	(0.299)	(0.806)	(0.340)	(0.380)	(0.272)	(0.397)	(0.323)	(0.677)	(0.348)
EoS between goods	1.377***	0.965***	1.191***	1.356***	1.264***	1.574***	1.010***	2.228***	1.776	2.117***
produced in different locations (σ)	(0.387)	(0.108)	(0.377)	(0.353)	(0.293)	(0.461)	(0.047)	(0.701)	(2.576)	(0.526)
Mex. Low skill	-1.007*	0.149	-0.675**	-0.450**	-0.822*	-0.907**	-0.007	-1.409	-1.698	-1.304
migration elasticity (θ_l^M)	(0.593)	(0.184)	(0.326)	(0.178)	(0.444)	(0.444)	(0.011)	(0.920)	(1.678)	(0.831)
Mex. High skill	0.991	-0.277	0.655	0.794	0.760	1.376	0.053*	1.344	1.737	1.020
migration elasticity (θ_h^M)	(1.158)	(0.190)	(0.667)	(0.699)	(0.887)	(1.601)	(0.031)	(2.527)	(4.555)	(2.804)
U.S. Low skill	0.171	0.014	0.014	1.189	-0.023	0.474	-0.146	-1.520	-4.644	-1.059
migration elasticity (θ_l^U)	(0.971)	(0.098)	(0.694)	(1.750)	(0.507)	(1.273)	(0.337)	(7.006)	(14.061)	(3.955)
U.S. High skill	0.147	-0.181**	1.247	0.205	2.213	-1.971	0.012	-2.522	-1.881***	-2.654
migration elasticity (θ_h^U)	(0.935)	(0.086)	(1.300)	(0.951)	(2.884)	(2.474)	(0.043)	(2.313)	(0.489)	(2.630)
Pooled migration	0.036	-0.030	-0.153	-0.533	0.032	0.212	-0.011	0.792	-0.922	0.886
elasticity ($\bar{\theta}$)	(0.596)	(0.031)	(0.402)	(0.423)	(0.377)	(1.010)	(0.024)	(4.911)	(1.403)	(4.804)
Controls:										
1990-2000 pop. growth (by type)	No	**Yes**	No	No	No	No	**Yes**	No	No	No
2000-2005 pop. growth (by type)	No	No	**Yes**	No	No	No	**Yes**	No	No	No
Distance to border (log)	No	No	No	**Yes**	No	No	**Yes**	No	No	No
2000 U.S. Ag. employ. share	No	No	No	No	**Yes**	No	**Yes**	No	No	No
Housing shock	No	No	No	No	No	**Yes**	**Yes**	No	No	No
IV construction:										
IV interacted with..	Country	Country	Country	Country	Country	Country	Country	**None**	Country	None
Wall location used..	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted	**Actual**	Predicted
Sample	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	**U.S. only**
Fixed Effects	State	State	State	State	State	State	State	State	State	State
Weighting	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.
Standard errors	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters

Notes: This table shows the estimated structural parameters for under a variety of alternative specifications. Every row is a result from a different regression; in each regression, each observation is a (log) difference in a U.S. or Mexico location pre- and post-the SFA. Pre- and post- data come from the 2000 and 2010 censuses in Mexico, respectively; pre- data in the U.S. comes from the 2000 census and post-data come from an average of the 2010-2012 ACS. Column (1) summarize the preferred results presented in Tables 3, 4, and 5. Columns (2) - (7) include additional control variables including the 1990-2000 population growth rate of each of the four types of labor, the 2000-2005 population growth rate of each of the four types of labor, the (log) distance to the border, the year 2000 agricultural employment share of each U.S. location, and a measure of the housing shock from Mian and Sufi (2014). Column (8) requires the instrument to have the same impact in the U.S. and Mexico by removing the country interaction. Column (9) constructs the instrument using the actual location of the border wall expansion (instead of the predicted location due to geography along the border). Column (10) restricts the analysis to U.S. locations only. Standard errors are reported in parentheses. Stars indicate statistical significance: * p<.10 ** p<.05 *** p<.01.

Appendix Table 21: Robustness of estimated structural parameters: Network instrument

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EoS between Mex. and	4.490***	3.947***	3.705**	4.265	4.215***	4.648**	2.871	3.465**	4.921***	3.973***
U.S. low skill (ρ_l)	(1.513)	(1.476)	(1.615)	(5.347)	(1.006)	(1.818)	(2.421)	(1.353)	(0.847)	(0.666)
EoS between Mex. and	8.784	-11.011	35.047	-27.910	5.043	9.645	-4.489	1.613	4.366	2.612*
U.S. high skill (ρ_h)	(11.861)	(16.177)	(222.906)	(109.576)	(4.007)	(15.071)	(3.791)	(1.379)	(2.777)	(1.346)
EoS between high and	1.930***	1.576***	1.831**	2.028**	1.945***	1.840***	1.449*	1.443***	1.711***	1.669***
low skill (ρ)	(0.528)	(0.566)	(0.897)	(0.917)	(0.496)	(0.466)	(0.833)	(0.118)	(0.264)	(0.267)
EoS between goods	2.975***	1.088***	2.143***	3.157***	2.705***	3.023***	1.023**	3.943	2.146***	2.503***
produced in different locations (σ)	(0.420)	(0.334)	(0.483)	(0.396)	(0.569)	(0.150)	(0.430)	(5.073)	(0.602)	(0.305)
Mex. Low skill	-1.114**	-0.346	-1.061**	-0.805**	-1.363**	-1.020**	-0.036	-1.124*	-0.166	-1.124**
migration elasticity (θ_l^M)	(0.518)	(0.373)	(0.513)	(0.333)	(0.690)	(0.469)	(0.029)	(0.617)	(0.275)	(0.547)
Mex. High skill	1.178	0.908	1.130	1.162	0.828	1.238	0.162	1.203	2.138	0.595
migration elasticity (θ_h^M)	(1.786)	(1.189)	(1.754)	(1.638)	(1.142)	(1.868)	(0.102)	(1.803)	(1.647)	(0.988)
U.S. Low skill	1.188	0.178	0.898	-0.953	1.229	1.504	0.022	1.191	2.075	1.211
migration elasticity (θ_l^U)	(1.827)	(0.261)	(1.935)	(0.828)	(1.270)	(2.450)	(0.217)	(1.961)	(2.103)	(1.757)
U.S. High skill	-11.684	0.637**	-8.304	4.663	-4.671	-10.400	0.176	-11.503	-9.732	-32.135
migration elasticity (θ_h^U)	(22.411)	(0.273)	(26.778)	(16.029)	(8.861)	(16.088)	(0.178)	(18.910)	(7.553)	(155.095)
Pooled migration	-0.397	0.071	-0.565	-0.397	-0.369	-0.404	-0.015	-0.169	0.540	1.136
elasticity ($\bar{\theta}$)	(0.511)	(0.144)	(0.495)	(0.384)	(0.716)	(0.528)	(0.053)	(0.569)	(0.592)	(0.780)
Controls:										
1990-2000 pop. growth (by type)	No	**Yes**	No	No	No	No	**Yes**	No	No	No
2000-2005 pop. growth (by type)	No	No	**Yes**	No	No	No	**Yes**	No	No	No
Distance to border (log)	No	No	No	**Yes**	No	No	**Yes**	No	No	No
2000 U.S. Ag. employ. share	No	No	No	No	**Yes**	No	**Yes**	No	No	No
Housing shock	No	No	No	No	No	**Yes**	**Yes**	No	No	No
IV construction:										
IV interacted with..	Country	Country	Country	Country	Country	Country	Country	**None**	Country	None
Wall location used..	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted	**Actual**	Predicted
Sample	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	**U.S. only**
Fixed Effects	State	State	State	State	State	State	State	State	State	State
Weighting	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.
Standard errors	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters

Notes: This table shows the estimated structural parameters for under a variety of alternative specifications. Every row is a result from a different regression; in each regression, each observation is a (log) difference in a U.S. or Mexico location pre- and post-the SFA. Pre- and post- data come from the 2000 and 2010 censuses in Mexico, respectively; pre- data in the U.S. comes from the 2000 census and post-data come from an average of the 2010-2012 ACS. Column (1) summarize the preferred results presented in Tables 3, 4, and 5. Columns (2) - (7) include additional control variables including the 1990-2000 population growth rate of each of the four types of labor, the 2000-2005 population growth rate of each of the four types of labor, the (log) distance to the border, the year 2000 agricultural employment share of each U.S. location, and a measure of the housing shock from Mian and Sufi (2014). Column (8) requires the instrument to have the same impact in the U.S. and Mexico by removing the country interaction. Column (9) constructs the instrument using the actual location of the border wall expansion (instead of the predicted location due to geography along the border). Column (10) restricts the analysis to U.S. locations only. Standard errors are reported in parentheses. Stars indicate statistical significance: * p<.10 ** p<.05 *** p<.01.

Appendix Table 22: Robustness of estimated structural parameters: GE network instrument

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
EoS between Mex. and	4.533***	4.182**	3.912**	5.139	4.179***	4.749**	3.757	3.102***	4.486***	3.734***
U.S. low skill (ρ_l)	(1.521)	(1.769)	(1.771)	(7.209)	(1.062)	(1.927)	(4.595)	(1.079)	(0.389)	(0.604)
EoS between Mex. and	8.581	-33.238	18.647	-42.459	5.217	9.337	-8.347	1.602	3.788**	2.645**
U.S. high skill (ρ_h)	(10.852)	(129.167)	(58.037)	(229.052)	(4.060)	(13.607)	(11.208)	(1.442)	(1.905)	(1.166)
EoS between high and	2.036***	1.490***	1.787**	2.132**	2.092***	1.902***	1.197**	1.487***	1.818***	1.723***
low skill (ρ)	(0.624)	(0.474)	(0.908)	(1.002)	(0.602)	(0.496)	(0.545)	(0.171)	(0.371)	(0.340)
EoS between goods	3.141***	0.976***	1.795***	3.139***	2.706***	3.168***	0.971***	11.407	1.827***	2.494***
produced in different locations (σ)	(0.756)	(0.242)	(0.371)	(0.682)	(0.830)	(0.279)	(0.146)	(97.382)	(0.445)	(0.535)
Mex. Low skill	-1.543*	0.156	-1.340*	-1.030**	-1.718*	-1.420*	0.081	-1.723	-0.887*	-1.354*
migration elasticity (θ_l^M)	(0.856)	(0.263)	(0.785)	(0.425)	(0.955)	(0.774)	(0.065)	(1.160)	(0.509)	(0.808)
Mex. High skill	1.273	-0.400	1.019	0.763	0.773	1.532	-0.238	1.831	0.644	0.466
migration elasticity (θ_h^M)	(3.277)	(0.547)	(2.397)	(1.157)	(1.898)	(3.871)	(0.158)	(6.709)	(0.519)	(1.294)
U.S. Low skill	1.724	-0.046	1.071	-3.660	1.465	2.647	0.481	1.631	1.433	1.368
migration elasticity (θ_l^U)	(4.459)	(0.092)	(3.030)	(11.266)	(2.061)	(7.914)	(0.702)	(5.831)	(2.006)	(3.439)
U.S. High skill	-6.090	-0.182**	-9.536	5.641	-8.038	-5.661	-0.353	-4.571	-5.741**	-7.798
migration elasticity (θ_h^U)	(5.102)	(0.076)	(25.294)	(47.143)	(10.902)	(4.355)	(1.129)	(2.838)	(2.575)	(8.293)
Pooled migration	-1.130	-0.001	-1.048	-0.950	-1.245	-1.174	0.082	-0.824	-0.244	1.134
elasticity ($\bar{\theta}$)	(1.101)	(0.047)	(0.987)	(0.718)	(1.411)	(1.182)	(0.088)	(0.928)	(0.355)	(1.374)
Controls:										
1990-2000 pop. growth (by type)	No	**Yes**	No	No	No	No	**Yes**	No	No	No
2000-2005 pop. growth (by type)	No	No	**Yes**	No	No	No	**Yes**	No	No	No
Distance to border (log)	No	No	No	**Yes**	No	No	**Yes**	No	No	No
2000 U.S. Ag. employ. share	No	No	No	No	**Yes**	No	**Yes**	No	No	No
Housing shock	No	No	No	No	No	**Yes**	**Yes**	No	No	No
IV construction:										
IV interacted with..	Country	Country	Country	Country	Country	Country	Country	**None**	Country	None
Wall location used..	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted	Predicted	**Actual**	Predicted
Sample	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	U.S. and Mex.	**U.S. only**
Fixed Effects	State	State	State	State	State	State	State	State	State	State
Weighting	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.	Pre-pop.
Standard errors	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters	State clusters

Notes: This table shows the estimated structural parameters for under a variety of alternative specifications. Every row is a result from a different regression; in each regression, each observation is a (log) difference in a U.S. or Mexico location pre- and post- the SFA. Pre- and post- data come from the 2000 and 2010 censuses in Mexico, respectively; pre- data in the U.S. comes from the 2000 census and post-data come from an average of the 2010-2012 ACS. Column (1) summarize the preferred results presented in Tables 3, 4, and 5. Columns (2) - (7) include additional control variables including the 1990-2000 population growth rate of each of the four types of labor, the 2000-2005 population growth rate of each of the four types of labor, the (log) distance to the border, the year 2000 agricultural employment share of each U.S. location, and a measure of the housing shock from Mian and Sufi (2014). Column (8) requires the instrument to have the same impact in the U.S. and Mexico by removing the country interaction. Column (9) constructs the instrument using the actual location of the border wall expansion (instead of the predicted location due to geography along the border). Column (10) restricts the analysis to U.S. locations only. Standard errors are reported in parentheses. Stars indicate statistical significance: * p<.10 ** p<.05 *** p<.01.

Appendix Table 23: Counterfactual Results: Robustness

	Baseline	Labor group elasticity		Trade elasticity		Migration elasticity	
		Low ($\rho_h = \rho_l = 1.1$)	High ($\rho_h = \rho_l = 30$)	Low ($\sigma = 2$)	High ($\sigma = 11$)	Low ($\theta = 0.1$)	High ($\theta = 8$)
Secure Fence Act							
Change in Mex. to U.S. migration (persons)	-49956	-27350	-68173	-48861	-51931	-917	-30720
Change in welfare (per capita 2012 USD):							
Mex. Low Skill	-0.81	-0.51	-1.31	-0.71	-1.04	-8.04	-0.03
Mex. High Skill	-1.82	0.23	-3.57	-2.08	-1.21	-15.69	-0.42
U.S. Low Skill	0.28	-1.75	2.32	0.29	0.20	0.02	0.20
U.S. High Skill	-2.73	-2.05	-3.25	-2.78	-2.56	0.00	-1.67
Additional Border Wall Expansion: 25% expansion							
Change in Mex. to U.S. migration (persons)	-74937	-40960	-102307	-73323	-77846	-1491	-46103
Change in welfare (per capita 2012 USD):							
Mex. Low Skill	-1.22	-0.77	-1.98	-1.07	-1.57	-12.89	-0.05
Mex. High Skill	-2.70	0.35	-5.31	-3.10	-1.77	-25.29	-0.62
U.S. Low Skill	0.43	-2.64	3.50	0.45	0.31	0.04	0.31
U.S. High Skill	-4.11	-3.09	-4.90	-4.19	-3.86	0.00	-2.51
Additional Border Wall Expansion: 50% expansion							
Change in Mex. to U.S. migration (persons)	-87392	-47069	-119961	-85571	-90708	-2361	-53537
Change in welfare (per capita 2012 USD:)							
Mex. Low Skill	-1.43	-0.88	-2.35	-1.27	-1.83	-20.37	-0.07
Mex. High Skill	-3.06	0.41	-6.04	-3.52	-2.00	-40.01	-0.68
U.S. Low Skill	0.47	-3.24	4.15	0.49	0.32	0.05	0.31
U.S. High Skill	-4.78	-3.53	-5.75	-4.87	-4.50	0.06	-2.90
Reducing International Trade Costs: 25% reduction							
Change in Mex. to U.S. migration (persons)	-107030	-20339	-176650	-245209	-20651	-11315	-144122
Change in welfare (per capita 2012 USD):							
Mex. Low Skill	100.12	101.63	97.82	215.23	21.44	13.19	103.97
Mex. High Skill	244.95	253.46	237.93	529.57	51.61	27.38	250.45
U.S. Low Skill	57.63	48.27	66.72	124.09	12.36	27.14	57.98
U.S. High Skill	78.27	81.31	75.86	172.21	16.11	42.29	75.20
Reducing International Trade Costs: 50% reduction							
Change in Mex. to U.S. migration (persons)	-409761	-114062	-644476	-896651	-86313	-39055	-560532
Change in welfare (per capita 2012 USD):							
Mex. Low Skill	340.01	345.59	331.93	732.00	73.02	44.43	354.86
Mex. High Skill	822.09	851.74	797.23	1786.46	173.09	91.77	845.54
U.S. Low Skill	195.11	162.00	226.53	427.03	40.92	90.22	200.69
U.S. High Skill	261.37	271.26	253.62	587.23	52.14	141.92	256.68

Notes: This table shows how the estimated impacts of the existing border wall expansion and counterfactual international trade cost reductions differ across a variety of alternative assumptions regardling the structural parameters. The Secure Fence Act counterfactual calculates the equilibrium effect of the estimated increase in migration costs for Mexican born workers due to the construction of additional segments of border wall. The reducing trade costs counterfactual reduces the additional estimated distance elasticity for international trade over and above the distance elasticity of domestic trade flows by a given percentage. Absolute changes in real GDP calculated by scaling the model estimated baseline GDP by current real GDP figures for U.S. and Mexico, respectively.

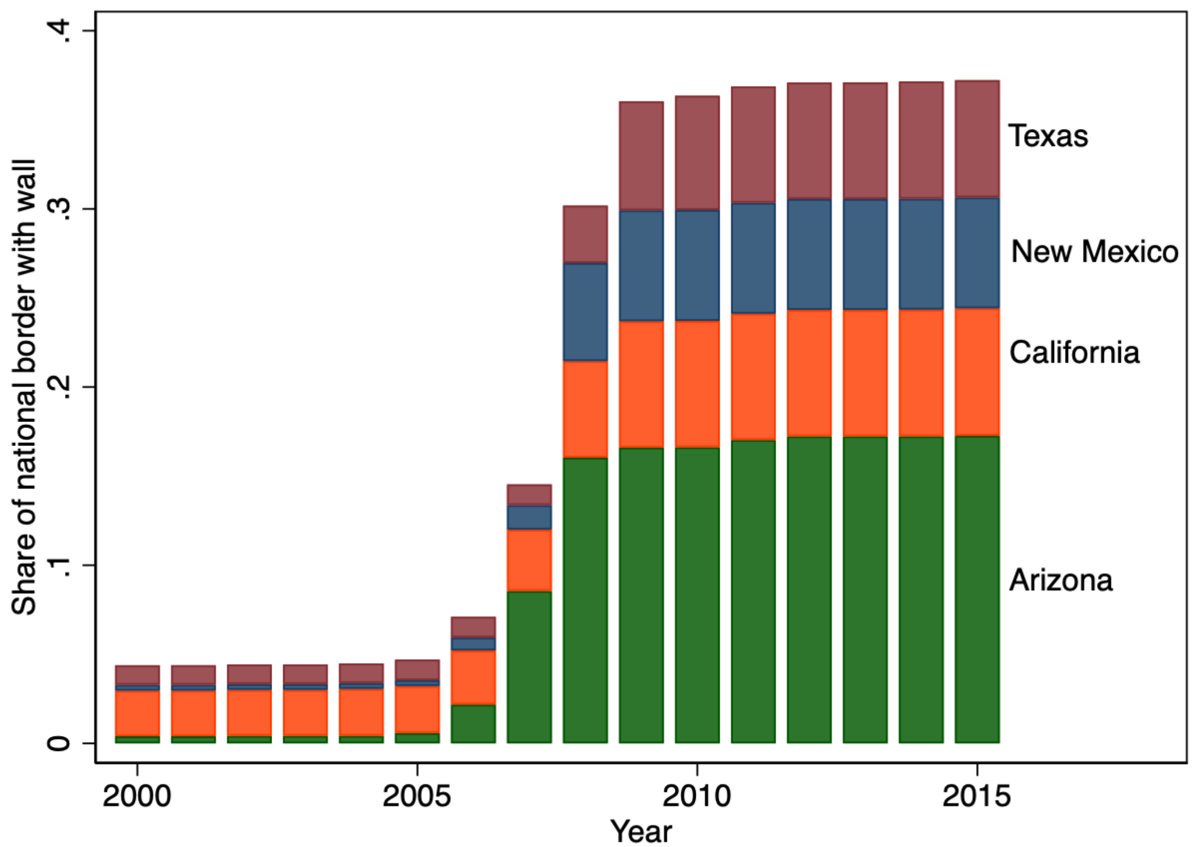
Appendix Figure 1: Example of border walls

(a) Pedestrian Fence

(b) Vehicular Fence

Notes: Source: (a) https://www.memphisflyer.com/memphis/against-the-wall/Content?oid=4602862; (b) http://mexicowall.net/gallery/

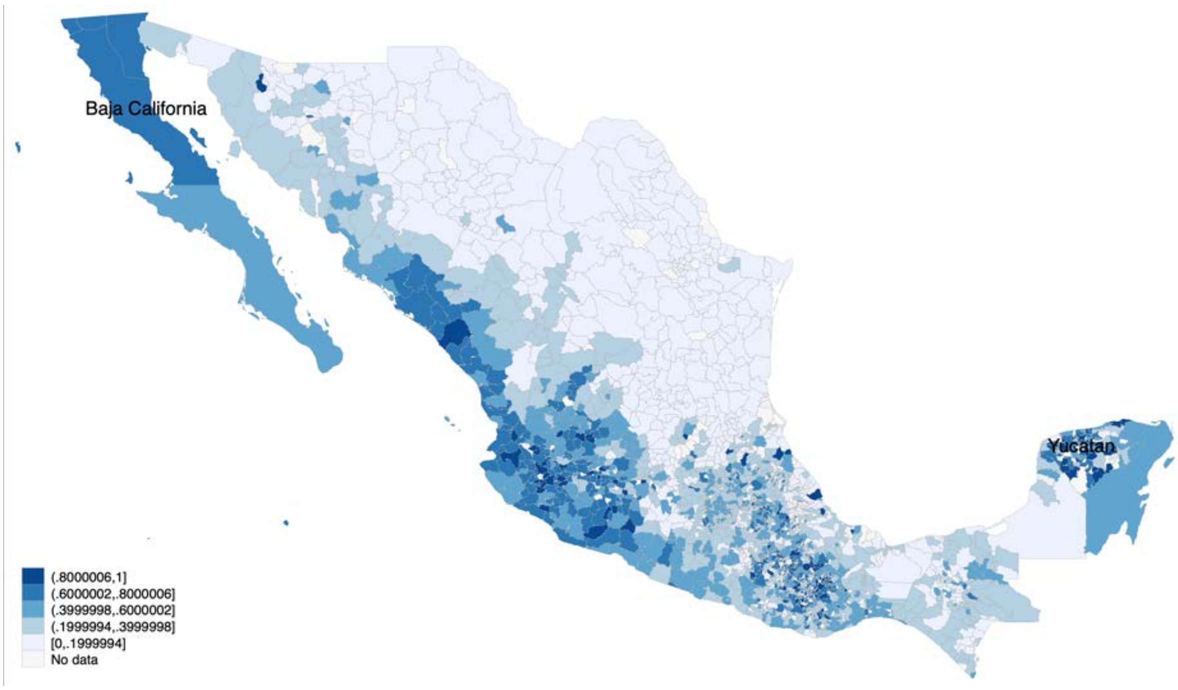
Appendix Figure 2: Wall expansion by year



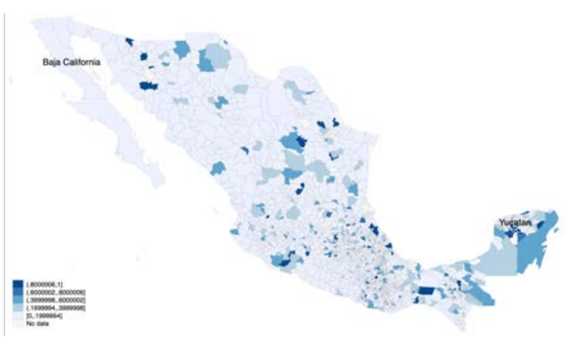
Notes: Source: Data shared by Guerrero and Castañeda (2017).

Appendix Figure 3: Matrícula database: Migration to CA

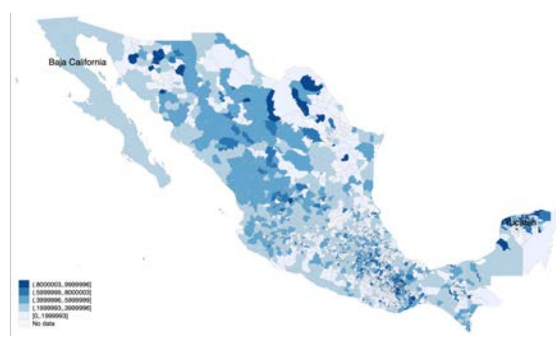
(a) Destination: California



(b) Destination: Bay Area



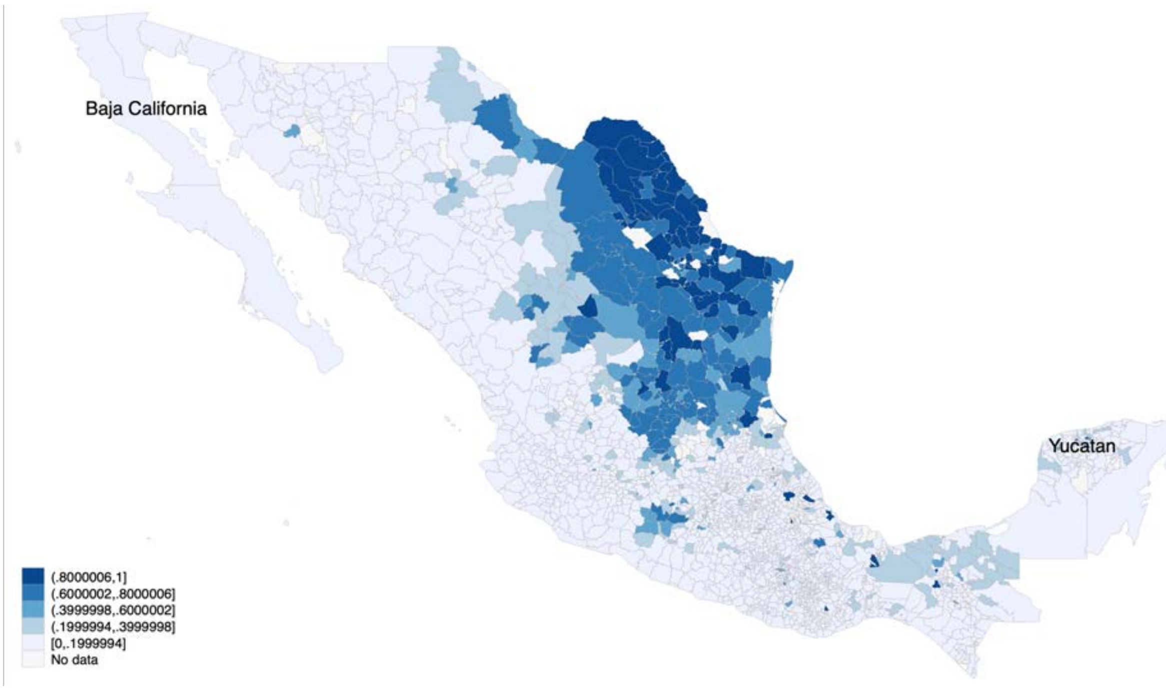
(c) Destination: Los Angeles



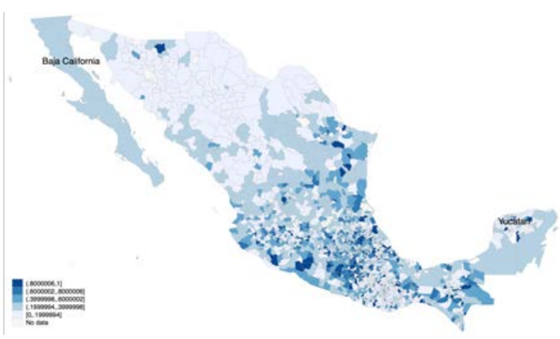
Notes: Source: 2006 Matrícula Consular database.

Appendix Figure 4: Matrícula database: migration to Texas

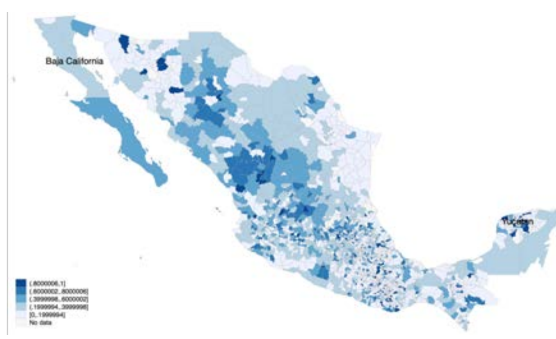
(a) Destination: Texas



(b) Destination: Houston



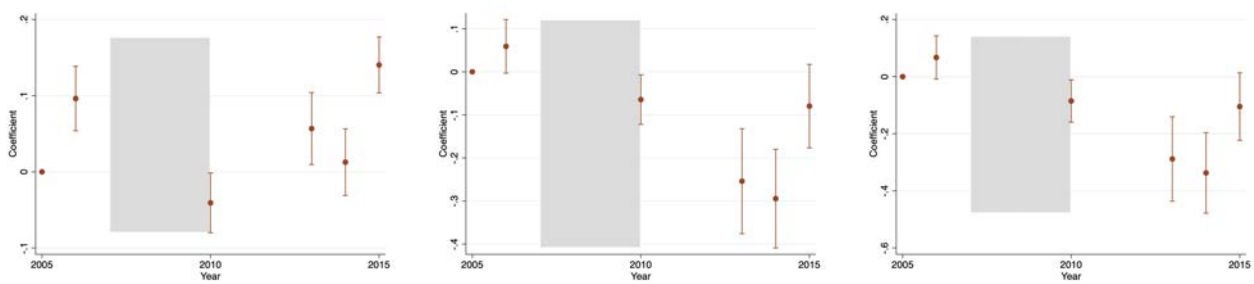
(c) Destination: Dallas



Notes: Source: 2006 Matrícula Consular database.

Appendix Figure 5: Matrícula gravity: Event study

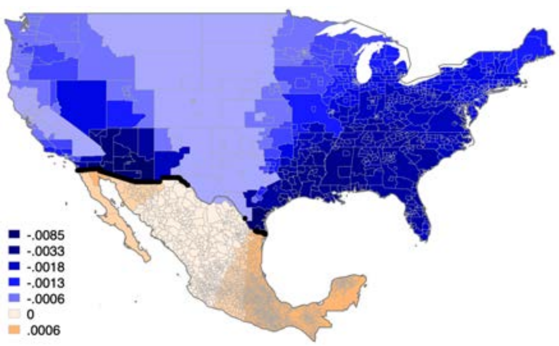
(a) Log(1+x): OLS (b) Log(1+x): RF (c) Log(1+x): IV



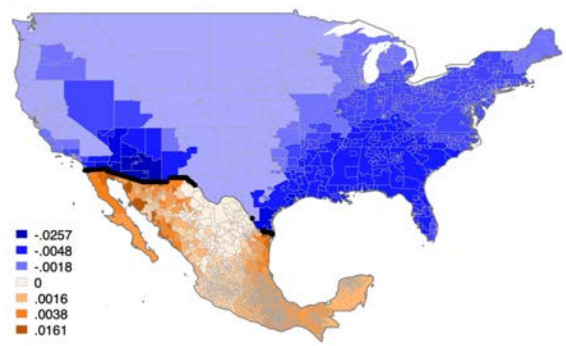
Notes: Data: 2005, 2006, 2010, 2012-2015 Matrícula database. Figure plots the coefficient, by year, on log change travel time from a gravity regression. Regression weighted by flows. Standard errors clustered at the pair-spatial cluster, as defined in the text.

Appendix Figure 6: Predicted change in low-educated Mexican-born: different instruments

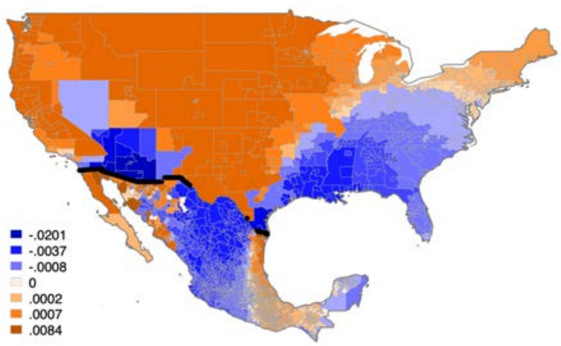
(a) Simple instrument



(b) Network instrument



(c) GE network instrument

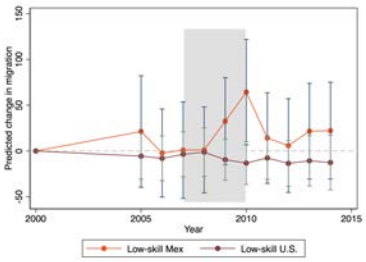


Notes: Figure shows the predicted change in low-skill Mexican born for each of the three instruments. Instruments defined in text.

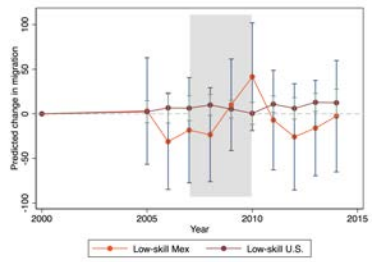
Appendix Figure 7: Event studies (Simple instrument)

Panel (i): United States

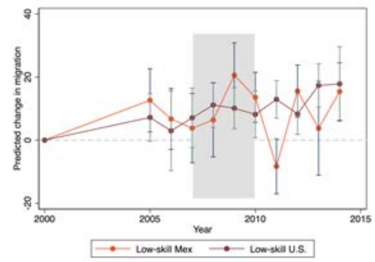
(a) No controls, unweighted



(b) Controls, unweighted

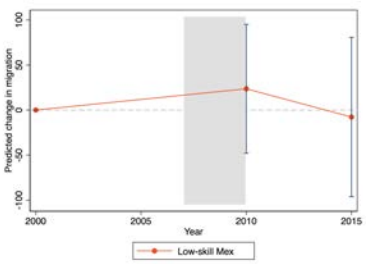


(c) Controls, weighted

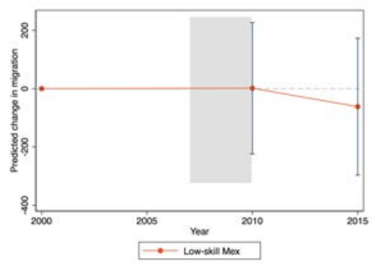


Panel (ii): Mexico

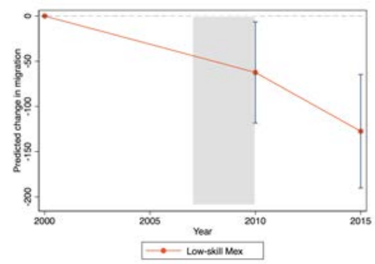
(d) No controls, unweighted



(e) Controls, unweighted



(f) Controls, weighted

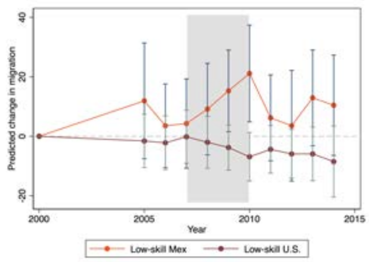


Notes: Figure shows the predicted change in low-skill Mexican born for one of the three instruments. Panel (i) considers the effect on destinations in the United States. Panel (ii) considers the effect on origins in Mexico. Instruments defined in text.

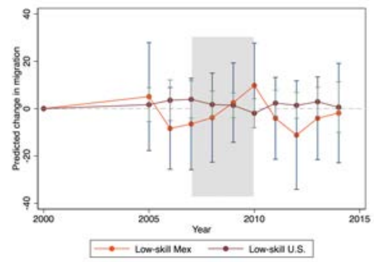
Appendix Figure 8: Event studies (Network instrument)

Panel (i): United States

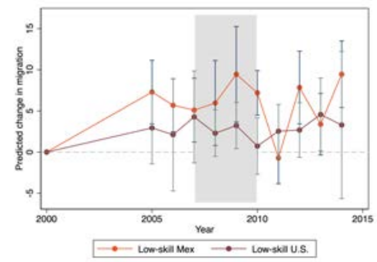
(a) No controls, unweighted



(b) Controls, unweighted

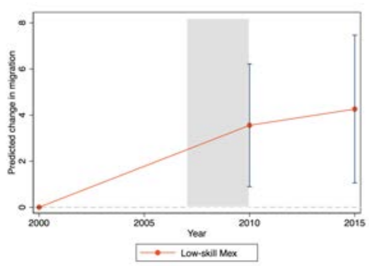


(c) Controls, weighted

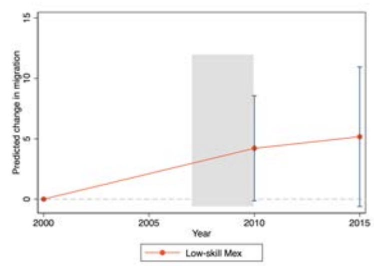


Panel (ii): Mexico

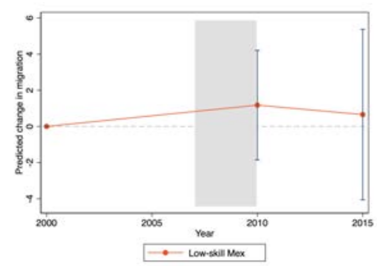
(d) No controls, unweighted



(e) Controls, unweighted



(f) Controls, weighted

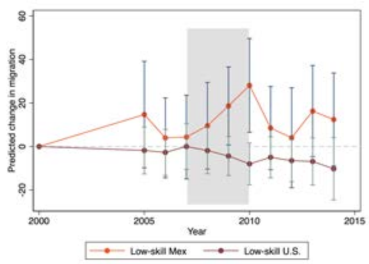


Notes: Figure shows the predicted change in low-skill Mexican born for one of the three instruments. Panel (i) considers the effect on destinations in the United States. Panel (ii) considers the effect on origins in Mexico. Instruments defined in text.

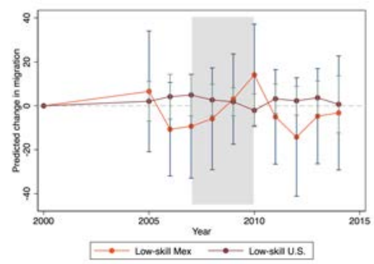
Appendix Figure 9: Event studies (GE Network instrument)

Panel (i): United States

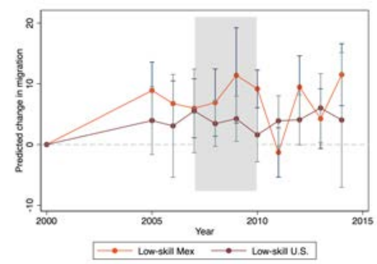
(a) No controls, unweighted



(b) Controls, unweighted

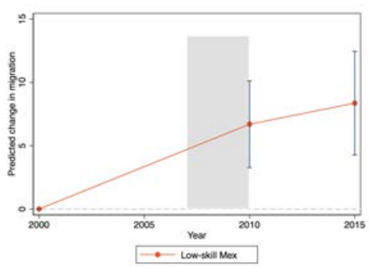


(c) Controls, weighted

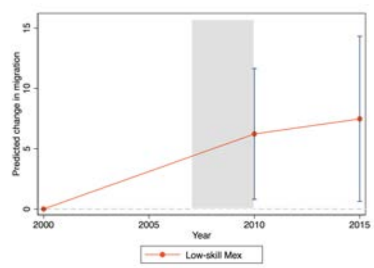


Panel (ii): Mexico

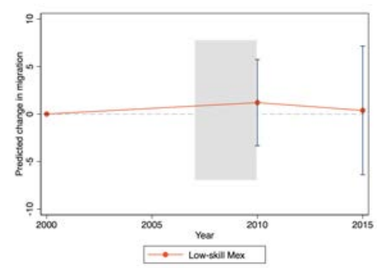
(d) No controls, unweighted



(e) Controls, unweighted

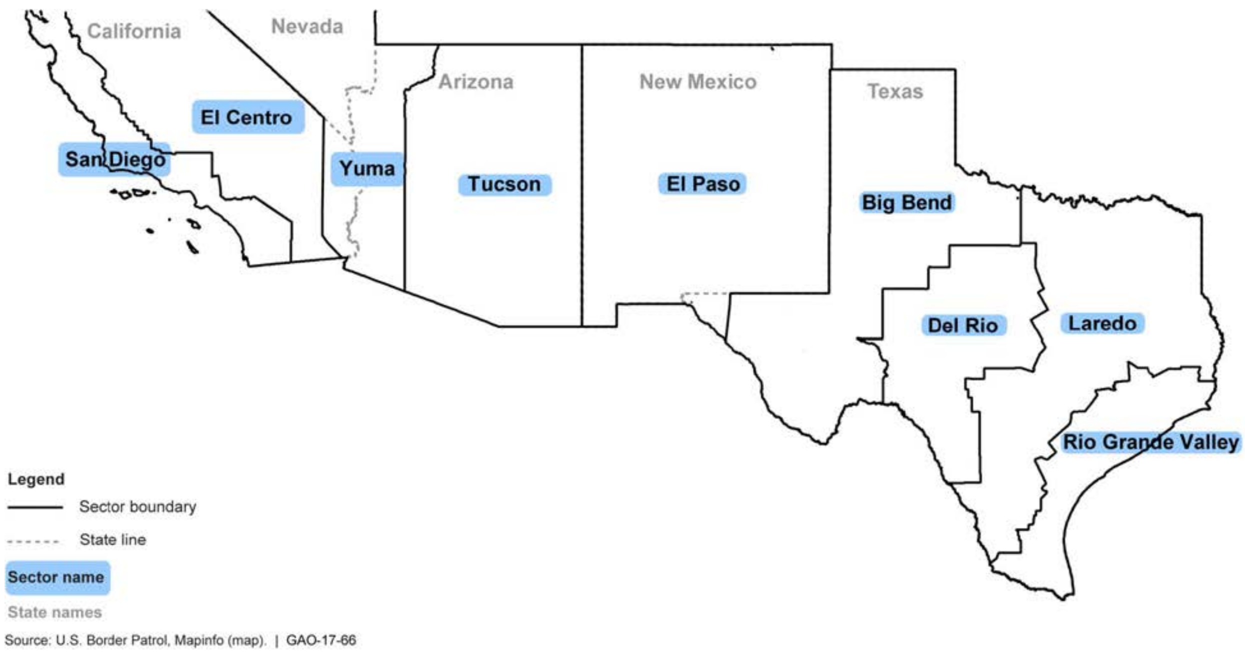


(f) Controls, weighted



Notes: Figure shows the predicted change in low-skill Mexican born for one of the three instruments. Panel (i) considers the effect on destinations in the United States. Panel (ii) considers the effect on origins in Mexico. Instruments defined in text.

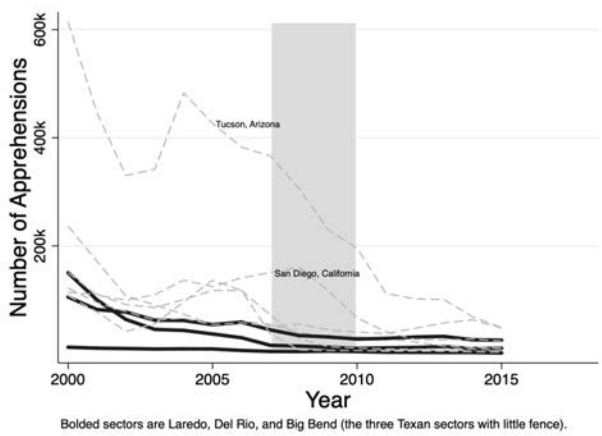
Appendix Figure 10: Border Patrol Sectors



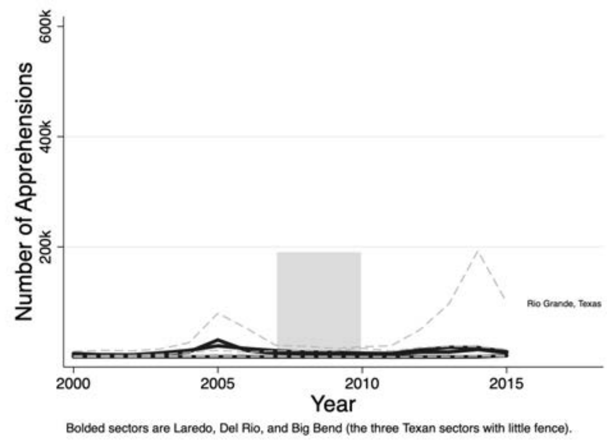
Notes:Source:United States Government Accountability Office (2017a)

Appendix Figure 11: Apprehensions of Mexican and non-Mexican nationals by border sector

(a) Mexican nationals



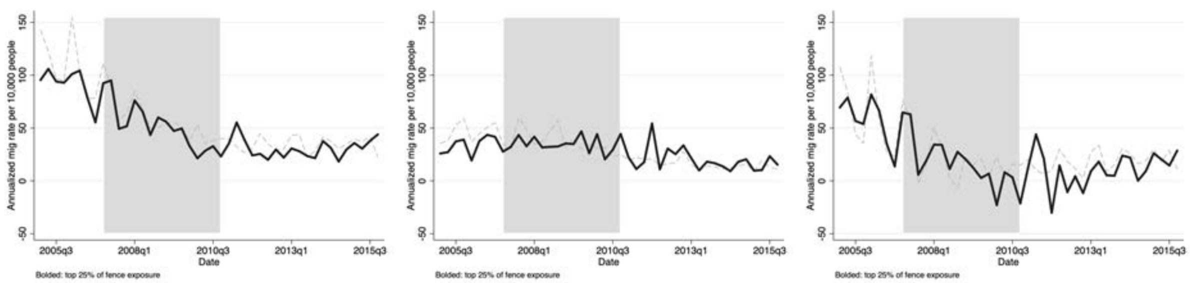
(b) Non-Mexican nationals



Notes: Figure shows apprehensions of Mexican and non-Mexican nationals on the United States-Mexico border between 2000 and 2015 fiscal year for each of the nine border sectors. The three Texan border sectors with little wall are bolded. Data source: United States Customs and Border Patrol. Downloaded: 1/14/2018.https://www.cbp.gov/sites/default/files/assets/documents/2017-Dec/BP%20Total%20Apps%2C%20Mexico%2C%20OTM%20FY2000-FY2017.pdf

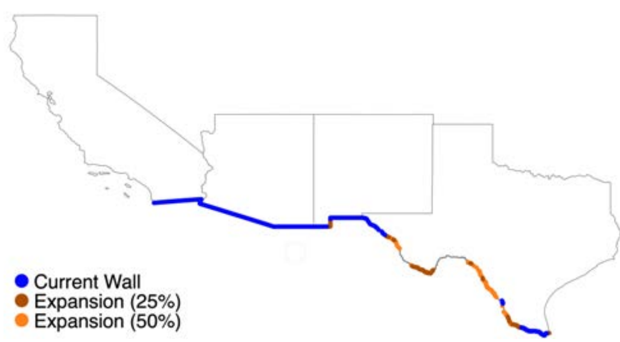
Appendix Figure 12: Migration rates from ENOE

(a) Outflow (b) Inflow (c) Netflow



Notes: Data source: ENOE survey. Wall exposure is measured by the network instrument. Migration rates computed from the ENOE following the Mexican Statistical Agency methodological guidelines (INEGI (2012)).

Appendix Figure 13: Counterfactual wall expansion



Notes: Figure shows the expansion of the wall. We fill in the wall based on our geographical prediction of where the wall was built, filling in the next 25% and 50% of the remaining pixels.