Border Walls*

Treb Allen
Dartmouth and NBER

Cauê Dobbin
Stanford

Melanie Morten
Stanford and NBER

November 2019

Abstract

Between 2007 and 2010 the U.S. government built 548 miles of border wall along the U.S.-Mexico border. Using administrative data on 5.7 million (primarily unauthorized) Mexican migrants, we study how the border wall expansion affected migration patterns between Mexican municipalities and U.S. counties. The wall changed migrants' choice of route and their choice of destination within the United States, but it did not have a large effect on the choice of whether or not to migrate. On net, we estimate the wall decreased annual migration flows by 46,000. Incorporating the decrease in migration into a spatial equilibrium model, we estimate that the wall increased (decreased) wages of low-skill (high-skill) U.S. workers by a modest \$2.89 (\$3.60) per year.

---

*We thank audiences at Stanford, UC Santa Cruz, U.S.C, University of Connecticut, Princeton, Boston University, MIT/Harvard, the UCLA/UCSD trade and development mini-conference, the 2018 Migration and Development Conference, 2018 SED, the 2018 NBER Labor Studies Summer Institute, SITE, and the CEGA faculty retreat for comments. We thank Ran Abramitzky, David Atkin, Sam Bazzi, Kirill Borusyak, Levi Boxell, Michael Clemens, Alonso De Gortari, Rebecca Diamond, Pascaline Dupas, Christian Dustmann, Liran Einav, Matthew Gentzkow, Gordon Hanson, Caroline Hoxby, Diego Jiménez, John Kennan, Brian Kovak, Ethan Lewis, Ana Raquel Minian, Caylee O'Connor, Steve Redding, Enrique Seira, and Na'ama Shenhav for helpful comments. We are grateful to Julián Rodríguez at the Ministry of Foreign Affairs and Rodrigo Garibay Aymes at the Department of Consular Affairs for generously assisting us with the *Matrícula Consular* database. This material is based upon work supported by the National Science Foundation under Grants SES-1658838 (Allen) and SES-1753002 (Morten). Carlos Bustos, Stone Kalisa, Dante Mangiaracina, and Yihang (Genna) Liu provided excellent research assistance. The usual disclaimer applies.

1 Introduction

There has been substantial recent debate over the merits of a possible wall along the U.S.-Mexico border. The political debate over funding a wall on the southern border led to a shutdown of the U.S. government for 35 days in December 2018 and January 2019, and a declaration of a "National Emergency" in February 2019.[1] Proponents argue that a border wall is necessary to stem unauthorized immigration, whereas opponents contend a border wall is expensive and ineffective. Empirical evidence on the efficacy of a border wall, however, is scant. This is due primarily to two difficulties. First, it is difficult to measure unauthorized migration. Second, there are many possible responses to a border wall: migrants could choose alternative routes, they could choose alternative destinations, or they could choose not to migrate at all. Knowing the effect of a border wall requires knowing the magnitude of each of these potential responses, the determination of which is further complicated by their interaction through general equilibrium forces.

This paper overcomes these difficulties to assess the economic impact of a border wall. To overcome data limitations, we assemble several rich sources of data on unauthorized migration flows. To disentangle the various responses to a border wall, we develop a general equilibrium migration model that allows for flexible responses of migrants' choices of route, destination, and whether or not to migrate. Combining data and theory, we assess the magnitude of each of these margins using a large expansion in the border wall between 2007 and 2010. Finally, we use our framework and estimates to assess the impact of a counterfactual completion of a wall along the entire border on both migration flows and the economy as a whole.

We find that while migrants' choices of route and destination within the United States are quite responsive to the border wall expansion, their choice of whether to migrate is not. We estimate that the border wall expansion reduced migration flows by about 46,000 persons, just 5% of the observed decline in migration from 2005 to 2015. The broader economic impacts are also small, with slight losses for high-skill U.S. workers and slight gains for low-skill U.S. workers. Given our estimates, our model predicts that a counterfactual complete (and upgraded) border wall would have been similarly modest, reducing migration flows by 129,000 persons.

Our empirical analysis relies on the several sources of data. First, we use confidential administrative data from the Mexican government's *Matrícula Consular* ID database to observe the migration patterns of 5.7 million (primarily unauthorized) Mexican mi-

---

[1] Proclamation 9844, "National Emergency Concerning the Southern Border of the United States", February 15 2019. For background on the shutdown, see, e.g., the January 2019 debate surrounding a possible U.S. government shutdown.

grants. This database allows us to construct annual bilateral migration flows between pairs of Mexican and U.S. labor markets. Second, we use survey data (the *La Encuesta sobre Migración en la Frontera Norte de México (EMIF)*) to observe where migrants traveling from a particular origin to a particular destination choose to cross the border. Third, we assemble high resolution spatial data of the location and type of barrier present along the U.S.-Mexico border in each year since 2000.

To guide our empirical analysis, we begin by presenting a simple model of migration. Individuals choose whether or not to migrate, where to migrate to, and which route to get to their destination. When they arrive in the destination, they then compete in a labor market with other workers. The model thus highlights four mechanisms through which a border wall expansion can affect migration: (1) a *detour* effect, where migration flows decrease because migrants either have to surmount the wall or avoid it by using longer or more difficult routes; (2) a *diversion* effect, where migration flows increase to destinations less affected by the border wall expansion; (3) a *deterrence* effect, where individuals may choose to stay in Mexico and not to migrate at all; and (4) a *general equilibrium* effect, where wages in the destination respond to changes in migration.

We then combine our model and data to assess the impact of a large border wall expansion. In 2006, motivated by a concern that the United States needed to regain "control of its borders,"[2] the U.S. Congress authorized the construction of 548 additional miles of border wall. This border wall was of two main types: pedestrian wall and vehicular fence. Figure 1 shows that the border wall expansion occurred at the same time as the flow of Mexican migrants to the United States declined substantially from 1.4 million recently arrived Mexican-born workers in 2005 to 400,000 in 2015. While it is tempting to attribute this concurrent decline to the border wall expansion, our estimates suggest that the vast majority of the decline was due to other factors.

We first examine how the border wall expansion affected migrants' choice of which route to take (the detour effect). We partition the U.S.-Mexico border into two-mile segments and calculate how costly it would be to travel from every municipality in Mexico to every core-based statistical unit (CBSA) in the United States across each segment along the border, accounting for both natural (e.g., deserts and mountains) and man-made geographic features (e.g., roads). We then combine these cost estimates with the EMIF survey data on migrants' route choice. We estimate that migrants' route choice is very sensitive to the cost of the route, with an elasticity of route choice to cost of 13.8. The ability of migrants to change their routes has important implications for the impact of the border wall expansion on migration costs: while we estimate that a pedestrian wall increases the

---

[2] See, e.g., President Bush's 2006 televised address to the nation.

cost of a route by 15% (and 11% for a vehicular fence), because migrants can choose alternative routes, the average origin-destination pair faced only a 3.9% increase in migration costs due to the wall expansion.

Next, we estimate how the border wall expansion affected where individuals migrated to within the United States (the diversion effect). To do this, we use the *Matrícula Consular* database to estimate how migration between a Mexican origin municipality and a U.S. destination CBSA pair changed after the wall. The fact that we observe both migration and the exposure to the border wall expansion at the pair level allows us to control for origin-year and destination-year fixed effects in the regression. As a result, we can identify the effect of the wall on migration holding constant any "pull" factors (such as the Great Recession) of a particular destination. By similar logic, we can control shocks to the "push" factors of a particular origin by comparing migration to different destinations.[3] We estimate that migrants' choice of destination within the United States is sensitive to changes in migration costs, with an estimated elasticity of 4.3. The estimated diversion elasticity is robust to alternative measures of exposure to the border wall expansion, accounting for the changes in border patrol enforcement, controlling for sector-specific shocks that may have had differential effects at the bilateral level, and controlling for the endogeneity of where the wall expansion occurred by using an instrument based on the local geography along the border.

We then measure whether the border wall expansion deterred individuals from migrating at all (the deterrence effect). To do this, we combine the *Matrícula Consular* data with Mexican Census data on population stocks to estimate how the out-migration rate from a Mexican municipality responded to the municipality's exposure to wall expansion. This analysis estimates the elasticity of migration to the United States to the value of migrating. A standard gravity model of migration assumes an "independence of irrelevant alternatives" (IIA) where this elasticity is one; in other words, IIA assumes individuals treat destinations in Mexico and the United States symmetrically. Instead, we estimate an elasticity of 0.4, indicating that demand for migration to the United States is relatively inelastic; that is, if some destinations in the United States become relatively more costly, individuals are more likely to migrate elsewhere in the United States than not migrate at all. The deterrence result is robust to controlling for the distance to the border, sectoral time trends, and origin "push" factors (violence and rainfall).

Finally, to allow for local wages and the labor supply of other types of workers to respond to the border wall expansion, we embed our migration model into a binational

---

[3] This identification strategy based on bilateral variation follows the trade "gravity" literature, see, e.g., Baldwin and Taglioni (2006) and Head and Mayer (2013).

spatial general equilibrium framework with many labor markets separated by flexible migration frictions, each employing workers of different nativities and skill levels. We estimate that the border wall expansion reduced the flow of migrants to the United States by 46,459 persons (standard error (s.e.) of 17,089). Each of the various margins of adjustment turn out to be quantitatively important: an analysis that ignores the detour effect by assuming that migrants' choice of route remained unchanged would have overstated the efficacy of the border wall expansion by 19%; an analysis that ignored the deterrence effect by assuming that migrants were equally willing to stop migrating would have overstated the efficacy of the border wall expansion by 105%; and an analysis that ignored general equilibrium responses would have overstated the efficacy of the border wall expansion by 10%.

The general equilibrium framework also allows us to evaluate the impact of the border wall expansion on U.S. workers, who are indirectly affected through the labor market when migration falls. As low-skill workers become relatively scarce, we find high-skill U.S. workers are made worse off and low-skill U.S. workers benefit, although the impacts are modest; our preferred results suggest high-skill U.S. workers are worse off on average by \$3.63 per person per year (s.e. of \$1.34), whereas low-skill U.S. workers are made better off by \$2.89 (s.e. of \$1.07). These averages, however, belie a substantial heterogeneity across space in the effects. For example, the largest gains to low-skill U.S. workers (and eighth largest losses to high-skill workers) occurred in Napa, California, where we estimate the low-skill U.S. workers benefited by \$51.83 per year. The aggregate results and patterns of spatial heterogeneity are similar for a variety of alternative parameter constellations.

Finally, we use our framework and estimated parameters to consider two policy-relevant counterfactuals: (1) upgrade of the entire existing vehicular fence to the more effective pedestrian wall, and (2) completion of a pedestrian wall along the entire border. We find that upgrading the vehicular fence to a pedestrian wall would cause a 7% larger decline in migration flows, to a total of 49,899 persons (s.e. of 20,662), and a 11% larger increase in economic gains to low-skill U.S. workers, to a total of \$3.75 a year. Building a complete border wall would reduce migration flows by 129,438 people (s.e. of 51,775) and increase wages of low-skill U.S. workers by \$7.99 per year. Note that these numbers do not include any of the construction or maintenance costs of building additional wall.

This paper contributes to a number of strands of the literature. First, our paper contributes to a growing quantitative literature examining how spatial frictions affects population movement.[4] In particular, like Ahlfeldt, Redding, Sturm, and Wolf (2015), this

---

[4] See, e.g., Allen and Arkolakis (2014); Tombe and Zhu (2019); Redding (2016); Monte, Redding, and

paper examines the impact of a wall on the spatial distribution of economic activity, albeit in the context of the U.S.-Mexico border wall and migration instead of the Berlin wall and commuting. Unlike that paper, however, here we observe bilateral migration flows both before and after the wall expansion, allowing us to directly estimate the cost of traversing a border wall of different types (while accounting for migrants' endogenous route choice). Also, like Allen and Arkolakis (2019), this paper embeds the endogenous route choice problem of agents into a spatial framework, although here the choice is over places to cross a border rather than paths to take through an infrastructure network.[5] Unlike that paper, however, here we use survey data on migrants' choice of different routes to estimate the elasticity of route choice to route cost. Finally, like Burstein, Hanson, Tian, and Vogel (2019) and Caliendo, Parro, Opromolla, and Sforza (2018), we allow for workers to differ by their nativity and skill levels. However, we abstract from the heterogeneity in tradability across different occupations in the former and forward-looking migration decisions in the latter. Instead, we focus on the heterogeneous impacts of shocks to bilateral migration costs by relaxing the IIA assumption implicit in spatial migration models exhibiting gravity.[6]

Second, our paper contributes to the literature examining the causes and consequences of Mexico-U.S. migration by using a confidential version of the *Matrícula Consular* database. *Matrícula Consulares* are identification cards that are issued by the Mexican government to Mexican citizens residing in the United States. Previous works (see, e.g., Caballero, Cadena, and Kovak (2018); Clemens (2015); Massey, Rugh, and Pren (2010)) have used a publicly available version (matching Mexican origin municipality to U.S. destination state) of this database, whereas we have been granted access to a confidential individual-level database where we observe sub-state (Mexican municipality to U.S. county) location information as well as observing each time (after the initial year of 2006) that migrants have renewed their cards. The sub-state variation allows us to exploit more local variation in migration patterns as well as control for state-level shocks that may impact migration. The fact that we observe individuals instead of aggregate counts allows us to separate out renewed matrícula cards from first-time issuances. We show that the latter more closely correlate to measures of the number of newly arrived migrants in the American Community Survey (ACS).

Rossi-Hansberg (2019); Bryan and Morten (2019); Morten and Oliveira (2018); Caliendo, Dvorkin, and Parro (2019) and summarized in the recent review article (Redding and Rossi-Hansberg, 2017).

[5] In this way, the paper is also related to Allen (2015), which considers the alternative paths runaway slaves may take to freedom, albeit without a micro-founded model of route choice.

[6] In this way, the paper is related to Adao, Costinot, and Donaldson (2017), who show how to conduct counterfactual analysis in quantitative trade models when IIA may not hold.

Third, our paper contributes to a growing migration literature examining the efficacy of migration enforcement. The literature has thus far primarily focused on the role of the U.S. Border Patrol in deterring migrants (Hanson and Spilimbergo (1999); Lessem (2018); Bazzi, Burns, Hanson, Roberts, and Whitley (2018)); we focus instead on the role of physical barriers. One exception is Feigenberg (2019), who examines the impact of the same border wall expansion we consider. Unlike that paper, however, our analysis relies on bilateral migration flow data and bilateral variation in exposure, allowing us to disentangle the impact of the border wall expansion estimate from other contemporaneous economic shocks in both origins and destinations. This allows us to estimate the aggregate and distributional impacts of the existing and counterfactual border wall expansions.

Finally, our paper complements the expansive literature on the effect of immigration on U.S. labor markets (see, e.g., Piyapromdee (2019); Card (2001); Borjas, Grogger, and Hanson (2012); Clemens, Lewis, and Postel (2018)) by using estimates from that literature to embed our migration model into a framework with many labor markets spanning two countries and separated by flexible migration frictions, where wages of different worker types are determined in equilibrium. This allows us to use our estimates of the impact of a border wall expansion to perform policy-relevant counterfactuals in a general equilibrium framework.

The rest of the paper is organized as follows. We first provide a brief description of the border wall expansion we consider and the data we use to assess its effect. Section 3 provides a model of migration used to guide the empirical analysis, which follows in Section 4. We then combine our model with our empirical results to estimate the aggregate and distributional impacts of the border wall expansion and other counterfactual border wall scenarios in Section 5. Section 6 concludes.

2 Empirical context and data

This section briefly 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; we refer interested readers to Appendices A and B for more details. Throughout the paper our unit of analysis for the United States is the CBSA, a definition constructed to capture distinct labor markets, adjusted to constant boundaries between 2000 and 2010. Dropping observations in Hawaii and Alaska yields 977 unique markets. Our unit of analysis is the Mexican *municipio* (municipality), adjusted to consistent boundaries over time. This yields 2331 unique markets in Mexico.

2.1 The 2007--2010 border wall expansion

Between 2000 and 2005, approximately 1.2 million people (95% of whom were Mexican nationals) were apprehended each year attempting to cross the U.S.-Mexico border, increasing the pressure on policy makers to do something about unauthorized migration.[7]

This pressure culminated in the passage of the 2006 Secure Fence Act (SFA), which resulted in the construction of 548 additional miles of border wall between 2007 and 2010 – a five-fold increase – at a construction cost of $2.3 billion (United States Government Accountability Office (2017b,a)).[8] We digitize and geocode an engineering report that displays all the constructed walls along the border at a 1:50,000 scale (Michael Baker Jr. Inc., 2013). This report identifies the type of wall and whether or not the wall existed prior to the SFA.[9] Panel (a) of Figure 2 depicts the location of the border wall both before and after the SFA. The border walls constructed under the SFA took one of two forms: 288 additional miles of "pedestrian walls" meant to deter crossings on foot, and 260 additional miles of "vehicular fences" meant to deter crossings by vehicle; see panels (b) and (c) of Figure 2 for examples.[10]

We segment the U.S.-Mexico border into 1001 equally spaced points, approximately two miles apart. We then identify which of these border points are within 10 km of a border wall both before and after the border wall expansion (this choice of distance prevents small gaps in the barrier from impacting our measurement of exposure). By this measure, the expansion increased the fraction of the border within 10 km of a border wall from

---

[7] Unauthorized immigrants in the United States either enter the country illegally or enter legally (for example, with a tourist visa) and then overstay their visa. In 2017, the overstay rate for Mexican nationals who entered the United States by land or sea with a tourist visa was 1.7% (4.1% for those with a student or exchange visa) Department of Homeland Security (2017). In order to acquire a tourist visa, an individual needs to show proof of income and ties to their home country and pass an interview with a U.S. consular officer. This process is difficult for poor migrants who are seeking to migrate to the United States for work precisely because they do not have good economic opportunities in Mexico. Data from the 2006 Mexican demographic (ENADID) survey shows that just 15% of low-skill migrants who migrated to the United States to work report having legal documentation to enter the country, compared with 43% of high-skill migrants.

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

[9] Prior to 2006 only 110 miles of the 1954 mile long border had any sort of physical barrier. In the majority of cases, the SFA built walls in locations that previously did not have any barrier, although in several cases, existing barriers were upgraded. For example, the SFA repaired six miles of fence along the San Diego portion of the U.S.-Mexico border that had been constructed during Operation Gatekeeper in 1994.

[10] 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 datasets.

22% in 2006 to 51% in 2010. Where did this expansion occur? Our analysis shows that geography along the border strongly predicts where the wall expansion occurred: Column (1) of Table 1 shows that of the 781 border locations not near a border wall in 2006, those along a river were 83% less likely to receive a border wall, those at higher elevation were 23% less likely to receive a border wall (for every additional kilometer of elevation); and desert areas were 5% less likely (for each additional temperature degree). These results are robust to including state fixed effects and controlling for the population density along the border (see column 2 of Table 1). The local geography also predicts the type of border wall expansion that occurs: of the 285 border locations that received new walls, those with a river were 62% more likely to receive a pedestrian wall than a vehicular wall (see columns 3 and 4 of Table 1). We leverage this geographic variation in predicting where the border wall expanded and what type of wall was used below to mitigate concerns of the possible endogeneity of where the wall was built.

Measuring the cost of a route

We calculate both the overland distance and the cost-weighted distance of traveling from each of the 2,311 Mexican municipalities to each of the 977 U.S. CBSAs through each of the 1,001 border crossing points. To calculate the cost-weighted distance, we partition the continental United States and Mexico into grid cells of 0.25 square miles. We then assign a cost of traversing each grid cell based on four factors: ruggedness, climate (i.e., whether or not it is desert), composition (i.e., land or water), and the presence and type of any roadway or railway.[11] We then calculate the origin-border-destination triad travel cost by integrating these costs over the least-cost route traversed.[12] To calculate the overland distance, we follow the same procedure but treat all land pixels as equally costly.

Panel (a) of Figure 3 provides an illustration of two different overland distance routes from Monterrey, Mexico to Los Angeles, California. The yellow line indicates the shortest route overland route that avoids a border wall prior to the border wall expansion, while the maroon line shows the same information after the border wall expansion. Panel (b) exhibits the same routes after incorporating the cost of travel (where the grayscale image

---

[11] The cost assigned to a grid cell is inversely proportional to the speed of travel. In the presence of infrastructure, we assume the speed of travel is 60 mph on freeways, 45 mph on highways, 30 mph on other roads, and 25 mph on railroads. In the absence of infrastructure, we assume a speed of 10 mph (capturing the possibility of minor roads) and, following Naismith's rule, add an additional hour of travel time for every 2,000 foot change in elevation. If the maximum July temperature is between 40 and 44 C (45+ C), we slow the speed of walking by half (three quarters). Rivers or lakes can be crossed at 1/100 the speed of walking. The results that follow are robust to varying each of these assumptions.

[12] This calculation is achieved using the "Fast Marching Method" developed by Tsitsiklis (1995) and Sethian (1996) and originally applied to economics by Allen and Arkolakis (2014).

in the background shows the cost of travel over each pixel). Intuitively, the cost differences between the yellow and the maroon routes provides a measure of exposure to the border wall expansion. We formalize this intuition when we examine migrants' route choices below.

2.2 Migration and economic data

We briefly describe the datasets we have assembled, see Appendix B for more details, including summary statistics of each sample.

Measuring where unauthorized migrants choose to cross the border

To examine the route choice of migrants, we rely on the EMIF data. This survey is conducted in 17 traditional border-crossing locations spanning the width of the U.S.-Mexico border. We use the 2006 and 2010 survey waves, where we observe a total of 13,000 migrants traveling from 1406 different Mexican municipalities to 171 different U.S. CBSAs. From this data, we calculate the probability that a migrant going from a given origin to a particular destination chooses to cross the border at each of the crossing points. We use these data to assess how responsive migrants' choice of route is to the cost of the route. While unique in providing information on the actual route a migrant takes to cross the border, this dataset does have three shortcomings. First, unauthorized migration is a clandestine activity, and so the sample may not be representative of all migrants attempting to cross the border. Second, the dataset measures migration attempts, which may differ from successful crossings. Third, the surveyed locations are all traditional crossing points and hence may not be representative of all routes across the border. This is evidenced by the fact that, of the 17 locations, 11 already had a wall before the border wall expansion and all but one have a wall post-expansion. We discuss how we overcome these limitations below.

Measuring where unauthorized migrants choose to migrate

To measure Mexican origin (municipality) to U.S. destination (CBSA) bilateral migration, we use a confidential version of the Mexican government's *Matrícula Consular* database. The *Matrícula Consular* is an identification document widely accepted by U.S. banks and financial institutions, issued by Mexican consulates in the United States to Mexican citizens residing in the United States. The card requires proof of Mexican citizenship, but no proof of legal status in the United States. We observe 5.7 million individuals who are issued a total of 8.1 million cards over the period 2006–2015. For each individual, we see their birth municipality in Mexico, the U.S. county where they were living each time a card was issued (which we match to CBSA), as well as a few demographic details such as age, gender, occupation, and education. The primary benefit of the *Matrícula Consular* database is that we see the birthplace municipality in Mexico and the destination U.S. CBSA, allowing us to measure bilateral migration flows. This is in contrast to databases such as the ACS, where only the country (and not the municipality) of origin is observed. Appendix Table 2 shows that 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.

The highly disaggregated geographical coverage in the matrícula card dataset allows us to recover rich patterns of migration. To illustrate these patterns, Figure 4 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 (b) plots the relative share of migrants who travel to Los Angeles compared with the Bay Area. There is rich heterogeneity in regional specialization – 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. Figure 5 shows similar patterns for migration to Texas. The role of geography is clearly shown in the concentration of migration from the northeastern states of Coahuila and Nuevo León to Texas, but a large amount of regional heterogeneity also exists, especially regarding the location of those who migrate to Dallas instead of Houston. Given this rich heterogeneity in migration destinations, the same event – i.e., the construction of a wall on the border – may have very different effects on how it changes the migration destination of migrants from two different origin municipalities.

The *Matrícula Consular* database does have some shortcomings. First, applying for a card is voluntary. This concern is partly attenuated by the fact that the richness of the data allows us to control for origin-year, destination-year, and pair fixed effects, so we can allow for take-up rates to vary across time and space. Second, migrants who have been in the United States for many years may also apply for a matrícula card, so changes in the number of cards could reflect a change in the take-up rate of preexisting migrants rather than newly arrived migrants. To quantify the relationship between a migrant and a matrícula card, we undertake a substantial accounting exercise in Appendix B.6 comparing the matrícula card database to the ACS. We estimate that each matrícula card corresponds to somewhere between 0.88 and 0.99 of a recently arrived migrant (i.e., one who has been in the country for five years or less) in the ACS, whether varied over time or over time and across space. Third, a card is valid for five years, so some observations are renewals rather than new cards. We can directly observe renewals as we see all cards issued to each individual from 2006.

Migration flows and economic outcomes within the United States We use the ACS and Census waves from 2000 to 2012 to examine within-U.S. migration, population stocks, and wages of different types of workers. We follow Borjas, Grogger, and Hanson (2012) and Ottaviano and Peri (2012) in the construction of the sample.[13] 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. 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-skill (if they have completed at least some college) and low-skill (if they have completed high school or less).

To measure CBSA-to-CBSA migration flows of a particular worker type during the period before adoption of the SFA, we convert the annual migration flows from the 2005 and 2010 ACS, converting from the measured *migpuma* (an aggregated statistical unit used for confidentiality reasons), and apportion population flows to CBSA using a population-based country concordance. We then multiply by five to accord with the definition of an across-country migrant as someone who has been in the country for five years or less. In addition to using the ACS and Census to measure migration flows within the United States, we also observe the stock of workers of a given type within a year and their wage, where the wage is defined as the average weekly wage, multiplied by 50 to convert to annual wages. We use the wage data from the 2000 Census ("pre" border wall expansion) when estimating aggregate economic impacts and counterfactuals to align with the year of the Mexican census.

Migration flows and economic outcomes within Mexico We proceed similarly for measuring within-Mexico values using the Mexican Census waves from 1990, 2000, 2005,

---

[13] We differ from the sample definition used in Borjas, Grogger, and Hanson (2012) in two ways. Because 40% of matrícula cards are issued to women, we keep women in the sample. We also do not drop from the population counts people who worked zero hours, as not working is likely an endogenous outcome.

2010, and 2015. We follow the same definition for the variables as we did for the United States data. We calculate within-Mexico migration flows of a particular worker type by computing the municipality-to-muncipality flows, which are computed using data from where an individual reported living five years earlier. To match the wall construction period, we use the retrospective migration data from the 2015 (i.e., location in 2010) and 2010 (i.e., location in 2005) censuses. We compute wages as the monthly income earned adjusted by the number of hours worked, multiplying by 12 to be comparable with the U.S. data. We follow the same education classifications and define workers as low-skill if they have completed high school or less and high-skill if they have completed some college. We keep self-employed individuals in the income data. Wage data is only collected in the decennial census, so we use the wage data from 2000 Census ("pre" border wall expansion) when estimating aggregate economic impacts and counterfactuals.

3 A simple model of migration

To guide the subsequent analysis, we begin by presenting a simple two-period partial equilibrium model of migration. The model serves three purposes: (1) it decomposes the impact of a border wall on migration into four separate effects, (2) it provides estimating equations that can be brought to the data to estimate those effects, and (3) it can be embedded into a general equilibrium framework to assess the aggregate and distributional impacts of a border wall expansion on the economy as a whole.

3.1 Setup

Consider an individual ω who in period 1 resides in an origin location o and makes a three-step decision of where to reside in period 2. First, she decides in which country to reside. Second, conditional on her choice of country, she decides where to live in that country. Third, conditional on her choice of destination, she chooses how to get there. The economy comprises N locations, N_{MEX} of which are in Mexico and N_{US} of which are in the United States.

Let the payoff of individual ω initially residing in origin o migrating to destination d (in country $c(d)$) via route r be $V_{od,r}(\omega)$, where:

$$V_{od,r}(\omega) = \frac{V_d}{C_{od,r} \times \epsilon_{od,r}(\omega)} \times \varepsilon_{c(d)}(\omega) \times \nu_d(\omega),$$

where V_d the value of residing in location d (which includes e.g., the real wage and/or the amenity value in location d), $C_{od,r}$ is the migration cost incurred traveling from o to d via route r, and $\epsilon_{od,r}(\omega)$, $\varepsilon_{c(d)}$, and $\nu_d(\omega)$ are individual-specific idiosyncratic preferences for route r, country c, and location d, respectively.[14]

For tractability, we make both a timing and a parametric assumption on the idiosyncratic preference terms. Our timing assumption is that $\nu_d(\omega)$ is realized only after individual ω decides which country to reside in and $\epsilon_{od,r}(\omega)$ is realized only after an individual decides to which destination to migrate. This assumption captures, for example, the uncertainty that migrants face concerning where they will be delivered in the United States and how they will get there when enlisting the help of *coyotes* to cross the border. Our parametric assumption is that $\epsilon_{od,r}(\omega)$, $\varepsilon_{c(d)}(\omega)$, and $\nu_d(\omega)$ are all independent and identically distributed with the extreme value Frechet distribution with shape parameters θ_r, θ_c and θ_d, respectively.[15]

3.2 Migration patterns

The model is solved through backwards induction.

Step #3: Which route should an individual take?

Consider an individual who has decided to migrate from o to d: how does she get there? She chooses her route r in order to minimize the migration cost incurred, i.e., $\min_r C_{od,r} \times \epsilon_{od,r}(\omega)$. Given the assumed extreme value distribution of $\epsilon_{od,r}$, the probability she chooses route r, $\pi_{od,r}$, is:

$$\pi_{od,r} = C_{od,r}^{-\theta_r} / \sum_r C_{od,r}^{-\theta_r} \tag{1}$$

and her expected cost of migrating, $\mu_{od} \equiv E_\epsilon\left[\min_r C_{od,r} \times \epsilon_{od,r}(\omega)\right]$ is:

$$\mu_{od} = c\left(\sum_r C_{od,r}^{-\theta_r}\right)^{-\frac{1}{\theta_r}}, \tag{2}$$

where $c = \Gamma\left(\frac{\theta_r - 1}{\theta_r}\right)$ is a constant.

---

[14] Here, we take the destination value V_d as exogenous. When we embed the migration model into the general equilibrium framework in Section 5 below, we allow the destination value to respond endogenously to changes in migration costs.

[15] Neither the timing assumption nor the assumption that the error terms are independent from each other is strictly necessary, as an alternative framework where the three draws are arbitrarily correlated and realized simultaneously is isomorphic to our setup. However, because this alternative framework places restrictions on the relative magnitude of the three migration elasticities (because correlations are no greater than one in absolute value) and we do not wish to impose such restrictions in our estimation, we proceed with the assumptions as given.

Step #2: Where should an individual migrate to within a country?

Conditional on the choice of her country c and taking into account her expected migration cost μ_{od} given her optimal route choice, individual ω will choose her destination within that country in order to maximize her payoff. Given the assumed extreme value distribution of ν_d, the probability an individual from origin o chooses to reside in destination $d \in N_c$, conditional on her choice of country c, $\pi_{od|c}$, is:

$$\pi_{od|c} = \frac{\left(V_d/\mu_{od}\right)^{\theta_d}}{\sum_{d' \in N_c}\left(V_{d'}/\mu_{od'}\right)^{\theta_d}}. \tag{3}$$

Step #1: Should an individual migrate or not?

Taking into account her expected payoffs from steps #2 and #3, individual ω will choose in which country to reside, $L_{oc}(\omega)$ in order to maximize her expected payoff of doing so. Given the assumed extreme value distribution of ε_c, the probability an individual from origin o chooses to reside in country $c \in \{US, MEX\}$, π_c, is:

$$\pi_{oc} = \frac{\left(\sum_{d' \in N_c}\left(V_{d'}/\mu_{od'}\right)^{\theta_d}\right)^{\frac{\theta_c}{\theta_d}}}{\sum_{c \in \{US,MEX\}}\left(\sum_{d' \in c}\left(V_{d'}/\mu_{od'}\right)^{\theta_d}\right)^{\frac{\theta_c}{\theta_d}}}. \tag{4}$$

Together, the unconditional probability that an individual from origin o chooses to reside in destination d, π_{od}, is simply the product of the two probabilities above:

$$\pi_{od} = \pi_{od|c} \times \pi_{oc}. \tag{5}$$

Applying the law of large numbers, π_{od} is also the fraction of individuals from origin o who choose to migrate to destination d.

3.3 How does a border wall expansion affect migration flows?

We now use this simple framework to study how a border wall expansion affects migration patterns.

Suppose that the border wall expansion increases the origin-destination-route migration cost from $\{C_{od,r}\}$ to $\left\{C'_{od,r}\right\}$ and changes the vector of destination payoffs from $\{V_d\}$ to $\left\{V'_d\right\}$. Let $\{\pi_{od}\}$ and $\left\{\pi'_{od}\right\}$ be the migration patterns of the economy before and after the border wall expansion, respectively. Finally, let $\hat{C}_{od,r} \equiv \frac{C'_{od,r}}{C_{od,r}}$, $\hat{V}_d \equiv \frac{V'_d}{V_d}$, and $\hat{\pi}_{od} \equiv \frac{\pi'_{od}}{\pi_{od}}$

denote the changes (measured in ratios) of the migration costs, destination payoffs, and migration patterns.[16]

From equations (1), (3), (4), and (5), we can write the change in migration flows as:

$$\hat{\pi}_{od} = \underbrace{\frac{\overbrace{\left(\sum_{r} \pi_{od,r} \hat{C}_{od,r}^{-\theta_r}\right)^{\frac{\theta_d}{\theta_r}}}^{\text{detour effect}} \overbrace{\hat{V}_d^{\theta_d}}^{\text{GE effect}}}{\sum_{d' \in N_c} \pi_{od'|c} \left(\hat{V}_{d'} / \hat{\mu}_{od'}\right)^{\theta_d}}}_{\text{diversion effect}} \times \underbrace{\left(\frac{\left(\sum_{d' \in N_c} \pi_{od'|c} \left(\hat{V}_{d'} / \hat{\mu}_{od'}\right)^{\theta_d}\right)^{\frac{\theta_c}{\theta_d}}}{\sum_{c \in \{US,MEX\}} \pi_{oc} \left(\sum_{d' \in c} \pi_{od'|c} \left(\hat{V}_{d'} / \hat{\mu}_{od'}\right)^{\theta_d}\right)^{\frac{\theta_c}{\theta_d}}} \right)}_{\text{deterrence effect}}, \quad (6)$$

where $\hat{\mu}_{od} \equiv \left(\sum_r \pi_{od,r} \hat{C}_{od,r}^{-\theta_r}\right)^{-\frac{1}{\theta_r}}$.

Equation (6) highlights four possible effects of a border wall expansion. First, there is a *detour effect*: by increasing the cost of certain origin-destination-routes, migrants either have to incur those costs along those routes or choose alternative higher cost routes. This raises the cost of migrating, reducing migration flows. From equation (6), we see that the impact of an increase in the cost of a route on the expected migration cost is larger the more that route is used (i.e., the higher the $\pi_{od,r}$). This is intuitive: a border wall expansion increases migration costs more for origin-destination pairs that use that border crossing more intensively, thereby reducing migration flows.

Second, increases in migration costs elsewhere can divert migrants to destinations less affected by the border wall; this *diversion effect* will, all else equal, increase migration flows. The diversion effect will be larger if (1) θ_d is larger (i.e., migrants are more homogeneous in their preferences for destinations within a country and hence more responsive to changes in payoffs) and/or (2) $\pi_{od'|c}$ is larger (in which case there are a greater fraction of migrants who are affected by the higher costs and hence more migrants who will be considering substituting elsewhere).

Third, increases in migration costs in any destination within the United States will make migrating less attractive; this *deterrent effect* will, all else equal, result in a decline in the number of migrants to all destinations in the United States The magnitude of the deterrence effect will be larger with greater θ_d and $\pi_{od'|c}$; unlike with the substitution effect, however, the deterrence effect will be large if θ_c/θ_d is larger, i.e., potential migrants are more homogeneous in their preferences for countries than they are in their preferences for locations within countries. The opposing forces of the diversion and deterrence

---

[16] The discussion applies the "exact hat algebra" approach pioneered by Dekle, Eaton, and Kortum (2007) in the international trade literature to the migration literature; see Costinot and Rodríguez-Clare (2014) for an excellent review.

effects highlight that the extent to which a border wall reduces total migration depends crucially on the relative values of θ_c and θ_d. For example, in the extreme case that $\theta_c = 0$, the expansion of the border wall will only result in migrants changing where they migrate within the United States; the total flow of migrants to the United States will remain unchanged. More generally, if $\theta_c < \theta_d$ (conversely, $\theta_d > \theta_c$), the increase in share of migrants to unaffected destinations in the United States will be more than proportional (conversely, less than proportional) to their initial unconditional migration shares.[17]

Finally, a border wall expansion may directly change the payoffs of certain destinations, e.g., by changing the equilibrium wage in the destination. In what follows, we control for such *general equilibrium* effects in order to estimate the other three effects; we then embed this simple model of migration into a general equilibrium framework in Section 5 in order to account for these effects as well.

4 Disentangling the effects of the border wall expansion on migration flows

We now turn to estimating the impact of the border wall expansion on migration flows.

4.1 The detour effect

To estimate the how the border wall expansion affected migrants' choice of routes, we assume that each point along the border comprises a different route with the following cost:

$$C_{od,r,t} = C_{od,r} \times \tau_{w_t(r)} \times \chi_{od,r,t}, \tag{7}$$

where $w_t(r) \in \{ped, veh, none\}$ is the type of barrier present at the border crossing r in period $t \in \{pre, post\}$, $\tau_w \geq 1$ is the associated cost of crossing a barrier of type w, and $\chi_{od,r,t}$ is an origin-destination-route-year idiosyncratic error term. Substituting equation (7) into the route share equation (1) and taking logs yields:

$$\ln \pi_{od,r,t} = -\theta_r \ln C_{od,r} - \theta_r \ln \tau_{w_t(r)} + \delta_{od,t} - \theta_r \ln \chi_{od,r,t}, \tag{8}$$

---

[17] In the knife-edge case $\theta_c = \theta_d$, the redistribution of migrants from the impacted location d' to all other destinations will be proportional to their unconditional migration shares – this is the "independent of irrelevant alternatives" underpinning the substitution effects in standard "gravity" models of migration, see, e.g., Tombe and Zhu (2019); Desmet, Nagy, and Rossi-Hansberg (2018).

where $\delta_{od,t} = \ln \sum_r C_{od,r,t}^{-\theta_r}$ is an origin-destination-year fixed effect. Intuitively, the more migrants that choose to migrate along a low-cost route, the more responsive they must be to differences in the cost of the route.

Table 8 presents the results of regression (8) using the EMIF migrant route-choice data. The top panel uses the overland distance of a route as our measure of cost, whereas the bottom panel uses the cost-weighted distance measure that accounts for heterogeneity in cost of travel across different grid cells. Regardless of the measure, the methodology (least squares or Poisson to account for zero shares[18]), or the data sample (just pre-expansion or both pre- and post-), we find that migrants are much more likely to cross the border at points that are close to the least-cost route from their origin to their destination. Our preferred estimate (panel (b) column (6)) suggests an elasticity over routes of $\theta_r = 13.067$ (with a crossing-point level clustered standard error of 0.887). [19]

We also find suggestive evidence that conditional on cost, migrants prefer to cross the border at places without a border wall. While this result is strongly statistically significant in the pre-expansion cross section, it is only marginally statistically significant (and only for least squares) with the inclusion of crossing-point fixed effects in the panel. This is perhaps because 16 of the 17 crossing points in the data receive a fence after the expansion. As a result, we do not use this estimate in our subsequent analysis.

Instead, we proceed as follows. By combining equations (2) and (7), we can write the change in migration costs as follows:

$$\Delta \ln \mu_{od} = -\frac{1}{\theta_r} \ln \left(\frac{\sum_{w \in \{no,p,v\}} \tau_w^{-\theta_r} \alpha_{od,w,post}}{\sum_{w \in \{no,p,v\}} \tau_w^{-\theta_r} \alpha_{od,w,pre}} \right) \iff \tag{9}$$

$$\Delta \ln \mu_{od} = \left(\ln \tau_p\right) \Delta\alpha_{od,p} + \left(\ln \tau_v\right) \Delta\alpha_{od,v} + \eta_{od} \tag{10}$$

where $\alpha_{od,w,t} \equiv \frac{\sum_{r|w_t(r)=w} C_{od,r}^{-\theta_r}}{\sum_r C_{od,r}^{-\theta_r}}$ captures how exposed migrants traveling from o to d are to border walls of time w in period t – i.e., the probability an individual would have chosen to cross the border at a point with barrier type w if there were no additional cost of doing

---

[18] Appendix Table 8 compares Poisson and OLS estimates when both use the same sample, i.e., when zeros are excluded, and finds that they yield very similar results.

[19] Another measure of border crossing activity is apprehensions by the U.S. Border Patrol. The southern border is divided into nine border sectors. 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 3. 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 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.

so, η_{od} is a second-order error term resulting from the first order approximation of the first line around $\tau_p = \tau_v = 1$ (it also captures any other time varying changes in migration costs), and Δ is a first difference operator between pre and post, i.e., $\Delta x \equiv x_{post} - x_{pre}$. Equation (10) says that an origin-destination pair is more affected by the border wall expansion if the cost of crossing a border wall is high (i.e., τ_p of τ_v is large) and/or if expansion occurred at border crossing points along relatively more attractive routes from o to d.

Given our estimate of θ_r, we can calculate the change in the exposure of an origin-destination pair to pedestrian and vehicular border walls as a result of the border wall expansion, i.e., $\Delta\alpha_{od,p} = \frac{\sum_{r|w_{post}(r)=p} C_{od,r}^{-\theta_r} - \sum_{r|w_{pre}(r)=p} C_{od,r}^{-\theta_r}}{\sum_r C_{od,r}^{-\theta_r}}$ and $\Delta\alpha_{od,v} = \frac{\sum_{r|w_{post}(r)=v} C_{od,r}^{-\theta_r} - \sum_{r|w_{pre}(r)=v} C_{od,r}^{-\theta_r}}{\sum_r C_{od,r}^{-\theta_r}}$. Panel (c) of Figure 3 provides an illustration of what this looks like in practice for the Monterrey-Los Angeles origin-destination pair (we only show the route over every fiftieth border crossing point for legibility). Each route is color coded by its relative cost, with yellow indicating a relatively low cost and maroon a relatively high cost). In general, more westward routes had lower relative costs and hence receive greater weight in the aggregation. Because the border expansion mostly occurred in the west, this suggests that this pair will be particularly exposed to the border wall expansion; indeed, we find $\Delta\alpha_{od,p} = 0.276$, $\alpha_{od,v} = 0.035$; i.e., there would be an 27.6% (conversely, 3.5%) increase in the probability that a migrant would have encountered a pedestrian wall (conversely, vehicular fence) if the border walls did not directly increase the cost of migration.

Of course, the border wall likely did increase the cost of migration; we turn to estimating its effect next.

4.2 The diversion effect

Taking logs of equation (3) and substituting in equation (10) results in the following estimating equation for how the border wall expansion affected the decision of where to migrate within the United States, conditional on migrating:

$$\Delta \ln \pi_{od|US} = \kappa_p \Delta\alpha_{od,p} + \kappa_v \Delta\alpha_{od,v} + \underbrace{\ln \hat{\Phi}_{o,US}}_{\text{orig. FE}} + \underbrace{\theta_d \Delta \ln V_d}_{\text{dest. FE}} + \theta_d \eta_{od} \tag{11}$$

where $\kappa_p \equiv \theta_d \ln \tau_p$, $\pi_v \equiv \theta_d \ln \tau_p$, the origin fixed effect $\ln \hat{\Phi}_{o,US} \equiv \sum_{d' \in N_{US}} \pi_{od'|US} \left(\hat{V}_{d'} / \hat{\mu}_{od'} \right)^{\theta_d}$ captures the change in the option value of migrating to the United States and the destination fixed effect $\theta_d \Delta \ln V_d$ captures the change in the value of residing in the destination δ. Intuitively, equation (11) says is that we can infer the extent to which the border wall does increase the cost of migration based on how responsive migration flows are to changes in exposure to the border wall. Any time-invariant pair-specific migration costs are absorbed by looking at changes in migration shares before and after the border wall expansion. The inclusion of a destination fixed effect absorbs any changes in the value of migrating to particular destinations, whereas the inclusion of the origin fixed effect captures any change in the option value of migrating[20] (which will prove helpful in estimating the deterrence effect below).

A consistent estimate of κ_p and κ_v requires that the unobserved component of migration cost changes $\theta_d \eta_{od}$ is orthogonal to the border wall exposure. Violation of this orthogonality condition would occur, for example, if the location of the border wall expansion was chosen to target origin-destination pairs where migration flows were expected to increase (or decrease) disproportionately. To address this concern, we leverage the fact that the topography along the border is strongly predictive of where the border wall expanded (and what type of border wall was constructed). We use this relationship to construct a "predicted" border wall expansion that depends only on the local geography (and has the same length and composition of the actual wall). We then use the same procedure in the previous section to compute the exposure of each origin-destination pair to this "predicted" border wall, which provides an instrument for exposure to the actual border wall expansion.[21] The exclusion restriction of this instrumental variables procedure requires that the topography at the point that one crosses the border is uncorrelated with bilateral pair specific unobserved changes in the costs of migration, conditional on origin and destination fixed effects. We assess this assumption below.

Table 3 presents the main results of equation (11).[22] Columns 1 through 4 use two simpler measures of exposure to the border wall expansion: columns 1 and 2 (for the OLS and IV) show that migration flows declined disproportionately for pairs that were more exposed to the border wall expansion, where we measure exposure simply by the percentage increase in overland distance required to avoid any wall.[23] Columns 3 and 4

---

[20] Appendix Table 9 shows that exposure to wall expansion correlates with several origin and destination characteristics, most importantly, with exposure to the 2008 housing crisis, which happened at the same time. This highlights the importance of using bilateral flows in our estimation, allowing for the inclusion of origin and destination fixed effects.

[21] Appendix Table 10 shows the first-stage results for each of our measures of exposure. F-statistics are above 100 in all specifications.

[22] The bilateral migration matrix is sparse, i.e., a substantial share of the origin-destination flows is zero. Therefore, our benchmark specification, which has log matrículas as an outcome, will not use the full sample, which could bias our results. Appendix Table 11 estimates the same parameters using a Poisson framework, which allows for the inclusion of zeros, and shows that the results are similar.

[23] The distance and cost-weighted distance measures are special cases of the endogenous route choice model above where $C_{od,r}$ is the overland distance from o to d along route r, and $\tau_p = \tau_v = \theta_r = \infty$. The route-choice regressions presented in Table 2 reject this parameter constellation. This parameter constella-

(for the OLS and IV) show a similar pattern when we measure exposure as the percentage increase in cost-weighted distance to avoid any wall. All results (with the exception of the OLS for the cost-weighted distance) are highly statistically significant after two-way spatially clustering at the 1 degree × 1 degree level; in both cases, the IV coefficients are more negative than the OLS, consistent with the border wall targeting in part origin-destination pairs with greater migration growth.

Columns 5 through 8 consider exposure measure consistent with the route choice results above. Columns 5 and 6 treat all border wall segments as having the same effect (i.e., $\tau_p = \tau_v$), whereas columns 7 and 8 allow vehicular fence and pedestrian wall to have different effects. We find that migration flows declined disproportionately between pairs more exposed to the border wall expansion. While both types of border wall have negative point estimates, the coefficient on the pedestrian wall is larger and more precisely estimated, which is as to be expected as the pedestrian wall is a more substantial barrier. All estimates (with the exception of vehicular fence in the IV specification) are statistically significant at conventional levels with two-way spatial fixed effects.

What are the magnitudes of the effects? To answer this question, columns (9) and (10) take our preferred estimated coefficients for vehicular fence and pedestrian wall from column (8) and calculates $\Delta \ln \mu_{od}$ using equation (9).[24] The coefficients reported are then equal to the migration elasticity between destinations within the United States, which in our preferred IV specification are equal to $\theta_d = 4.345$ (with a standard error of 0.800).[25] Combined with the estimates of column 8, this in turn suggests $\tau_v = 1.11$ ($\exp\left(\frac{0.464}{4.345}\right)$) and $\tau_p = 1.15$ ($\exp\left(\frac{0.595}{4.345}\right)$); i.e., directly surmounting a border wall increases the total cost of migration by 15% for a pedestrian wall and 11% for a vehicular fence. However, because migrants can choose to avoid directly surmounting the border wall by taking longer or more costly routes, the average increase in migration costs is much smaller: only 3.9%. [26]

Even with the full set of fixed effects and the instrumental variables strategy, several

---

tion is also rejected by the substantial evidence that migrants can and do surmount the border wall (there have been 9,200 documented breaches between 2010 and 2015; see Congressional Research Service (2009)). However, we include it to show the following results are robust to alternative (simpler) measures of border wall exposure.

[24] Here the regression results rely on a nonlinear least squares procedure, as the migration elasticity (which is the estimated coefficient of the linear regression) also enters the calculation of $\Delta \ln \mu_{od}$.

[25] This migration elasticity is similar to but slightly higher than previous estimates from the literature (e.g., of 1.4 in Fajgelbaum, Morales, Suárez Serrato, and Zidar (2018), 1.5 in Tombe and Zhu (2019) and 3 in Bryan and Morten (2019)), which is consistent with evidence from Cadena and Kovak (2016) that migrants are more mobile across cities within the United States than U.S.-born workers.

[26] In Table 3, standard errors are two-way spatially clustered at the 1 degree × 1 degree level. Appendix Table 12 shows results with several other clustering specifications.The results remain significant in all specifications.

concerns remain. First, one could imagine that conditions at the border endogenously respond to the border wall expansion. For example, border patrol agents may direct a greater share of their resources toward patrolling segments of the border without walls, creating a negative correlation between our measure of exposure and the unobserved change in migration costs and causing us to underestimate the impact of the border wall on the diversion effect. Similarly, one could imagine that the segments without a border wall could become more dangerous to cross, as *coyotes* concentrate their smuggling efforts toward these locations. To the extent we are interested in measuring the total impact of the border wall expansion (including these responses), we ought not control for them. However, to identify the direct impact of the border wall expansion conditional on these responses, we collect data on the allocation of border patrol resources (i.e., the number of agents assigned to each border sector) and the number of reported homicides at each point along the border and control for these directly in our regressions. Columns 2 and 3 of Table 4 show that the negative relationship between changes in migration flows and the border wall expansion remains robust to these controls, although the inclusion of homicides as a control does cause our estimated coefficient to decline by roughly 40%, suggesting one reason that the border wall expansion caused migration flows to decline was because of the increased riskiness of unwalled routes. Column 4 of Table 4 shows that the parameter estimate is robust to defining the buffer zone as 4 km instead of 10 km.

A second concern is that the effect of the border wall expansion on migration patterns may vary across origin-destination pairs and the results in Table 3 are perhaps being driven by a subset of pairs. To assess this, column 5 of Table 4 restricts the sample to only destinations in states where there is a permanent Mexican consul that issues matrícula cards and column 6 drops pairs that have flows in the top 1% of observed data. As can be seen, the coefficient changes very little.

A third concern is that there may exist time-varying origin-destination pair shocks to migration costs that are correlated with exposure to the border wall expansion. For example, it could be that origin-destination pairs that were disproportionately exposed to the border wall were also concurrently exposed to economic shocks resulting from the Great Recession. As the Great Recession disproportionately affected the housing sector, one could imagine that municipalities where migrants were disproportionately employed in the construction sector would have been more affected. To assess this, we control directly for the interaction of the origin share of migrants in the construction sector and the housing shock in the destination (as measured by Mian and Sufi (2014)). Column 7 of Table 4 presents the results; as can be seen, controlling for the housing shock has very little effect on the estimated fence coefficients. More generally, there may be unobserved sector-specific shocks in the destination that disproportionately affect migrants from origins also employed in those sectors. To address this, column 8 of Table 4 controls directly for the interaction of the share of migrants from an origin employed in an industry and the employment share of that industry in the destination for two major industries: agriculture and mining, and services (with construction as the omitted category). As is evident, the impact of the border wall remains stable.

Finally, a fourth concern is that the timing of the migration effects do not align with when the border wall expanded. Figure 6 presents the results of estimating Equation 11 year-by-year. While we cannot directly examine pretrends in the data as we only have one year of data prior to the construction of the border wall expansion, we find that the pattern of the migration effects corresponds to the time expansion of the wall, with negative effects of the fence accumulating between 2006 and 2012 as the wall is built out along the border.

We conclude that there is a robust evidence that the border wall expansion resulted in a substitution of migration toward less exposed destinations. It remains to be seen, however, what this meant for how the border wall expansion affected the total number of migrants into the United States.

4.3 The deterrence effect

We now examine whether the wall led to an overall decrease in migration. To assess the strength of this deterrence effect, we take logs of equation (4) and then take differences across destination countries to yield:

$$\ln \hat{\pi}_{o,US} - \ln \hat{\pi}_{o,MEX} = \kappa \left(\ln \hat{\Phi}_{o,US} - \ln \hat{\Phi}_{o,MEX} \right), \tag{12}$$

where o is a municipality in Mexico, $\kappa_2 \equiv \frac{\theta_c}{\theta_d}$ is the relative magnitude of the deterrence and substitution effects, $\hat{\Phi}_{o,US}$ is the origin fixed effect we estimated above in equation (11), $\hat{\Phi}_{o,MEX}$ is the origin fixed effect we estimated from equation for internal migration flows within Mexico,[27] and $\ln \hat{\pi}_{o,US}$ ($\ln \hat{\pi}_{o,MEX}$) is the share of the population that migrates to the United States (Mexico), computed by combining the *Matrícula* data with population stocks in Mexico. Intuitively, the greater the decline in migration to the United States (relative to the staying in Mexico) in response to a fall in the expected value of migrating to the United States (relative to staying in Mexico), the stronger its deterrence

---

[27] Note that no origin-destination pairs within Mexico are impacted by the border wall expansion. As a result, $\hat{\Phi}_{o,MEX}$ is simply the origin fixed effect of a regression of the change in out-migration shares from o before and after the wall expansion on an origin and destination fixed effect.

effect.

Column 1 of Table 5 reports the corresponding regression results; we estimate a relative elasticity of 0.18, suggesting that migrants are inelastic about their choice of country and respond to the wall by changing their migration destination rather than ceasing migrating.

However, there are several potential concerns with the estimation of equation (11). First, as the regressors $\hat{\Phi}_{oc}$ are themselves estimates from the diversion effect regressions, they are likely measured with error, which potentially biases our estimates of the deterrence effect downward. Second, since $\hat{\Phi}_{oc} \equiv \sum_{d' \in N_c} \pi_{od'|c} \left(\hat{V}_{d'}/\hat{\mu}_{od'}\right)^{\theta_d}$, the changes in the option value of migrating incorporate not only the effects of the border wall expansion, but also any changes in the value of residing in destinations (and any other changes in migration costs not related to the border wall). While this will not necessarily bias our estimate of κ, it strikes us as preferable for our estimating variation to arise solely from the border wall expansion. To address both concerns, we instrument the observed change in option values $\hat{\Phi}_{oc}$ with $\hat{\Phi}^{SFA}_{oc} \equiv \sum_{d' \in N_c} \pi_{od'|c} \hat{\mu}_{od'}^{-\theta_d}$, i.e., the model implied change in option values that would arise if the only change were the increased migration costs due to the border wall expansion given our estimate of the impact of the border wall exposure on the substitution effect.[28] Column 2 of Table 5 reports the results; as is evident, the point estimate of 0.412 (with a standard error of 0.169) implies that migrants are relatively inelastic about their choice of country and respond to the border wall expansion by changing their migration destination rather than ceasing migrating.

Third, like any other difference-in-difference regression, estimation of equation (11) requires an assumption of parallel trends, i.e., that the change in the migration shares to the United States relative to Mexico before and after the border wall expansion would have remained constant in the absence of changes to the relative expected value of migrating. Although impossible to test directly because the *Matrícula* data only begins in 2006, we assess the robustness of our estimates of θ_c/θ_d to the inclusion of a variety of municipality-level controls which could plausibly directly affect the changes in relative United States/Mexico migration shares: distance to the border (columns 3 and 4), industrial composition (columns 5 and 6), and push/pull factors including rainfall shocks in the origin, homicide rates in the origin, and the share-weighted housing shock in the destination (columns 7 and 8). Columns 9 and 10 combine all explanatory variables in one regression. We find that the point estimate remains consistent throughout.

We conclude that the deterrence effect is substantially smaller than would be implied

---

[28] Note that by this measure $\hat{\Phi}^{SFA}_{o,MEX} = 1$, i.e., the option value of remaining in Mexico was unaffected by the border wall expansion.

by the IIA assumption underlying a typical gravity migration model where $\theta_c = \theta_d$. Rather than the wall causing people to stop migrating, the wall leads mostly to changes in the choice of destination within the United States. We proceed by using our estimated substitution and deterrence effects to quantify the aggregate economic impact of the border wall expansion.

5 The economic effect of a border wall

In this section, we estimate the aggregate economic effects of the existing border wall expansion as well as two larger counterfactual border wall expansions.

We begin our analysis with a simple labor market clearing condition that the number of individuals who end up in a destination, L_d, is equal to the number of individuals who migrate to that destination, i.e., $L_d = \sum_{o\in\{1,\ldots,N\}} \pi_{od} L_o$, where L_o is the number of individuals who began in origin o.[29] Taking ratios, this implies the change in the number of individuals who end up in a destination as a result of a policy shock (such as a border wall expansion), $\hat{L}_d$, can be written as:

$$\hat{L}_d = \sum_{o\in\{1,\ldots,N\}} \lambda_{od} \hat{\pi}_{od}, \tag{13}$$

where $\lambda_{od} \equiv \frac{\pi_{od} L_o}{\sum_{o\in\{1,\ldots,N\}} \pi_{od} L_o}$ is the "in-migration" share of individuals who end up in destination d that come from origin o.

For any policy change defined by a change in migration costs $\{\hat{\mu}_{od}\}$ and destination benefits $\{\hat{V}_d\}$, if "out-migration" and "in-migration" shares $\{\pi_{od}\}$ and $\{\lambda_{od}\}$ are observed and elasticities $\{\theta_r, \theta_d, \theta_c\}$ are known, then one can calculate the matrix $\{\hat{\pi}_{od}\}$ using equation (6) and thereby determining the change in migration flows from equation (13).

---

[29] A static migration framework such as the one employed here requires a choice of how to relate the number of individuals who "begin" in a destination (who show up on the right hand side of equation (13)) to those who "end up" in a destination (who appear on the left hand side of equation (13)). One option would be to equate both sides, thereby calculating the effect of the border wall expansion in the "steady state," where the migration process has continued until the population stocks remain unchanged. We instead treat the number of individuals who begin in an origin as fixed and solve for the equilibrium population distribution one period later. This is both consistent with much of the literature (see, e.g., by Tombe and Zhu (2019); Bryan and Morten (2019)) and more relevant to our setting, as the matrícula card data capture migration flows (not stocks) and our period of study is reasonably short.

5.1 The direct effect of the border wall expansion on migration

Define the "direct effect" of the border wall expansion to be the equilibrium change in population in all locations as a result of the change in migration costs only, holding constant the destination benefits in all locations (i.e., $\hat{V}_d = 1$). To estimate this direct effect, we solve equations (6) and (13) using our estimates of $\hat{\mu}_{od}$ from Section 4.2 given our estimates of the migration elasticities over route, destination within the United States, and between migrating and not-migrating, i.e., $\{\theta_r, \theta_d, \theta_c\}$. Because both $\{\hat{\mu}_{od}\}$ and each of these elasticities are estimates, to calculate the standard errors over our estimated aggregate impacts, we use a bootstrap procedure, where we simultaneously (and independently) draw each of our estimated coefficients – i.e., $\left\{\theta_r, \kappa_v \equiv \theta_d \ln \tau_v, \kappa_p \equiv \theta_d \ln \tau_p, \theta_d, \kappa \equiv \frac{\theta_c}{\theta_d}\right\}$ – from the distribution implied by their standard errors and reconduct the counterfactuals 200 times.

Column 1 of Table 6 reports the direct effect of the border wall expansion. We estimate that the direct effect of the border wall expansion was to reduce migration flows by 51,073 persons, with a standard error of 20,268. This number corresponds to roughly 5% of the observed decline in migrations flows between 2005 and 2015 reported in Figure 1.

5.2 The general equilibrium effect of the border wall expansion

While informative, the direct effect of the border wall expansion on changes in migration has two important limitations. First, it ignores the fact that the benefits of migrating may themselves respond to changes in migration flows. Second, by ignoring the impact of the border wall expansion on economic conditions in the destination, it abstracts from any economic spillovers on other workers such as those born in the United States. To address both these concerns, we embed our simple migration model into a general equilibrium framework.[30]

5.2.1 Setup

Suppose that workers vary on two dimensions: their skill s (high-skilled and low-skilled) and their nativity n (United States and Mexico). Workers of different nativities and skills residing in the same location combine their inelastically supplied unit of labor in a nested CES production function to produce a costlessly traded numeraire good,[31] where the in-

---

[30] We briefly describe the framework here and refer the interested reader to Appendix D for a more detailed discussion.

[31] It is straightforward to extend the framework to incorporate costly trade and heterogeneous products, although it turns out including this margin has only small effects on the estimates of the impact of the

ner nest over nativities of a particular skill s (with elasticity of substitution ρ_s) and an outer nest over the skill composites (with elasticity of substitution ρ).

We allow workers of different types to potentially differ along four margins: their migration costs (denoted by $\{\mu_{od}^{n,s}\}$); their heterogeneity in preferences over routes, locations, and countries (denoted by $\{\theta_r^{n,s}, \theta_d^{n,s}, \theta_c^{n,s}\}$); their labor productivity (denoted by $\{A_d^{n,s}\}$); and their amenity value of residing in a destination (denoted by $\{u_d^{n,s}\}$). We assume the value of residing in a destination for a worker of a given type is the product of her wage in that destination and her amenity value in that destination, i.e., $V_d^{n,s} = w_d^{n,s} u^{n,s}$, where $w_d^{n,s}$ is the (endogenous) wage of worker of nativity n and skill s in destination d. Let $L_d^{n,s}$ denote the number of workers of nativity n and skill s in destination d.

5.2.2 The general equilibrium effect of any policy shock

Suppose there is any policy shock that changes any combination of migration costs, productivities, and/or amenities from $\{\mu_{od}^{n,s}, A_d^{n,s}, u_d^{n,s}\}$ to $\left\{\widetilde{\mu_{od}^{n,s}}, \widetilde{A_d^{n,s}}, \widetilde{u_d^{n,s}}\right\}$; what are the economic effects of this shock? Equation (6) (depicting the changes in migration patterns) and equation (13) (depicting the change in population) remain unchanged; they now just hold for each type of worker. What is new, however, is that the value of residing in a destination responds endogenously to the shock and the resulting changes in migration patterns. One can show that the change in the value of residing in destination d for a worker of nationality n and skill s can be written as:

$$\hat{V}_d^{n,s} = \overbrace{\left(\frac{\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{\rho-1}{\rho}\right)}}{\sum_{s\in\{h,l\}} \eta_d^s \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)}} \right)^{-\frac{1}{\rho-1}}}^{\text{change in relative skill scarcity}} \times \underbrace{\left(\frac{\hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}}{\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}} \right)^{-\frac{1}{\rho_s-1}}}_{\text{change in relative nationality scarcity}} \times \underbrace{\left(\hat{A}_d^{n,s}\right)^{\frac{\rho_s}{\rho_s-1}} \hat{u}_d^{n,s}}_{\text{direct effect}} \quad (14)$$

---

border wall expansion; see the NBER working paper version of the paper.

where $\eta_d^s \equiv \frac{\sum_{n\in\{M,U\}} w_i^{n,s} L_i^{n,s}}{\sum_{s\in\{h,l\}} \sum_{n\in\{M,U\}} w_i^{n,s} L_i^{n,s}}$ is the share of income in location d earned by workers of skill s (of both nationalities) and $y_d^{n,s} \equiv \frac{w_d^{n,s} L_d^{n,s}}{w_d^{MEX,s} L_d^{MEX,s} + w_d^{US,s} L_d^{US,s}}$ is the share of income earned by workers of skill s in location d that is paid to workers of nativity n. Equation (14) highlights the three ways in which a policy shock can endogenously affect the value of migrating to a particular destination. First, the policy can directly affect the payoffs by either changing the productivity or the amenity value of workers of a given type residing there. Second, it can change the relative scarcity of a given nationality of worker within a skill type. Third, it can change the relative scarcity of workers of different skill types. The magnitude of the relative nationality scarcity effect depends on the elasticity of substitution between workers of different nativities (ρ_s). Similarly, the magnitude of the relative skill scarcity effect depends on the elasticity of substitution between workers of different skill groups (ρ). For example, by holding constant the destination benefits, the direct effect of the border wall expansion implicitly assumed infinite elasticities of substitution of different types of workers.

5.2.3 The general equilibrium effect of the border wall expansion

We now evaluate the economic impact of the border wall expansion. The basic procedure is straightforward: we assume the border wall expansion only affected the migration costs of low-skill Mexican migrants, but had no direct effect on the productivities or amenities of any worker type in any location. We then simultaneously solve equations (6), (13), and (14) to determine the equilibrium change in wages and population of every worker type in every location. As above, we calculate the standard errors by bootstrapping the entire procedure 200 times, each time drawing all estimated parameters from their estimated distributions. However, unlike above, we now have to take a stand on the elasticities of substitution across different worker types in the production function and the migration elasticities of non-Mexican low-skill workers. We calibrate these values to the literature, following Piyapromdee (2019) in assuming $\rho_l = 18$, $\rho_h = 7$, and $\rho = 2$ and following Tombe and Zhu (2019) in assuming $\theta_d^{n,s} = \theta_c^{n,s} = 1.5$ for all non Mexican low-skill worker types. (Note that $\theta_r^{n,s}$ does not affect the counterfactuals as other worker types route costs are assumed unchanged.). We also assess how the results vary under alternative parameter constellations from the literature.

Column 2 of Table 6 presents the total effect of the border wall expansion. We estimate that the border wall expansion reduced migration flows from Mexico to the United States by 46,459 persons, with a standard error of 17,089, equal to a little less than 5% of the actual decline in migration flows from 2005 to 2015. The general equilibrium effect is smaller than the direct effect, as wages for low-skill Mexican workers in the United States rise as migration declines, which makes migrating more attractive – indeed, ignoring the general equilibrium forces would cause one to overstate the effectiveness of the border wall by 10%. Accounting for the detour and deterrence effects is even more important. Panel (b) of Table 7 shows that if migrants were not able to re-optimize their route choice after the border wall expansion, the decline in migration would have been 19% larger (i.e., 55,347 instead of 46,459). Even more important is the deterrence effect: recall from Section 4.3 that we find that the demand for migration is inelastic with $\frac{\theta_c}{\theta_d} = 0.41$. Panel (c) of Table 7 shows that if we had instead assumed migrants substituted equally between locations within and across countries (i.e., the IIA assumption common to migration gravity models held), we would overstate the efficacy of the border wall expansion by 105% (i.e., we would have predicted a decline in migration of 118,488).

Given the modest decline in migration, it is perhaps not particularly surprising that the economic impacts are small. We estimate the average low-skill U.S. worker earns \$2.89 more a year (s.e. of \$1.07), as low-skill labor in the United States becomes relatively more scarce. Conversely, the average high-skill U.S. worker earns \$3.63 less a year (s.e. of \$1.34). Panels (d) and (e) of Table 7 show that these figures are similar in magnitude for elasticities of substitution between U.S. and Mexican workers varying from 5 to 30, consistent with these small figures not being the result of our particular chosen parameters. Perhaps not surprisingly, the group hurt the most by the border wall expansion is low-skill Mexican workers, who we estimate lose on average \$17.33 per person per year (s.e. of \$6.41).

These average effects, however, belie substantial heterogeneity across space. Panel (a) and (b) of Figure 2 depict the change in population and income, respectively, of each type of worker in all $3,308$ locations. Locations near places where the border wall expanded saw the greatest declines in migration and the largest wage effects. For example, we estimate the border expansion reduced migration flows by $11,000$ to Los Angeles, where low-skill U.S. workers would have benefited by more than \$40 per year.

How seriously should we take the model's predictions of the impacts of the border wall expansion? One way of evaluating the goodness of the model fit is to examine the extent to which the model's predictions of the impact of border wall expansion correlate with the changes that actually occurred. One difficulty with such an exercise, however, is that the model implies that only a small fraction of the observed aggregate decline in migration is due to the border wall expansion, suggesting that there are many other larger changes in the economy happening simultaneously. To ameliorate this concern, we examine how the estimated relative impacts of the border wall between Mexican and

U.S. workers of the same skill correlate with observed relative impacts. This procedure controls for all other changes in the local labor market (e.g., shocks due to the Great Recession) that affect workers of a given skill type equally. Moreover, we compare only labor markets within a given state to control for any state-wide shocks that disproportionately affect Mexican workers relative to U.S. workers of a given skill type.

Figure 8 presents binned scatterplots comparing the estimated impact of the border wall expansion on relative population changes (panel (a)) and relative wage changes (panel (b)) to the actual relative population and wage changes for both skill types observed in the data, where all figures are residualized to include state fixed effects.[32] As is evident, for both low-skill and high-skill workers, the within-state variation in relative population changes predicted from the border wall expansion correlates strongly with the actual relative population changes that occurred. We emphasize that none of this data was used in our estimation above, so we take this as suggestive evidence that the model is able to capture the heterogeneity in the relative impact of the border wall expansion on workers of different nationalities of the same skill across labor markets within the same state.[33] Consistent with the border wall expansion being a small shock relative to other contemporaneous economic shocks, the variation in observed relative population changes is more than an order of magnitude larger than the estimated impacts of the border wall expansion. Unlike with relative within-state and within-skill population changes, we find no statistically significant relationship between the model predictions and the observed changes in relative wages, which is perhaps not very surprising given that the estimated effects of the border wall expansion on wages are so small.

5.3 The economic effects of a bigger and/or better wall

Finally, we analyze the impact of two counterfactual and more substantial border wall expansions: an upgraded wall and a complete border wall.

Upgrading the existing wall

Our estimates above find that pedestrian wall was a more effective deterrent to migration than vehicular fencing. In our first counterfactual, we assess what the change in migration flows would have been had the border wall expansion only used pedestrian barriers.

---

[32] See Appendix Table 13 for the corresponding regression results, as well as the corresponding changes for each nationality-skill group separately.

[33] In particular, the estimation of the diversion effect included destination-year fixed effects, whereas the estimation of the deterrence effect looked at changes in total migration from an origin labor market within Mexico; here, instead, we examine changes in the relative population in destination U.S. labor markets.

Column 3 of Table 6 presents the estimated effects of this upgraded wall (relative to the baseline prior to the expansion), while column 3 of Table 7 shows how the estimated effects would differ if we either abstract from some of the effects of the model or change the parameter values. As is evident, an upgraded wall would have had a negligible impact on migration flows, deterring only an additional 3,440 persons relative to the existing border wall expansion (49,899 instead of 46,459), well within the standard error of 20,662. This is perhaps not surprising, as our estimated difference in cost between pedestrian walls and vehicular fences was reasonably small, as the former increased migration costs by 15% instead of 11%.[34]

A complete border wall

We next consider a more substantial (and heroic) counterfactual: what if the United States were to build a complete (pedestrian) border wall? In this case, migrants would have to incur the 15% migration cost of surmounting the wall, regardless of their chosen route. Column 4 of Table 6 presents the estimated effects of the complete wall (relative to the baseline prior to the expansion), while column 4 of Table 7 shows how the estimated effects would differ if we either abstract from some of the effects of the model or change the parameter values. We estimate that a complete wall would have reduced migration flows by three times as much as the actual border wall expansion (129,438 instead of 51,073, with a s.e. of 51,775), albeit we note that this still comprises a small portion (13%) of the observed decline in migration flows between 2005 and 2015. The average economic effects show a similar pattern of U.S. low-skill workers being made better off (by $7.99 a year on average with s.e. of $3.25), whereas U.S. high-skill workers are being made worse off (by $10.03 a year on average with s.e. of $4.07). We should note, however, that these figures abstract from the construction and maintenance costs of such a border wall, which are upwards of $67 billion, roughly $200 for every U.S. citizen. Figure 10 shows that the spatial distribution of the impacts of a complete wall do differ substantially from the actual border wall expansion, with migration falling (and low-skill U.S. wages) rising in urban areas throughout the United States.

---

[34] While the existing pedestrian fence is not as substantial as the 30- to 50- foot-high concrete barriers initially proposed by the Trump administration (see panel (b) of Figure 2), it is consistent with the more modest recent proposal of "artistically designed steel slats."

6 Conclusion

In this paper, we contribute some empirical evidence to the debate over a U.S.-Mexico border wall. We combine confidential data on the bilateral flows of 5.7 million migrants with survey data on the exact migratory path of migrants to study how migration patterns responded to the construction of 550 new miles of border wall between 2007 and 2010. Guided by a simple model of migration, we document that the border wall expansion changed migrants' choice of route and choice of destination within the United States, but it did not have large effect on the choice of whether or not to migrate. This inelastic demand for migration meant that the impact of the border wall expansion on total migration was small, reducing flows by about 46,000 persons or 5% of the observed decline between 2005 and 2015. Counterfactual simulations suggest that a completed border wall would have similarly modest effects.

This paper highlights the importance of accounting for the many ways in which migrants can react to changes in immigration policy when assessing its impact. In the context of a border wall, we show that the choice of how to enter a country and where to reside within that country are both important margins in the migration decision. More generally, however, there are likely additional margins from which this paper abstracts that also play an important role, e.g., the choice of occupation and/or sector of employment, dynamic considerations including the choice of whether to move within the destination country or return home, or the extent to which to rely on the assistance of one's social networks. We look forward to future research incorporating such forces.

References

ADAO, R., A. COSTINOT, AND D. DONALDSON (2017): "Nonparametric Counterfactual Predictions in Neoclassical Models of International Trade," *American Economic Review*, 107(3), 633–89.

AHLFELDT, G., S. REDDING, D. STURM, AND N. WOLF (2015): "The Economics of Density: Evidence from the Berlin Wall," *Econometrica*, 83(6), 2127–2189.

ALLEN, T. (2015): "The Promise of Freedom: Fertility decisions and the Escape from Slavery," *Review of Economics and Statistics*, 97(2), 472–484.

ALLEN, T., AND C. ARKOLAKIS (2014): "Trade and the Topography of the Spatial Economy," *Quarterly Journal of Economics*, 129(3), 1085–1140.

——— (2019): "The Welfare Effects of Transportation Infrastructure Improvements," Discussion paper, National Bureau of Economic Research.

BALDWIN, R., AND D. TAGLIONI (2006): "Gravity for Dummies and Dummies for Gravity Equations," *NBER Working Paper*.

BAZZI, S., S. BURNS, G. HANSON, B. ROBERTS, AND J. WHITLEY (2018): "Deterring Illegal Entry: Migrant Sanctions and Recidivism in Border Apprehensions," Discussion paper, National Bureau of Economic Research.

BORJAS, G. J. (2003): "The Labor Demand Curve is Downward Sloping: Reexamining the Impact of Immigration on the Labor Market," *The Quarterly Journal of Economics*, 118(4), 1335–1374.

BORJAS, G. J., J. GROGGER, AND G. HANSON (2012): "Comment: On Estimating Elasticities of Substitution," *Journal of the European Economic Association*, 10(1), 198–210.

BORJAS, G. J., AND L. F. KATZ (2007): "The Evolution of the Mexican-Born Workforce in the United States," in *Mexican Immigration to the United States*, ed. by G. J. Borjas. University of Chicago Press.

BRYAN, G., AND M. MORTEN (2019): "The Aggregate Productivity Effects of Internal Migration: Evidence from Indonesia," *Journal of Political Economy*, 127(5), 2229–2268.

BURSTEIN, A., G. HANSON, L. TIAN, AND J. VOGEL (2019): "Tradability and the Labor-Market Impact of Immigration: Theory and Evidence from the U.S.," *NBER Working Paper*.

CABALLERO, M. E., B. C. CADENA, AND B. K. KOVAK (2018): "Measuring Sub-national Migration Networks using Matriculas Consulares," *Demography*, 55, 1119–1145.

CADENA, B. C., AND B. K. KOVAK (2016): "Immigrants Equilibrate Local Labor Markets: Evidence from the Great Recession," *American Economic Journal: Applied Economics*, 8(1), 257–90.

CALIENDO, L., M. DVORKIN, AND F. PARRO (2019): "Trade and Labor Market Dynamics: General Equilibrium Analysis of the China Trade Shock," *Econometrica*, 87(3), 741–835.

CALIENDO, L., F. PARRO, L. D. OPROMOLLA, AND A. SFORZA (2018): "Goods and Factor Market Integration: A Quantitative Assessment of the EU Enlargement," pp. 1–72.

CARD, D. (2001): "Immigrant Inflows, Native Outflows, and the Local Market Impacts of Higher Immigration," *Journal of Labor Economics*, 19(1), 22–64.

CLEMENS, M. A. (2015): "North American Labor Market Shocks and Violent Crime," .

CLEMENS, M. A., E. G. LEWIS, AND H. M. POSTEL (2018): "Immigration Restrictions as Active Labor Market Policy: Evidence from the Mexican Bracero Exclusion," *American Economic Review*, 108(6), 1468–1487.

CONGRESSIONAL RESEARCH SERVICE (2009): "Border Security : Barriers Along the U.S. International Border," Discussion paper.

COSTINOT, A., AND A. RODRÍGUEZ-CLARE (2014): "Trade Theory with Numbers: Quantifying the Consequences of Globalization," *Handbook of International Economics*, 4, 197–261.

DEKLE, R., J. EATON, AND S. KORTUM (2007): "Unbalanced Trade," *American Economic Review*, 97(2), 351–355.

DEPARTMENT OF HOMELAND SECURITY (2017): "Fiscal Year 2016 Entry/Exit Overstay Report," p. 50.

DESMET, K., D. K. NAGY, AND E. ROSSI-HANSBERG (2018): "The Geography of Development: Evaluating Migration Restrictions and Coastal Flooding," *Journal of Political Economy*, 126, 903–983.

DUSTMANN, C., U. SCHÖNBERG, AND J. STUHLER (2016): "The Impact of Immigration: Why Do Studies Reach Such Different Results?," *Journal of Economic Perspectives*, 30(4), 31–56.

FAJGELBAUM, P. D., E. MORALES, J. C. SUÁREZ SERRATO, AND O. ZIDAR (2018): "State Taxes and Spatial Misallocation," *The Review of Economic Studies*, 86(1), 333–376.

FEIGENBERG, B. (2019): "Fenced Out: Why Rising Migration Costs Matter," .

GUERRERO, J., AND L. CASTAÑEDA (2017): "America's Wall," *Inewsource/KPBS*.

HANSON, B. G. H., AND A. SPILIMBERGO (1999): "Illegal Immigration, Border Enforcement, and Relative Wages: Evidence from Apprehensions at the U.S.-Mexico Border," *The American Economic Review*, 89(5), 1337–1357.

HEAD, K., AND T. MAYER (2013): "Gravity Equations: Workhorse, Toolkit, and Cookbook," *Handbook of International Economics*, p. 63.

KATZ, L. F., AND K. M. MURPHY (1992): "Changes in Relative Wages, 1963-1987: Supply and Demand Factors," *The Quarterly Journal of Economics*, 107(1), 35–78.

LESSEM, R. (2018): "Mexico-U.S. Immigration: Effects of Wages and Border Enforcement," *Review of Economic Studies*, 85(4), 2353–2388.

MASSEY, D., J. DURAND, AND N. MALONE (2003): *Beyond Smoke and Mirrors: Mexican Immigration in an Era of Economic Integration*. Russel Sage Foundation.

MASSEY, D. S., J. DURAND, AND K. PREN (2016): "Why Border Enforcement Backfired," *American Journal of Sociology*, 121(5), 1557–1600.

MASSEY, D. S., J. S. RUGH, AND K. A. PREN (2010): "The Geography of Undocumented Mexican Migration," *Mexican Studies/Estudios Mexicanos*, 26(1), 129–152.

MIAN, A., AND A. SUFI (2014): "What Explains the 2007-2009 Drop in Employment?," *Econometrica*, 82(6), 2197–2223.

MICHAEL BAKER JR. INC. (2013): "Border Fence Locations," .

MINIAN, A. (2018): *Undocumented Lives*. Harvard University Press, Cambridge, Massachusetts.

MONTE, F., S. REDDING, AND E. ROSSI-HANSBERG (2019): "Commuting, Migration, and Local Employment Elasticities," *American Economic Review*, 108(12), 3855–3890.

MORTEN, M., AND J. OLIVEIRA (2018): "The Effects of Roads on Trade and Migration: Evidence from a Planned Capital City," .

MUNSHI, K. (2003): "Networks in the Modern Economy: Mexican Migrants in the US Labor Market," *Quarterly Journal of Economics*, 118(2), 549–597.

OTTAVIANO, G. I. P., AND G. PERI (2012): "Rethinking the Effects of Immigration on Wages," *Journal of the European Economic Association*, 10(1), 152–197.

PASSEL, J. (2007): "Unauthorized Migrants in the United States," *Oecd Social, Employment and Migration Working Papers*, (57).

PASSEL, J. S., AND D. COHN (2016): "Overall Number of U.S. Unauthorized Immigrants Holds Steady Since 2009," Discussion paper, Pew Research Center.

PIYAPROMDEE, S. (2019): "The Impact of Immigration on Wages, Internal Migration and Welfare," .

REDDING, S. (2016): "Goods Trade, Factor Mobility and Welfare," *Journal of International Economics*, 101, 148–167.

REDDING, S., AND E. ROSSI-HANSBERG (2017): "Quantitative Spatial Economics," *Annual Review of Economics*, 9, 21–58.

SETHIAN, J. A. (1996): "A Fast Marching Level Set Method for Monotonically Advancing Fronts," *Proceedings of the National Academy of Sciences*, 93(4), 1591–1595.

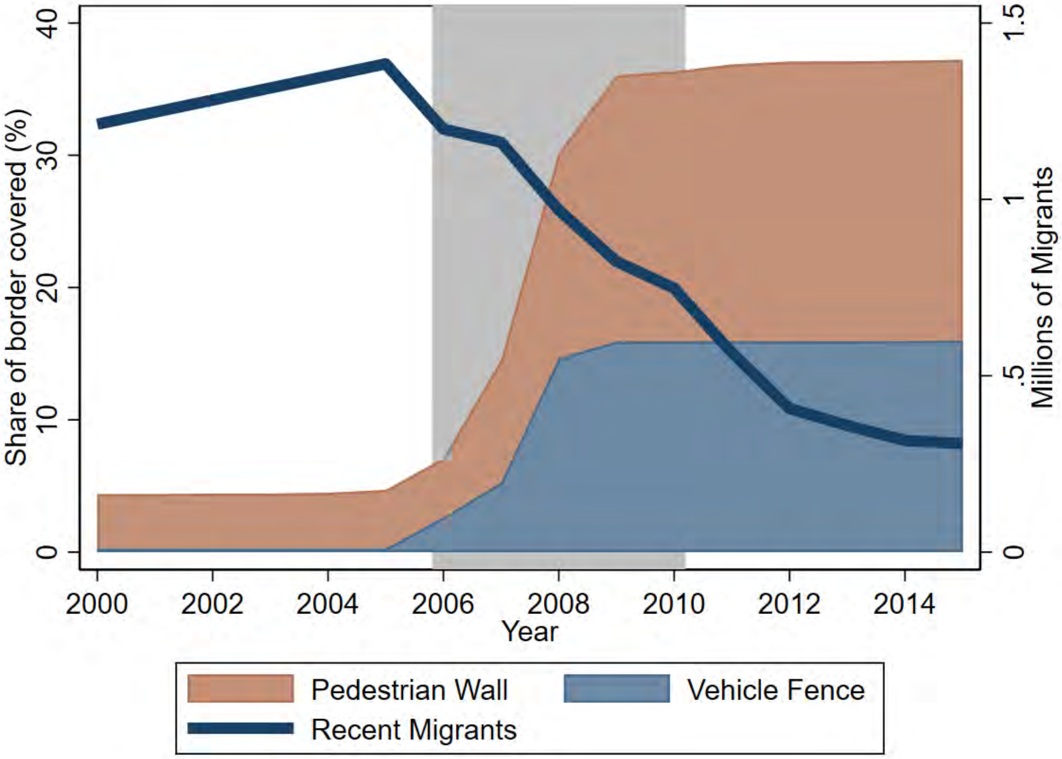
TOMBE, T., AND X. ZHU (2019): "Trade, Migration and Productivity: A Quantitative Analysis of China," *American Economic Review*, 109(5), 1–42.

TSITSIKLIS, J. N. (1995): "Efficient Algorithms for Globally Optimal Trajectories," *IEEE Transactions on Automatic Control*, 40(9), 1528–1538.

UNITED STATES GOVERNMENT ACCOUNTABILITY OFFICE (2017a): "Border Patrol: Actions Needed to Improve Oversight of Post-Apprehension Consequences," Discussion Paper January.

——— (2017b): "Southwest Border Security: Additional Actions Needed to Better Assess Fencing's Contributions to Operations and Provide Guidance for Identifying Capability Gaps," Discussion Paper February.

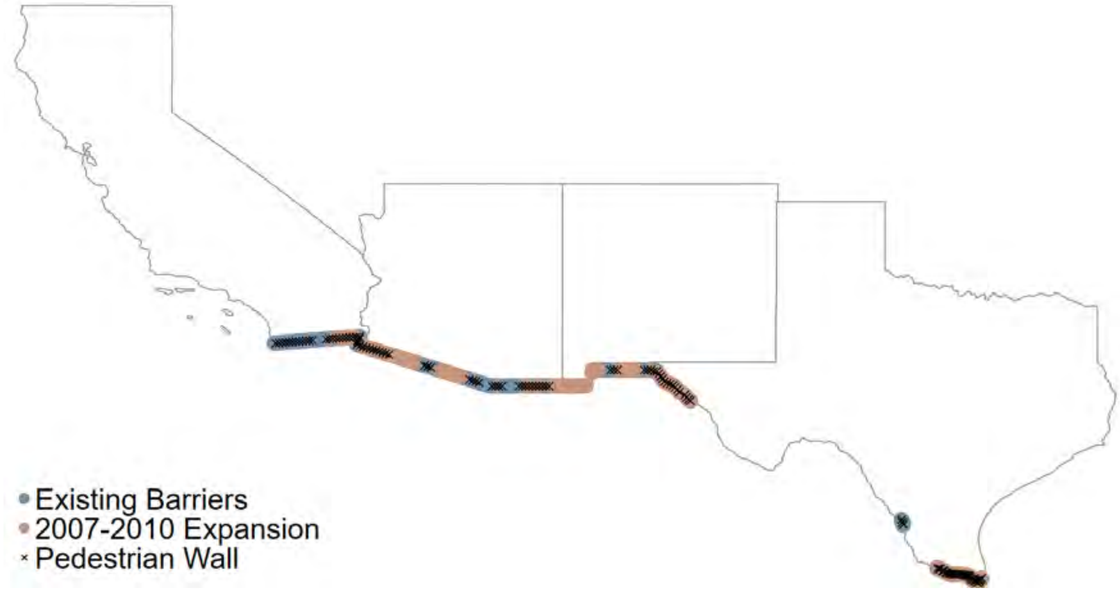
Figure 1: The border wall expansion and Mexico-U.S. migration flows



Notes: The left y-axis shows the share of the Mexico-U.S. border that is covered by some barrier. Data on location of the border wall digitized from Michael Baker Jr. Inc. (2013) and data on timing of the expansion shared by Guerrero and Castañeda (2017). The right y-axis shows the number of 18 to 65 old Mexican citizens who have been in the United States for five years or less. The source is the U.S. Census (for the year 2000) and the U.S. American community survey (for 2005 onwards). The shaded area is the period in which the Secure Fence Act border wall expansion occurred.

Figure 2: The 2007–2010 border wall expansion

(a) Expansion across space

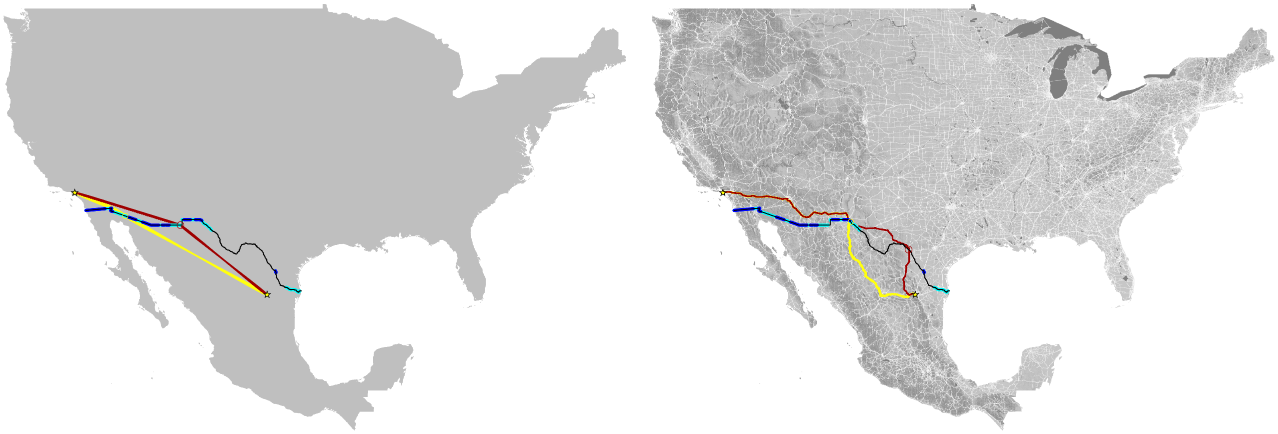


(b) Pedestrian wall

(c) Vehicular fence

Notes: Panel (a) shows the location of pedestrian walls and vehicular fences before and after the 2007–2010 border wall expansion. The non-hatched points indicate vehicular fences. Panels (b) and (c) provide illustrations of both barrier types. Sources: (a) Data digitized from Michael Baker Jr. Inc. (2013); (b) https://www.memphisflyer.com/memphis/against-the-wall/Content?oid=4602862; (c) http://mexicowall.net/gallery/.

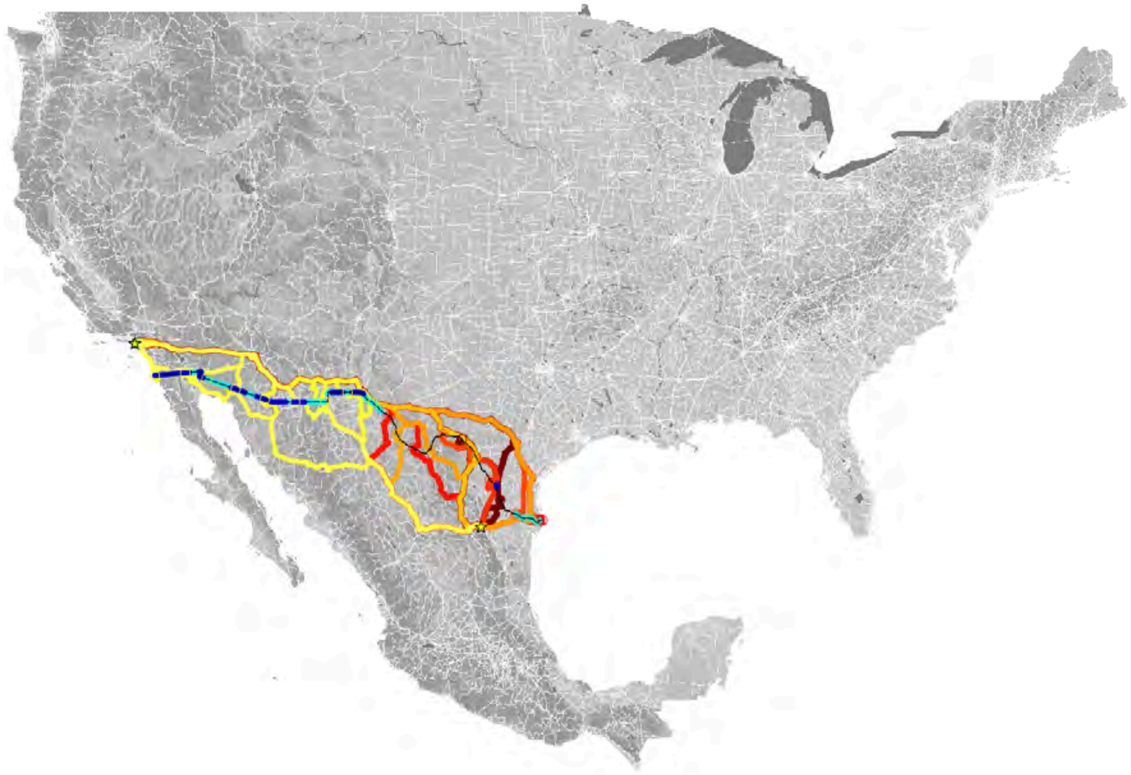
Figure 3: Exposure to the 2007–2010 border wall expansion: Monterrey to Los Angeles



(a) Distance

(b) Cost-weighted distance

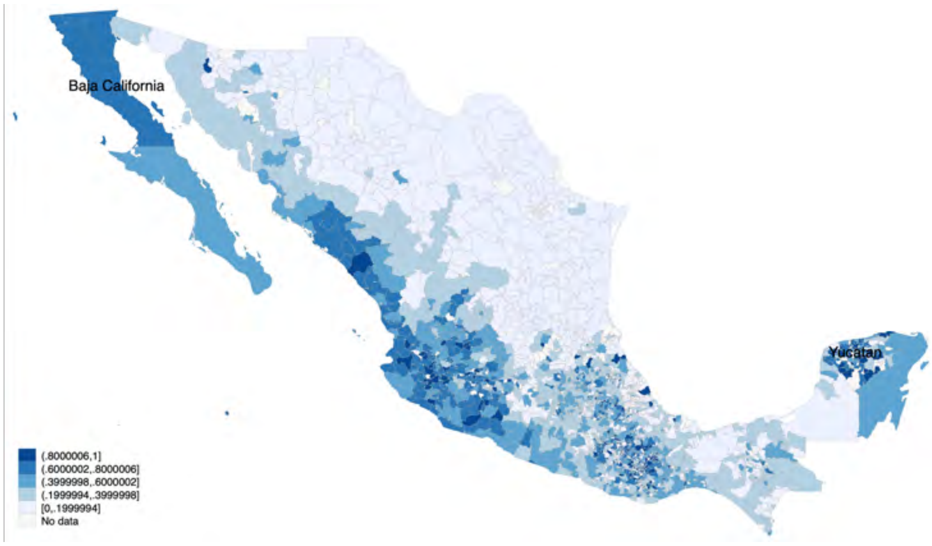
(c) Exposure



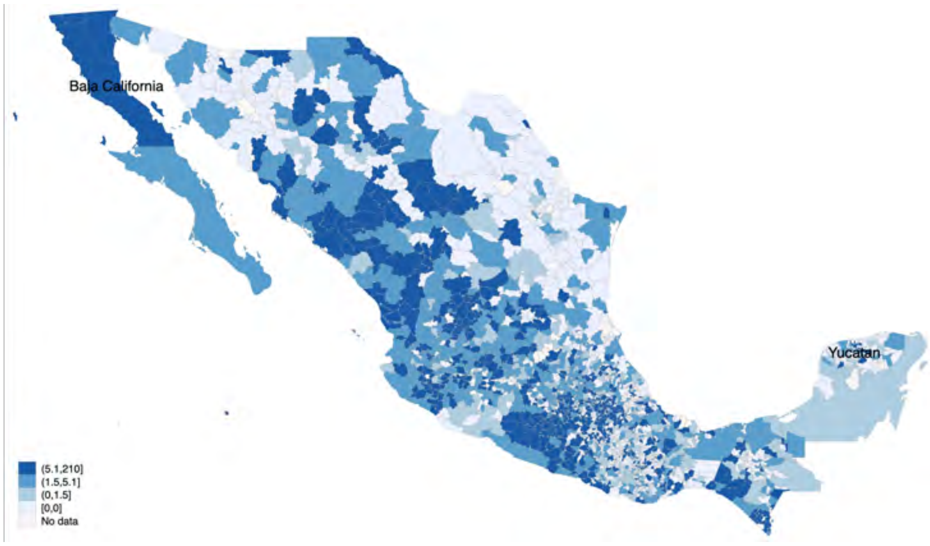
Notes: This figure shows three ways of measuring the exposure of the origin-destination pair of Monterrey (Mexico)-Los Angeles (Unites States) to the 2007–2010 border wall expansion. In each panel, dark (light) blue indicates the location of a border wall prior to (after the) the border wall expansion. Panel (a) depicts the increase in (overland) distance necessary to avoid the border wall, where yellow (maroon) indicates the optimal straight-line route prior to (after) the SFA. Panel (b) shows the same figure after accounting for the heterogeneity in the cost of travel arising from differences in geography and infrastructure (indicated in grayscale). Panel (c) incorporates both the uncertainty of which route is chosen and the possibility of crossing at a point with a border wall by calculating the cost of the optimal route through all possible border crossing points (see the text for details). The color of the route indicates its relative cost, with yellow (maroon) indicating lower (higher) relative costs; for readability, only every fiftieth crossing point is shown.

Figure 4: Examples of migration patterns: California

(a) Destination: California



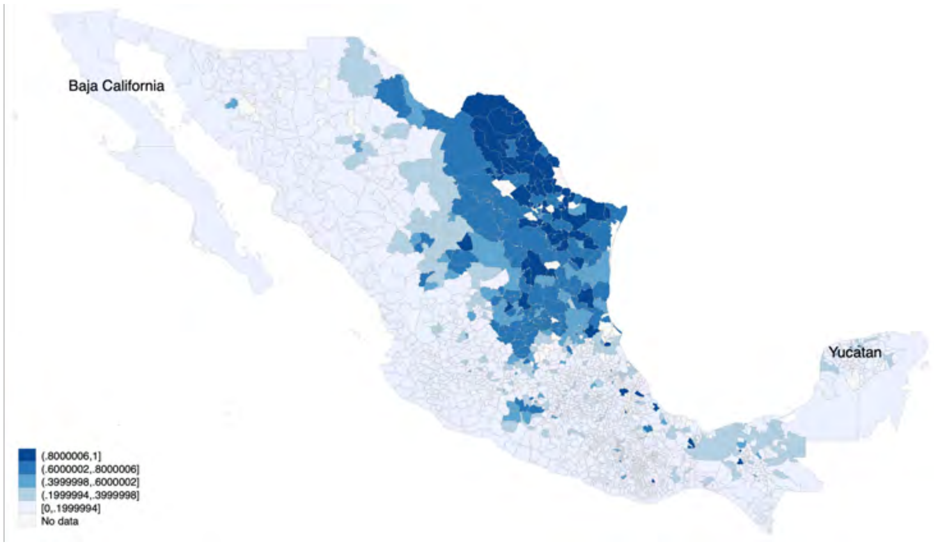
(b) Relative share: LA compared with Bay Area (conditional on migrating to California)



Notes: This figure shows probability of migrating to California, as well as the relative probability of migrating to different cities within California, conditional on migrating to California. Source: 2006 *Matrícula Consular* database.

Figure 5: Examples of migration patterns: Texas

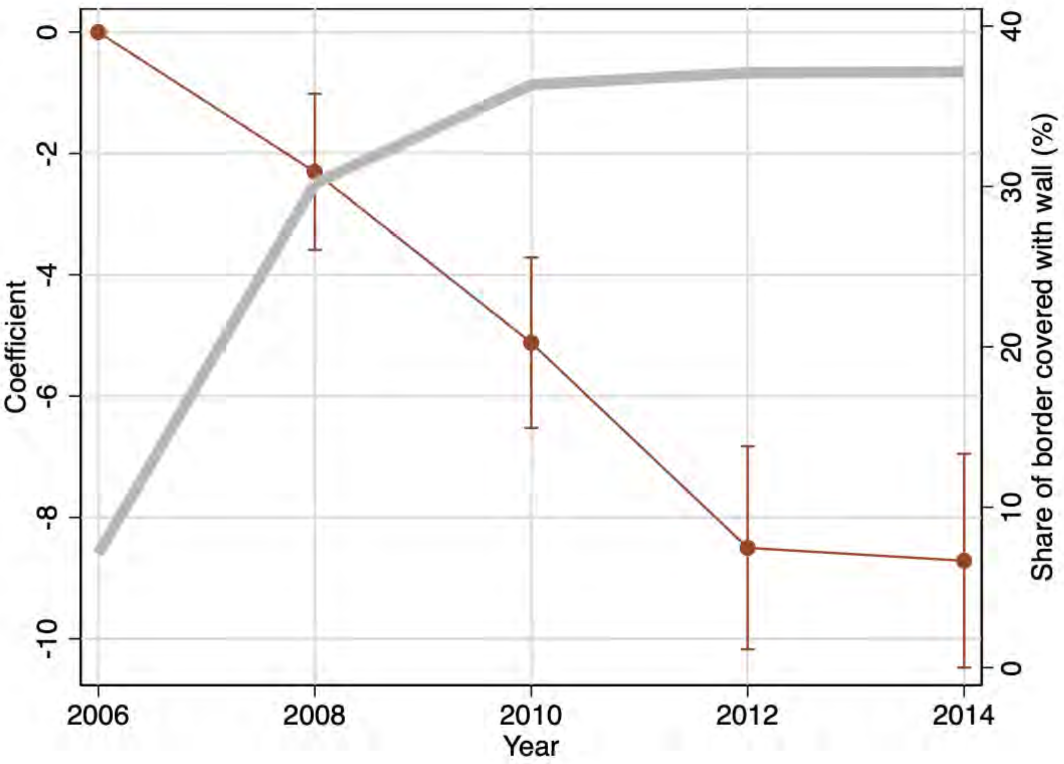
(a) Destination: Texas



(b) Relative share: Houston compared with Dallas (conditional on migrating to Texas)

Notes: This figure shows probability of migrating to Texas, as well as the relative probability of migrating to different cities within Texas, conditional on migrating to Texas. Source: 2006 *Matrícula Consular* database.

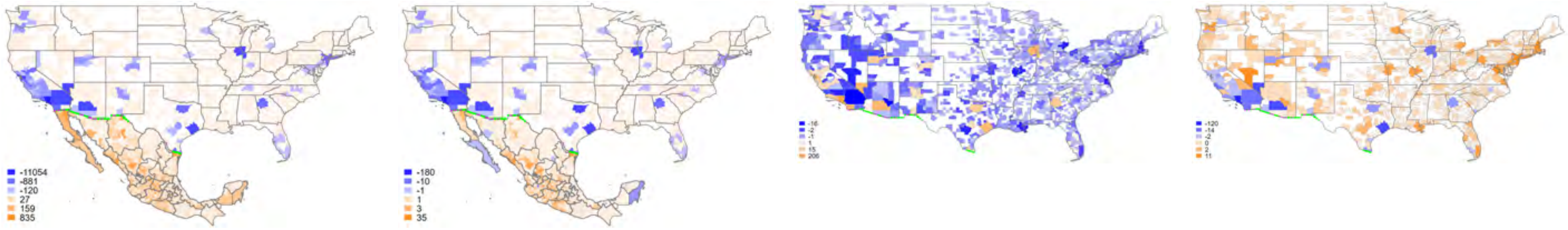
Figure 6: Estimated diversion effect by year



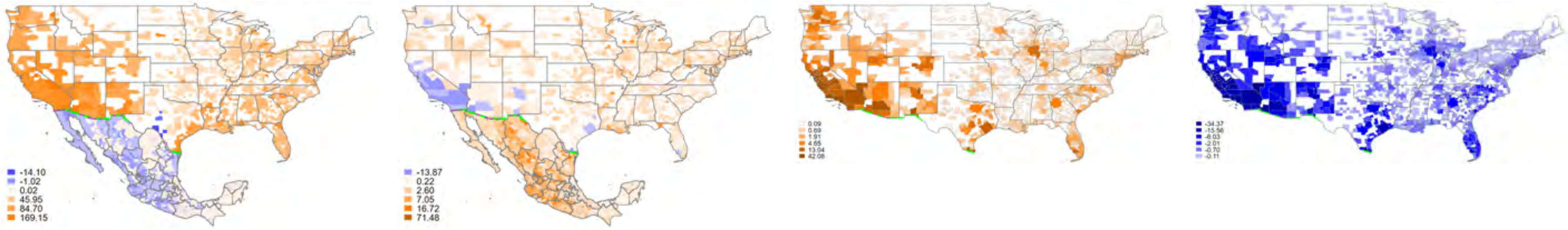
Notes: This figure shows the estimated diversion effect by year. Data: 2006–2014 *Matrícula* database. An observation is a Mexican (municipality)- U.S.(CBSA) pair, averaged across two consecutive years. The overlaid graph shows the share of the border covered by either a pedestrian or vehicular barrier.

Figure 7: Effect of the 2007–2010 border wall expansion

Panel (a): Population


(a) Mex. low-skill (b) Mex. high-skill (c) U.S. low-skill (d) U.S. high-skill

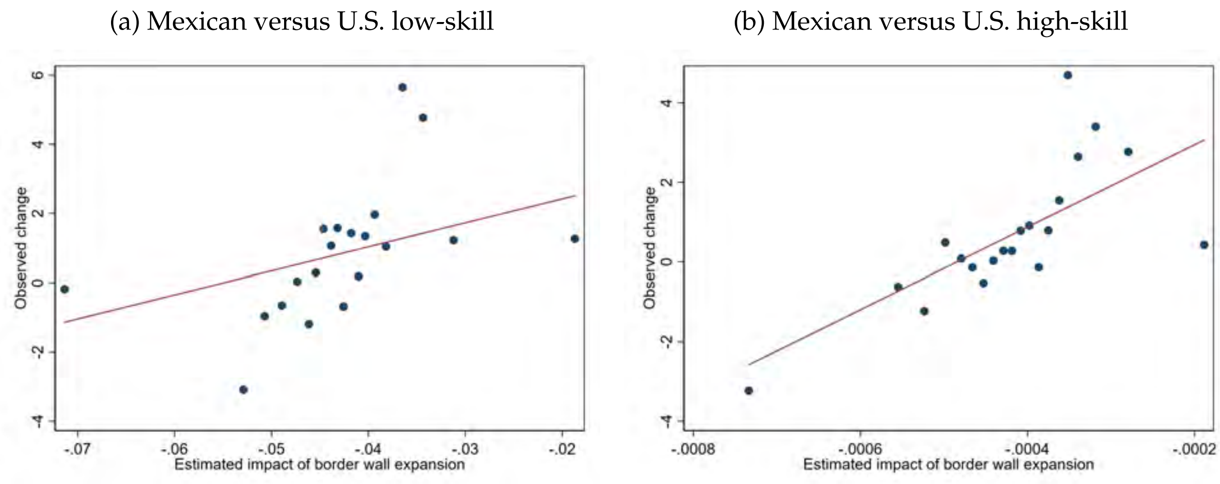
Panel (b): Income


(e) Mex. low-skill (f) Mex. high-skill (g) U.S. low-skill (h) U.S. high-skill

Notes: These figures show the effect of the 2007–2010 border wall expansion on the spatial distribution of population of each labor type (top panel) and the per capita annual income impact of each labor type (bottom panel). Income is measured in 2000 U.S.D.

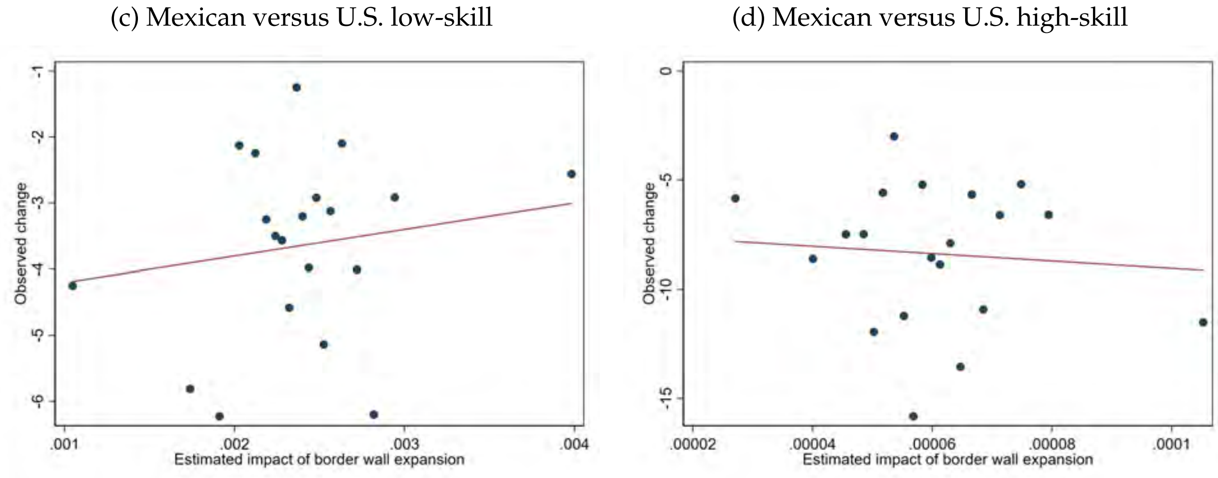
Figure 8: Model Fit: Estimated effect of the border wall expansion vs. actual changes

Panel (a): Relative population changes


(a) Mexican versus U.S. low-skill

(b) Mexican versus U.S. high-skill

Panel (b): Relative wage changes

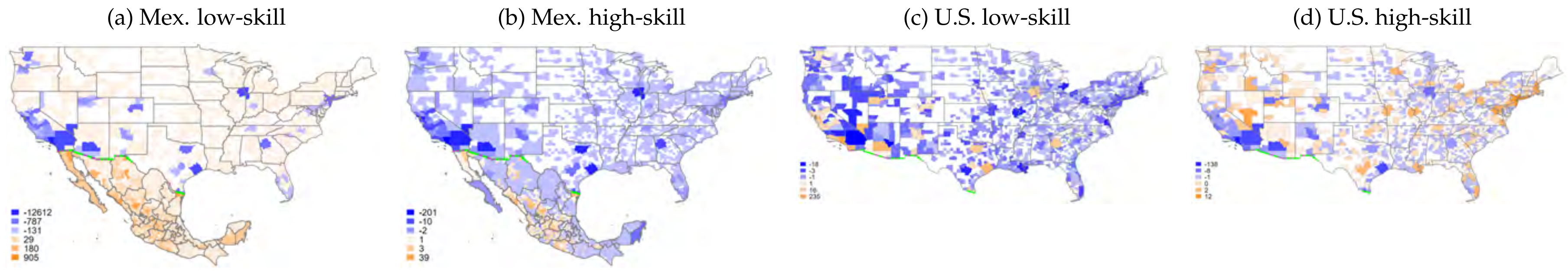

(c) Mexican versus U.S. low-skill

(d) Mexican versus U.S. high-skill

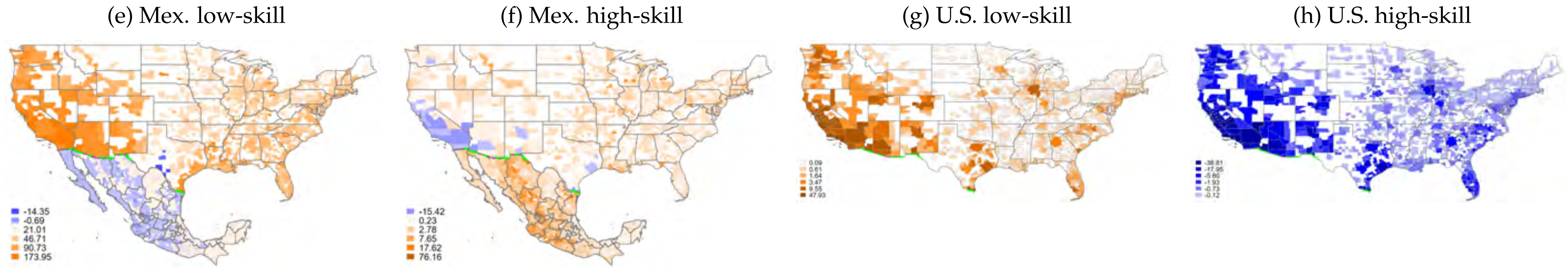
Notes: Each figure shows binned scatterplots comparing the estimated change from the border wall expansion (in log points) in either the relative Mexico to U.S. population (in panel (a)) or the relative Mexico to U.S. wages (in panel (b)) on the x-axis to the observed relative change before and after the wall expansion in the data on the y-axis. The sample includes all locations in the United States. Both estimated and observed changes have been residualized after including U.S. state fixed effects. See Appendix Table 13 for the corresponding regression results, as well as the corresponding changes for each nationality-skill group separately.

Figure 9: Effect of an "upgraded" border wall

Panel (a): Population


(a) Mex. low-skill (b) Mex. high-skill (c) U.S. low-skill (d) U.S. high-skill

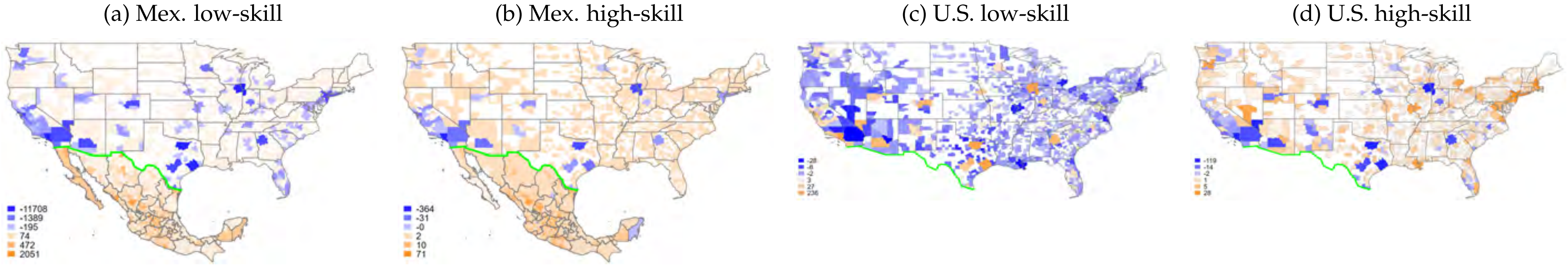
Panel (b): Income


(e) Mex. low-skill (f) Mex. high-skill (g) U.S. low-skill (h) U.S. high-skill

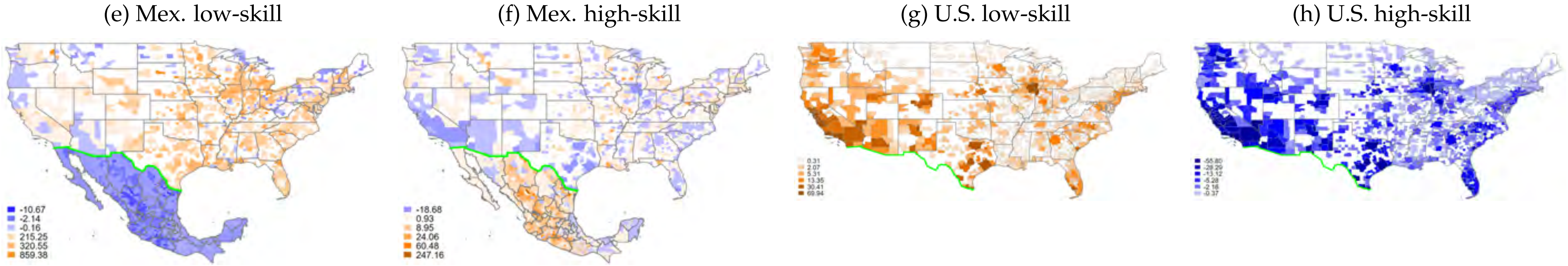
Notes: These figures show estimated effect of a counterfactual "upgraded" border wall expansion comprised entirely of pedestrian wall on the spatial distribution of population of each labor type (top panel) and the per capita annual income impact of each labor type (bottom panel) relative to the pre-period. Income is measured in 2000 U.S.D.

Figure 10: Effect of a complete border wall

Panel (a): Population


(a) Mex. low-skill
(b) Mex. high-skill
(c) U.S. low-skill
(d) U.S. high-skill

Panel (b): Income


(e) Mex. low-skill
(f) Mex. high-skill
(g) U.S. low-skill
(h) U.S. high-skill

Notes: These figures show estimated effect of a counterfactual pedestrian border wall spanning the entire U.S.-Mexico border on the spatial distribution of population of each labor type (top panel) and the per capita annual income impact of each labor type (bottom panel) relative to the pre-period. Income is measured in 2000 U.S.D.

Table 1: Predicting where the wall expansion occurs

	Any wall		Ped. wall		Ped. vs any	
	(1)	(2)	(3)	(4)	(5)	(6)
River	-0.833	-0.449	-0.294	0.011	0.622	0.927
	0.034***	0.078***	0.039***	0.062	0.044***	0.084***
Elevation	-0.228	-0.536	-0.291	-0.535	-0.149	0.033
	0.041***	0.063***	0.042***	0.068***	0.023***	0.239
Temperature	-0.053	-0.136	-0.038	-0.108	0.023	-0.031
	0.006***	0.010***	0.007***	0.010***	0.008***	0.028
Populated location		0.181		0.205		0.043
		0.037***		0.038***		0.024*
TX		-1.139		-1.154		-1.117
		0.120***		0.122***		0.266***
AZ		-0.169		-0.494		-0.781
		0.059***		0.095***		0.094***
NM		-0.592		-0.657		-1.132
		0.117***		0.118***		0.176***
Mean dep. var	0.365	0.365	0.262	0.365	0.674	0.674
N	781	781	889	889	285	285
r2	0.401	0.544	0.100	0.280	0.522	0.727

Notes: The table shows OLS regressions. Dependent variable is having either a pedestrian wall or any wall in 2010. An observation is one of the 889 (781) points along the border, out of a total of 1001, without a pedestrian (any) wall in 2006. Omitted border state is California. Robust standard errors in parentheses. Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Table 2: The detour effect: estimating the elasticity of route choice to route cost

	OLS			Poisson		
Dep var: Log share migrants	(1)	(2)	(3)	(4)	(5)	(6)
Panel (a): Log distance						
Log distance	-1.223	-1.482	-1.359	-2.868	-8.779	-8.790
	0.337***	0.165***	0.178***	0.139***	0.902***	0.867***
Has any barrier	-0.504	-0.237		-0.914	-0.062	
	0.149***	0.123*		0.045***	0.295	
Panel (b): Log cost-weighted distance						
Log cost-weighted distance	-1.272	-2.523	-2.307	-5.463	-13.019	-13.067
	0.208***	0.257***	0.290***	0.192***	0.943***	0.887***
Has any barrier	-0.510	-0.234		-1.194	-0.086	
	0.138***	0.125*		0.045***	0.309	
Obs	559	1281	1281	39049	95183	88579
2006 data	✓	✓	✓	✓	✓	✓
2010 data		✓	✓		✓	✓
Orig-Dest FE	✓	✓	✓	✓	✓	✓
CrossingPoint FE		✓	✓		✓	✓
Orig-Dest-Year FE		✓	✓		✓	✓
CrossingPoint-Year FE			✓			✓
Sample	share>0	share>0	share>0	Full	Full	Full

Notes: This table reports estimates the elasticity of route choice to route cost using the EMIF dataset. The dependent variable is the share of migrants from origin o going to destination d that cross the border through point b. Distance is the distance from o to d, going through b and cost-weighted distance is the same, but accounting for both natural (e.g. deserts and mountains) and man-made geographic features (such as roads). The sample includes data from 2006 (pre border wall expansion) and 2010 (post expansion), but for columns (1) and (4), which use only 2006 data. Standard errors (in parentheses) are clustered at the crossing point level. Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Table 3: The diversion effect: elasticity of destination choice to border wall exposure

	Distance		Cost-weighted distance		Exposure		Exposure by type		Migration costs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. var: *log*num matr	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Post × change log distance	-0.145	-0.690								
	0.065**	0.206***								
Post × change log cost-weighted distance			-0.141	-0.730						
			0.113	0.257***						
Post × exposure					-0.568	-0.614				
					0.125***	0.144***				
Post × exposure to vec. fence							0.495	-0.464		
							0.273*	0.315		
Post × exposure to ped. wall							-0.550	-0.595		
							0.125***	0.137***		
Post × migration costs									-4.878	-4.345
									0.734***	0.800***
N	154518	154518	154518	154518	154518	154518	154518	154518	154518	154518
First-stage F stat		185.25		316.88		20995.29		5076.75		48721.19
origYrFE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
destYrFE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
pairFE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Data: 2006/2007 (pre border wall expansion) and 2010/2011 (post expansion) Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. CBSA statistical area) - year pair, averaged over two consecutive years. Log change travel time is the log change in travel time for the least-cost path between the origin and destination pair, assuming border barriers cannot be crossed. Log change travel time (pred) is the change in travel time for the predicted wall expansion. Exposure is a measure of how much each pair was affected by the fence expansion that combines alternative routes to the same destination using the an elasticity of 13.4. Migration costs is an estimate of the cost of going from a given origin to a given destination that takes into account the cost of crossing a pedestrian wall or a vehicular fence as well as the substitutability between different routes. Standard errors are reported in parentheses. Spatial cluster is origin-cluster (1 degree x 1 degree) x destination cluster (1 degree x 1 degree). Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Table 4: The diversion effect: robustness

	Baseline	Time-varying costs		Buffer choice	Sample choice		Time-varying shocks	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var: log num matr		Border patrol	Homicides	4km buffer	Consul states	Drop outliers	Recession	Industry
Post × migration cost	-4.345	-4.270	-2.692		-4.585	-4.206	-4.496	-4.341
	0.800***	0.810***	1.454*		0.849***	0.819***	0.839***	0.800***
Post × change border patrol staff		0.000						
		0.000**						
Post × change homicide rate			-0.048					
			0.034					
Post × migration cost (4km buffer)				-3.402				
				0.627***				
Post × construction × housing shock							-0.113	
							0.462	
Post × orig ag × dest ag								0.852
								3.085
Post × orig services × dest services								-1.016
								1.576
N	154518	154518	154518	154518	125368	151436	139080	154518
First-stage F stat	48721.19	103638.79	5277.73	249376.94	42123.69	47459.12	45714.93	48700.10
origYrFE	✓	✓	✓	✓	✓	✓	✓	✓
destYrFE	✓	✓	✓	✓	✓	✓	✓	✓
pairFE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Data: 2006/2007 (pre border wall expansion) and 2010/2011 (post expansion) Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. CBSA statistical area) -year pair, averaged over two consecutive years. Migration cost is an estimate of the cost of going from a given origin to a given destination that takes into account the cost of crossing a pedestrian wall or a vehicular fence, as well as the substitutability between different routes. Border patrol is the size of the patrol staff and homicide is the homicide rate in the Mexican side of the border. Both these variables are at the border segment level. They are converted to the origin-destination pair level by taking a weighted average where the weights are the probability a migrant of this pair will cross at each of the border segments. Services, ag and const are, respectively, the share of migrants from a given origin or at a given destination that work in services, agriculture or construction, according to the Matrícula database. Housing shock measures how much each destination was affected by the 2008 housing crisis (as in Mian and Sufi (2014)). 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 5: The deterrent effect: elasticity of migration to value of migrating

	No controls		Distance trends		Sectoral trends		Push factors		All	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. var: Log change share US - log change share Mx.	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Change value U.S. - change value Mexico	0.181	0.412	0.181	0.351	0.181	0.427	0.180	0.415	0.181	0.368
	0.016***	0.169**	0.016***	0.143**	0.016***	0.177**	0.016***	0.175**	0.016***	0.163**
Log distance border			-0.064	-0.064					-0.069	-0.072
			0.018***	0.018***					0.017***	0.021***
Share in ag/mining					0.347	0.226			0.365	0.272
					0.304	0.344			0.303	0.324
Share in services					-0.367	-0.455			-0.381	-0.442
					0.351	0.389			0.349	0.229*
Change in drought							0.014	0.013	0.057	0.058
							0.056	0.061	0.053	0.068
Change in homicide rate							5.512	-0.937	2.177	-3.132
							10.853	10.877	9.730	8.773
N	1762	1762	1762	1762	1762	1762	1762	1762	1762	1762
First stage F stat		6.195		6.758		6.179		7.225		11.888
stateFE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Data source: 2015 and 2010 Mexican Census and 2006,2007,2010,2011 Matrícula database. Migration in the Mexican census is measured retrospectively. The dependent variable is the log change in share migrating to the U.S. minus the log change in share staying in Mexico, using a conversion rate between a Matrícula and a Census observation of 1. The value of being in the U.S. is the origin-year fixed effect from the Matrícula gravity equation. The value of being in Mexico is the origin-year fixed effect from the within-Mexico gravity equation. The instrument for the value of being in the U.S. is the share-weighted exposure to migration cost. Standard errors are clustered at origin-cluster (1 degree x 1 degree). Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Table 6: Aggregate impacts of a border wall

	Actual border wall expansion		Counterfactual border wall expansions	
	Direct Effect	Total Effect	Upgrade wall	Complete wall
Change in Migration (persons per year)				
Mexico to U.S.	-51073	-46459	-49899	-129438
	(20268)	(17089)	(20662)	(51775)
Change in Income (per year per person)				
Mexican low skill		$-17.33	$-18.65	$-48.49
		(6.41)	(7.78)	(19.58)
Mexican high skill		$-0.45	$-0.51	$-0.81
		(0.15)	(0.22)	(0.44)
U.S. low skill		$2.89	$3.11	$7.99
		(1.07)	(1.30)	(3.25)
U.S. high skill		$-3.63	$-3.91	$-10.03
		(1.34)	(1.63)	(4.07)

Notes: This table reports both the aggregate economic impact of the actual 2007-2010 border wall expansion (both the direct effect holding wages constant and the total effect allowing wages to endogenously adjust) and the impact of two counterfactual policies: (1) a counterfactual expansion identical in scope to the actual one but where all wall constructed was a pedestrian barrier; and (2) a pedestrian border wall across the entire border. The change in migration is how many fewer migrants per year from Mexico arrive in the U.S. The change in wages is the average change in annual wages (measured in 2000 USD) across all workers of a given type. Bootstrapped standard errors across 200 simulations drawing from the distribution of the estimated coefficients of the migration elasticities to route choice, destination choice within country, and choice of country, as well as the estimated costs of the border wall; see text for details. The calibrated parameters are the migration elasticity of 1.5 for non Mexican-low skill worker types for both within-country and across-country, an elasticity of substitution across low skilled workers of different nationalities (ρ_l) of 18, an elasticity of substitution across high skilled workers of different nationalities (ρ_h) of 7 and an elasticity of substitution across high and low skill workers (ρ) of 2.

Table 7: Aggregate impacts of a border wall: Alternative parameter constellations

	Actual border wall expansion		Counterfactual border wall expansions	
	Direct Effect	Total Effect	Upgrade wall	Complete wall
Baseline estimates				
Change in Migration (persons per year)				
Mexico to U.S.	-51073	-46459	-49899	-129438
Change in Income (per year per person)				
Mexican low skill		\$-17.33	\$-18.65	\$-48.49
Mexican high skill		\$-0.45	\$-0.51	\$-0.81
U.S. low skill		\$2.89	\$3.11	\$7.99
U.S. high skill		\$-3.63	\$-3.91	\$-10.03
No detour effect: Route probabilities unchanged				
Change in Migration (persons per year)				
Mexico to U.S.	-60716	-55347	-60958	-112679
Change in Income (per year per person)				
Mexican low skill		\$-20.55	\$-22.71	\$-42.08
Mexican high skill		\$-0.39	\$-0.49	\$-0.57
U.S. low skill		\$3.38	\$3.75	\$6.90
U.S. high skill		\$-4.25	\$-4.71	\$-8.66
Equal deterrent and diversion effect (IIA: $\theta_s^{M,l} = \theta_d^{M,l}$)				
Change in Migration (persons per year)				
Mexico to U.S.	-118488	-95147	-101929	-250705
Change in Income (per year per person)				
Mexican low skill		\$-35.60	\$-38.19	\$-94.71
Mexican high skill		\$-0.80	\$-0.89	\$-1.84
U.S. low skill		\$5.92	\$6.36	\$15.68
U.S. high skill		\$-7.43	\$-7.98	\$-19.62
High elasticity of substitution between workers of different nativities ($\rho_l = \rho_h = 30$)				
Change in Migration (persons per year)				
Mexico to U.S.	-51073	-48056	-51605	-133694
Change in Income (per year per person)				
Mexican low skill		\$-18.34	\$-19.73	\$-51.18
Mexican high skill		\$-0.77	\$-0.86	\$-1.60
U.S. low skill		\$3.21	\$3.46	\$8.88
U.S. high skill		\$-3.71	\$-4.00	\$-10.25
Low elasticity of substitution between workers of different nativities ($\rho_l = \rho_h = 5$)				
Change in Migration (persons per year)				
Mexico to U.S.	-51073	-38462	-41346	-107942
Change in Income (per year per person)				
Mexican low skill		\$-12.04	\$-12.97	\$-34.16
Mexican high skill		\$-0.26	\$-0.30	\$-0.47
U.S. low skill		\$1.17	\$1.26	\$3.24
U.S. high skill		\$-3.03	\$-3.27	\$-8.51

Notes: This table reports the aggregate economic impacts of (1) the actual 2007-2010 border wall expansion; (2) a counterfactual "upgrade" expansion identical in scope to the actual one but where all wall constructed was a pedestrian barrier; and (3) a pedestrian border wall across the entire border under a variety of different parameter constellations. See notes on Table 6 for details.

Online Appendix (not for publication)

A The debate surrounding the Secure Fence Act of 2006

Since the passage of the Immigration Reform and Control Act in 1986, the United States has followed a policy of increased border enforcement on the U.S.-Mexico border. While prior to the adoption of the Secure Fence Act in 2006, only 110 of the 1954-mile U.S.-Mexico border had any sort of physical barrier, between 2000 and 2005 the Border Patrol employed 10,000 agents on the southern border and apprehended an average 1.1 million people each year. Sociologists and historians argue that rather than reducing unauthorized migration, the increased focus on enforcement since 1986 changed migration patterns from being circular and short-term in nature (primarily following the agricultural season) to being permanent, as a result increasing the number of unauthorized migrants in the U.S (Massey, Durand, and Malone (2003); Minian (2018)). Indeed, the Pew Reseach Center estimated that 11.1 million unauthorized migrants were living in the United States in 2005 (of which, 6.3 million were born in Mexico), up from 3.5 million in 1990. Data from the Mexican Migration Project between 2000 and 2005 shows that 95% of migrants hired a *coyote* to help them cross the border (at an average cost of $2000 in 2013 dollars). Using retrospective migration data, Massey, Durand, and Pren (2016) estimate that the apprehension probability during this period for a single attempt was 35%, but as migrants made multiple attempts to enter the United States, over 95% who attempted to enter the United States did so eventually.

In response to the growing consensus that something needed to be done about the growth in unauthorized migration, in 2006 the U.S. Senate passed a comprehensive immigration reform bill, which included the creation of a guest worker program, a path toward citizenship, and additional fencing along the U.S.-Mexico border. The U.S. House objected to all components of the bill that could be interpreted as offering amnesty, and the resulting compromise was the Secure Fence Act (SFA) – which provided only for the construction of 700 miles of additional fencing along the U.S.-Mexico border – was signed into law on October 26, 2006 by President George W. Bush.[35] Proponents of the SFA contended that the barriers were a proven deterrent and the border wall expansion was necessary to reduce unauthorized immigration; as Alabama Senator Jeff Sessions argued, "We know that fencing works. It's time to make it a reality."[36] Opponents contended that the proposed expansion would simply cause individuals to substitute toward migrating elsewhere; as Illinois Senator Richard Durbin argued, "You don't have to be a law enforcement or engineering expert to know that a 700-mile fence on a 2,000-mile border makes no sense."[37]

The extent to which the SFA succeeded in reducing unauthorized immigration remains highly contested. Proponents of the border wall pointing to declines in apprehension rates in areas with border walls, whereas opponents note that the border wall itself

---

[35] "Bush Signs Bill Ordering Fence on Mexican Border." *New York Times*. October 26, 2006.

[36] "Senate Moves Toward Action on Border Fence." *New York Times*. September 26, 2006.

[37] "Senate Passes Bill on Building Border Fence." *New York Times.* September 30, 2006.

was surmountable (there have been 9,200 documented breaches between 2010 and 2015) and that the fencing has shifted migrants to alternative routes where no wall exists.[38] A 2017 report by the U.S. Government Accountability Office ultimately concluded the impact of border walls on "border security operations have not been assessed." (United States Government Accountability Office, 2017b)

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)

---

[38] See, e.g., Congressional Research Service (2009) and "Border Wall Breached 9,000 times. Does it even work?" CNN. February 16, 2017.

- 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 CBSA.

B.4 Survey of Migration at Mexico's Northern Border (EMIF) data

The Survey of Migration at Mexico's Northern Border (EMIF) is a survey conducted in locations along the U.S.-Mexico border traditionally used as crossing points both by authorized and unauthorized migrants. The study is run by the Mexican government, in partnership with a local university (El Colegio de la Frontera Norte), and its target population is adult Mexican residents who do not live in the city where the interview takes place who are planning to migrate to the United States. The survey is designed to capture both the volume and characteristics of migration flows. We observe the place of birth, planned crossing point, and planned destination in the United States.

Appendix Table 1 presents descriptive statistics of the EMIF dataset. We see that the survey is geographically comprehensive: respondents come from 1406 different municipalities distributed accross all Mexican states; their planned destinations span 171 CBSAs in 40 American states; and, as we see in Appendix Figure 1, the 17 survey locations are spread across all the U.S.-Mexico border. Moreover, only 11% of the respondents hold a high-school diploma, fewer than 1% are college educated, and 87% are migrating to the United States for work-related reasons. This indicates that a large share of them are undocumented migrants, which are the focus of our study.

B.5 *Matrícula* Database

One of the datasets 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 did provide the names of these locations. In this appendix we describe how we constructed our dataset from this records. We will do so in two parts: first merging places of residency to CBSAs in the United States and then merging place of birth to GEOLEV2 locations in Mexico[39]

---

[39] CBSAs 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/

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 CBSAs, we made use of a crosswalk provided by the Missouri Census Data Center.[40] It contains the names of all counties, minor civil divisions, cities, villages, towns, etc. in the United States We matched these with the *Matrícula* dataset using the Stata function *reclink*. After this, we hand-coded the unmatched localities with the highest numbers of matrícula 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 CBSA, 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 the municipality codes, we used a list of all geographical divisions of Mexico provided by the *Instituto Nacional de Estadistica y Geografia*[41] and the Stata function *reclink*. As above, we hand-coded the unmatched localities with the highest numbers of matrícula cards. Finally we used the dictionaries provided by IPUMS to aggregate municipalities to GEOLEV2 areas. This procedure yields the following results: 86% of the *Matrículas Consulares* were matched to a GEOLEV2, 7% did not have place of birth in the data and 7% were not matched.

B.6 Verification of Matrícula database

This section undertakes several exercises to show that matrícula cards correlate with measures of migration from both U.S. and Mexican datasets.

Appendix Table 2 summarizes the sample size of the variables. On average, 810,732 matrícula cards are issued each year. We identify a first-time card as the first time we see a card issued to an individual. Once issued, a card is valid for five years. Appendix Figure 2 plots the hazard rate of renewal. As expected, we see a spike immediately when the card expires, and people continue renewing cards in the following years. For the cohort of individuals who were issued a card in 2006, 67% have renewed the card in 2015, nine years later. Column (4) gives the counts of migrants in the United States. Over the period 2006 through 2015, we see an average of 5.7 million Mexican-born adults in the United States. Of these, approximately 10% (686,000) have been in the country for less than five years.

---

[40] `http://matrículacardddc.missouri.edu/websas/geocorr2k.html`

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

Our first exercise correlates the number of matrículas with the number of migrants. Column (1) of Panel (a) of Appendix Table 3 shows that, within CBSA, a 10% increase in the number of matrícula cards is associated with a 0.6% increase in the number of Mexican migrants in a CBSA. Panel (b) shows that each matrícula card is correlated with an increase of 1.3 migrants on average. These results exploit only variation within CBSA. Column (2) shows that, on average, an additional matrícula card is associated with an extra 1.2 low-educated migrants in the CBSA. The population-pass through for each matrícula card for recently-arrived migrants (Columns (3) and (4)) are 0.51 (all recently arrived migrants) and 0.47 (low-skill recently arrived migrants). Columns (5) through (8) repeat the exercise, dropping renewed cards. We find very strong correlations and population pass-throughs close to 1 for all migrants and for recently arrived migrants.[42]

Appendix Table 4 repeat the same exercise for the Mexican population census. The Mexican population census is conducted every five years, so we create comparable measures of flows between the population counts and the *Matrícula* database by constructing the change in the Mexican population between each census and then summing all matrículas issued for the five years between censuses. We expect to see a negative coefficient if a matrícula card is associated with a migrant leaving the municipality. Columns (1) and (2) show the population pass-through per matrícula for all Mexican adults. We find a small negative, but insignificant, pass-through for the whole population and a positive but insignificant pass-through for low-skill adults. We then do the same exercise considering a fixed cohort of individuals, born between 1940 and 1987, to adjust for the fact that population growth in Mexico will change both the number of adults as well as the number of matrículas. Columns (3) finds that each additional matrícula card issued is associated with a reduction of 0.24 adults in an origin municipality, and Column (4) finds a matrícula card is associated with a reduction of 0.6 low-skill adults. Columns (5)-(8) repeat the exercise using first-time matrícula cards only. We estimate a pass-through of between 0.11 and 0.19 per matrícula card.

The next exercise is to estimate the takeup of matrícula cards separately by recent and established migrants. Here, we separate explicitly between first-time cards and renewed cards. Appendix Table 5 estimates that the take-up rate of the matrícula card for recently arrived migrants was 26% in the pre-wall period and 56% in the post-wall period.[43]

We also verify that the geographical patterns in the matrícula database mirror those of migrants in the ACS as well as data from the Mexican demographic survey (ENADID)[44] Appendix Table 6 shows that all three datasets agree with the broad shift away from California and Arizona and into Texas over the study period.

Finally, a drawback of the *Matrícula* dataset is the absence of certain covariates, such

---

[42] Demographers estimate that the ACS and the Census under-count unauthorized migration by 8–13% Passel and Cohn (2016), and so a number less than one may represent some undercounting in the ACS.

[43] We estimate that the annual takeup rate of matrícula cards for established migrants was 12.5% in the pre-period. In the post-period, we estimate that 4% of established migrants take up a matrícula card for the first time, and 11.6% of established migrants renew their card.

[44] The ENADID surveys households in Mexico and asks about household members who have left the household within the last five years. We use the surveys collected in 2009 and 2014. The ENADID is designed to be nationally representative of households within Mexico but by design will not include migrants who live in a household where the entire household has moved to the United States.

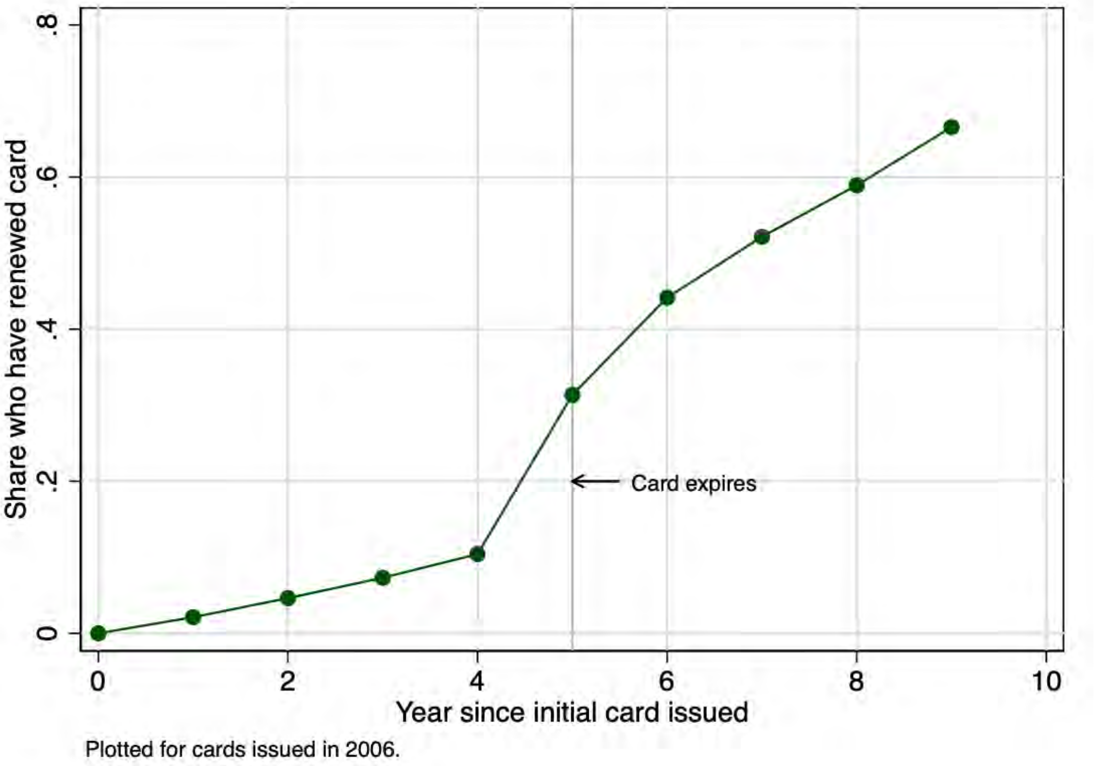
as income and time in the United States. The Pew Reseach Center surveyed a sample of individuals applying for a matrícula card in six different states and we compare this database to the sample of Mexican-born individuals in the 2005 ACS. Appendix Table 7 shows that the matrícula applicants are on average 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.

C Additional Tables and Figures

Appendix Figure 1: EMIF Survey Locations

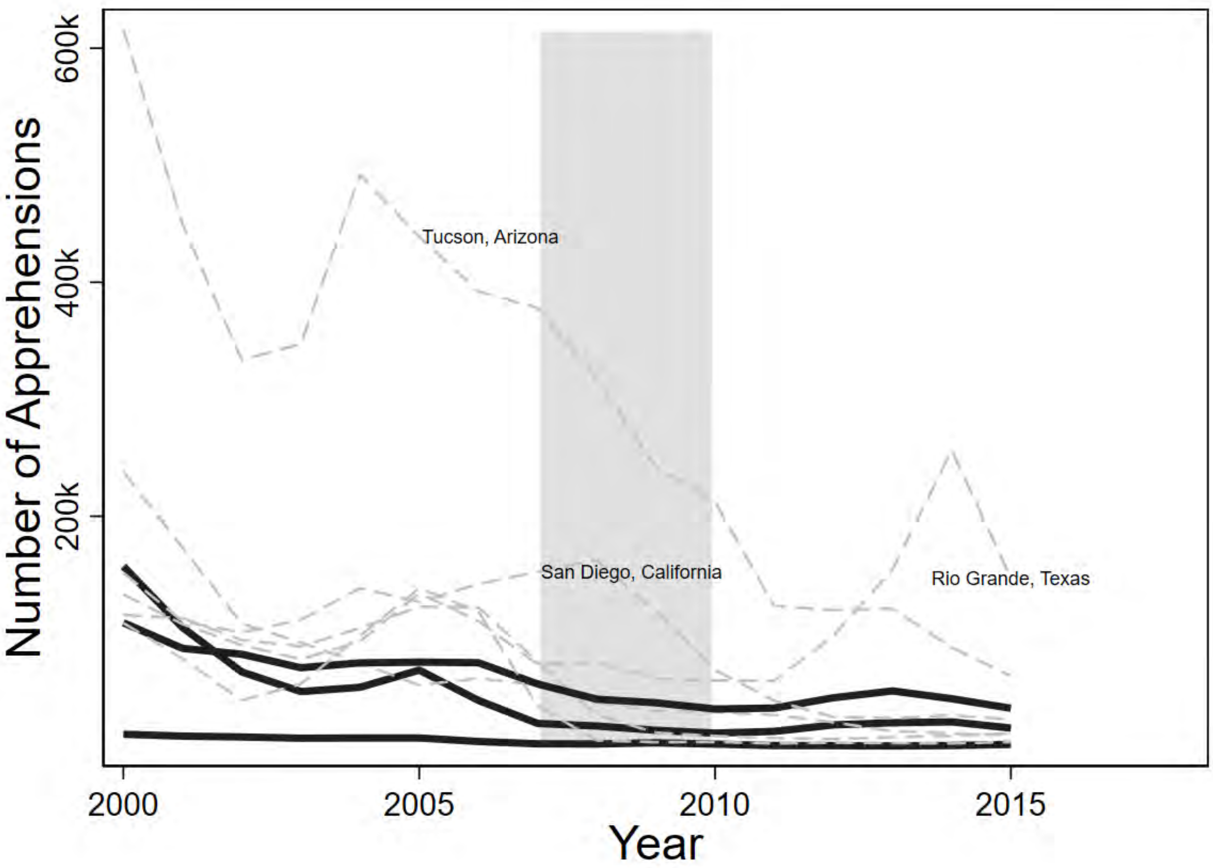
Notes: This figure shows the locations where the EMIF surveys were conducted in 2006 and in 2010.

Appendix Figure 2: Renewal probability of matrícula cards



Notes: Data source: 2006–2015 *Matrícula* database.

Appendix Figure 3: Apprehensions by border sector



Notes: This figure shows the number of unauthorized migrants apprehended in the Mexican-U.S. border per year in each of the border sectors. The bold lines are sectors that were unaffected by the wall expansion (all in Texas). The shaded area shows the period when the fence expansion occurred. The data is from the United States Border Patrol official reports.

Appendix Table 1: EMIF Dataset - Descriptive Statistics

Migrants	13262
Origin States	32
Origin Municipalities	1406
Destination States	40
Destination CBSAs	171
Crossing Points	17
Crossing Points w/ Barrier (pre-SFA)	11
Crossing Points w/ Barrier (post-SFA)	16
Share of High-School Diploma or Higher (%)	11
Share of College Diploma or Higher (%)	.3
Share Migranting for Work-Related Reasons (%)	87
Share Using Coyote/Guide (%)	35

Notes: This table containts a few descriptive statistics of the EMIF dataset. Our sample includes surveys from 2006 (pre-SFA) and 2010 (post-SFA).

Appendix Table 2: Counts: Matrícula and ACS

	Matricula			Migrants in ACS		
	(1)	(2)	(3)	(4)	(5)	(6)
	All cards	First-time	Renewed cards	All	Recent In US less than 5 years	Established In US more than 5 years
2006	799,260	790,556	8,704	6,042,228	1,180,518	4,861,710
2008	801,248	754,397	46,850	5,765,247	896,718	4,868,529
2010	724,100	561,062	163,038	5,716,321	656,509	5,059,812
2012	822,401	398,110	424,292	5,464,329	383,014	5,081,315
2014	907,668	326,332	581,336	5,407,318	311,890	5,095,428
Average	810,936	566,091	244,844	5,679,089	685,730	4,993,359
Share low-skill	0.96	0.96	0.96	1.00	1.00	1.00
Share women	0.42	0.41	0.45	0.35	0.28	0.36

Notes: Data source: 2006-2015 Matrícula database and 2005-2015 ACS. ACS is restricted to low-skill migrants only. Data is averaged across two years. An observation is a cbsa/two-year pair. A new card is defined as the first time an individual is in the database. A renewed card is a subsequent card issued to the same individual.

Appendix Table 3: Comparing Matrículas and ACS Mexican-born

	All cards				First-time cards			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep var: (log) Mx. pop	All	Low-ed	All Arrived < 5 years	Low-ed Arrived < 5 years	All	Low-ed	All Arrived < 5 years	Low-ed Arrived < 5 years
Panel (a): Log-Log								
Log matrícula	0.107	0.098	0.085	0.118	0.104	0.109	0.119	0.159
	0.027***	0.029***	0.053	0.057*	0.023***	0.025***	0.046**	0.050**
N	4452	4375	3402	3224	4434	4358	3397	3223
N region	977	977	977	977	977	977	977	977
Panel (a): Level-Level								
Matrícula	1.131	1.249	0.506	0.466	1.308	1.530	0.994	0.925
	0.049***	0.053***	0.036***	0.033***	0.015***	0.013***	0.009***	0.008***
N	4885	4885	4885	4885	4885	4885	4885	4885
N region	977	977	977	977	977	977	977	977
cbsaFE	✓	✓	✓	✓	✓	✓	✓	✓
yearFE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Data source: 2006-2015 ACS; 2006-2015 Matrícula database. Data is averaged across two years. An observation is a cbsa/two-year pair. A new card is defined as the first time an individual is in the database.

Appendix Table 4: Comparing Matrículas and Mexican census

	All cards				First-time cards			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep var: ΔMx. pop	All	Low-ed	All Born 1940-1987	Low-ed Born 1940-1987	All	Low-ed	All Born 1940-1987	Low-ed Born 1940-1987
Five-year sum of matriculas	-0.053	0.173	-0.238	-0.601	-0.146	-0.155	-0.106	-0.189
	0.133	0.138	0.043***	0.040***	0.040***	0.042***	0.009***	0.008***
N	4662	4644	4636	4614	4662	4644	4636	4614
No. municipalities	2331	2331	2331	2331	2331	2331	2331	2331
Municipality FE	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Data source: 2005, 2010, 2015 Mexican Census. 2006-2015 Matrícula database. In order to match the 2005 census to the Matrícula database we duplicate the observations for 2006 and merge to 2005. The Mexican census is only collected every five years. We therefore look at the change in population in a five year period in Mexico and compare to the sum of matrícula cards issued in the U.S. over the same five year period. An observation is an municipality/year. A new card is defined as the first time an individual is in the database.

Appendix Table 5: Estimating takeup rate of Matrícula

	Recent = 1 yr in US		Recent = 2 years in US		Recent = 5 years in US	
	(1) 2006-2011	(2) 2012-2015	(3) 2006-2011	(4) 2012-2015	(5) 2006-2011	(6) 2012-2015
All cards						
Recent migrants	0.509		0.509		0.257	
	0.031***		0.031***		0.008***	
Established migrants	0.133		0.133		0.125	
	0.001***		0.001***		0.001***	
Renewed cards only						
Established migrants		0.112		0.112		0.116
		0.001***		0.001***		0.001***
New cards only						
Recent migrants		1.702		1.702		0.561
		0.061***		0.061***		0.013***
Established migrants		0.046		0.046		0.038
		0.001***		0.001***		0.001***
Implied recent migrant share	0.090	0.259	0.090	0.259	0.252	0.529

Notes: Data source: 2006-2015 Matrícula database and 2005-2015 ACS. Data is averaged across two years. An observation is a cbsa/two-year pair. A new card is defined as the first time an individual is in the database. A renewed card is a subsequent card issued to the same individual. Matrícula cards are valid for five years so the earliest we can reliably identify renewals is five years after 2006 (i.e., 2011).

Appendix Table 6: Spatial distribution of Mexican migrants: ACS, Matrícula and ENADID

	Stocks		Flows			
	(1) Matrícula All active cards	(2) ACS All Mexican-born	(3) Matrícula Annual (all)	(4) Matrícula Annual (first-time)	(5) ACS Arrived U.S. last two years	(6) ENADID Left Mexico last five years
Pre-wall (2006-2007)						
Arizona		0.051	0.041		0.072	0.068
Texas		0.185	0.164		0.165	0.170
California		0.373	0.406		0.243	0.298
Illinois		0.068	0.082		0.044	0.036
Post-wall (2010-2012)						
Arizona	0.039	0.039	0.018	0.020	0.031	0.039
Texas	0.175	0.194	0.216	0.229	0.251	0.228
California	0.356	0.358	0.339	0.308	0.200	0.250
Illinois	0.081	0.068	0.072	0.060	0.042	0.040
Post-wall (2013-2015)						
Arizona	0.012	0.039	0.011	0.012	0.052	
Texas	0.241	0.196	0.214	0.249	0.270	
California	0.290	0.356	0.326	0.273	0.195	
Illinois	0.051	0.066	0.081	0.049	0.051	

Notes: Table shows share of migrants in each state. Data source: Matrícula Consular database and ACS. Only migrants with high-school education or lower included from ACS. A first-time matrícula card is a card issued to an individual that has not appeared in the database since 2006. Data for pre-wall (2006-2007) comes from the 2006 and 2007 ACS, 2006 and 2007 Matrícula database, and 2009 ENADID. Data for post-wall (2010-2012) comes from 2010-2012 ACS and Matrícula, and 2014 ENADID. Data from post-wall (2013-2015) comes from the 2012-2015 ACS and Matrícula.

Appendix Table 7: Comparison: Pew Matrícula applicants vs ACS Mexican-born

	(1) 2006 Matr. (all)	(2) 2006 Matr. (6 states)	(3) Pew	(4) 2005 ACS (all)	(5) 2005 ACS (6 states)
Share male	0.60	0.59	0.59	0.54	0.53
Age	31.68	32.36	31.29	36.18	36.93
High school educ or less	0.97	0.97	0.94	0.88	0.87
Married			0.46		
Avg weekly earnings			334.51	427.80	440.43
In U.S. for less than 5 years			0.39	0.21	0.17
In U.S. for less than 2 years			0.12	0.09	0.07
In U.S. for less than 1 years			0.12	0.05	0.04
No. obs (unweighted)	821241	577472	4836	79216	53567

Notes: Data source: Pew Matrícula survey. Pew survey conducted in CA, NY, IL, GA, TX, NC, between July 2004-Jan 2005 and 2006 Matrícula database.

Appendix Table 8: The detour effect: estimating the elasticity of route choice to route cost – Poisson versus OLS

	OLS			Poisson		
Dep var: Share migrants	(1)	(2)	(3)	(4)	(5)	(6)
Panel (a): Log distance						
Log distance	-1.223	-1.482	-1.359	-0.952	-1.158	-1.089
	0.337***	0.165***	0.178***	0.254***	0.115***	0.097***
Has any barrier	-0.504	-0.237		-0.449	-0.230	
	0.149***	0.123*		0.067***	0.094**	
Panel (b): Log cost-weighted distance						
Log cost-weighted distance	-1.272	-2.523	-2.307	-1.078	-1.888	-1.775
	0.208***	0.257***	0.290***	0.195***	0.189***	0.158***
Has any barrier	-0.510	-0.234		-0.446	-0.229	
	0.138***	0.125*		0.065***	0.095**	
N	559	1281	1281	559	1281	1281
2006 data	✓	✓	✓	✓	✓	✓
2010 data		✓	✓		✓	✓
Orig-Dest FE	✓	✓	✓	✓	✓	✓
CrossingPoint FE		✓	✓		✓	✓
Orig-Dest-Year FE		✓	✓		✓	✓
CrossingPoint-Year FE			✓			✓
Sample	share>0	share>0	share>0	share>0	share>0	share>0

Notes: This table reports estimates the elasticity of route choice to route cost using the EMIF dataset. The dependent variable is the share of migrants from origin o going to destination d that cross the border through point b. Distance is the distance from o to d, going through b and cost-weighted distance is the same, but accounting for both natural (e.g. deserts and mountains) and man-made geographic features (such as roads). The sample includes data from 2006 (pre border wall expansion) and 2010 (post expansion), except for columns (1) and (4), which use only 2006 data. Standard errors (in parentheses) are clustered at the crossing point level. Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Appendix Table 9: Correlates of change in travel time (pair level)

Dep. var: Change in log travel time	(1) Actual change	(2) Predicted change
Origin: log distance to border	-0.008	-0.001
	0.000***	0.000***
Origin: share ag	-0.002	0.001
	0.001**	0.000***
Origin: share services	0.000	0.000
	0.001	0.000***
Dest: log distance to border	-0.004	-0.000
	0.000***	0.000***
Dest: share ag	0.088	0.003
	0.003***	0.000***
Dest: share services	0.036	0.002
	0.001***	0.000***
Dest: housing shock	-0.065	-0.004
	0.001***	0.000***
Pair: baseline migration	0.000	0.000
	0.000***	0.000***
N	1260530	1260530
r2	0.206	0.029
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 10: Gravity equation: First Stage

	(1) Exposure	(2) Distance	(3) Cost-weighted distance	(4) Migration costs	(5) Exposure to vec.	(6) Exposure to ped.
Post x pred. exposure	0.737					
	0.005***					
Post X pred. change log distance		0.656				
		0.048***				
Post X pred. change log cost-weighted distance			1.470			
			0.083***			
Post x pred. migration costs				0.898		
				0.004***		
Post x pred. exposure to vec. fence					0.637	0.464
					0.009***	0.006***
Post x pred. exposure to ped. wall					0.830	-0.070
					0.006***	0.002***
N	154518	154518	154518	154518	154518	154518
First-stage F stat	20995.29	185.25	316.88	48721.19	13060.88	5448.60
origYrFE	✓	✓	✓	✓	✓	✓
destYrFE	✓	✓	✓	✓	✓	✓
pairFE	✓	✓	✓	✓	✓	✓

Notes: Data: 2006 and 2010 Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. cbsa10) 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 11: The diversion effect: elasticity of destination choice to border wall exposure (Poisson)

	Distance		Cost-weighted distance		Exposure		Exposure by type		Migration costs	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Dep. var: *log*num matr	OLS	RF	OLS	RF	OLS	RF	OLS	RF	OLS	RF
Post × change log distance	-0.047									
	0.042									
Post × pred. change log distance		-0.076								
		0.088								
Post × change log cost-weighted distance			-0.035							
			0.086							
Post × pred. change log cost-weighted distance				-0.368						
				0.267						
Post × exposure					-0.301					
					0.122**					
Post × pred. exposure						-0.359				
						0.101***				
Post × exposure to vec. fence							-0.291			
							0.224			
Post × exposure to ped. wall							-0.302			
							0.122**			
Post × pred. exposure to vec. fence								-0.412		
								0.174**		
Post × pred. exposure to ped. wall								-0.359		
								0.101***		
Post × migration costs									-0.988	
									0.679	
Post × pred. migration costs										-1.492
										0.691**
N	362386	362386	362386	362386	362386	362386	362386	362386	362386	362386
First-stage F stat										
origYrFE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
destYrFE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
pairFE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes: Data: 2006/2007 (pre border wall expansion) and 2010/2011 (post expansion) Matrícula database. Each observation is an origin (Mexican municipality) - destination (U.S. CBSA statistical area) - year pair, averaged over two consecutive years. Log change travel time is the log change in travel time for the least-cost path between the origin and destination pair, assuming border barriers cannot be crossed. Log change travel time (pred) is the change in travel time for the predicted wall expansion. Exposure is a measure of how much each pair was affected by the fence expansion that combines alternative routes to the same destination using the an elasticity of 13.4. Migration costs is an estimate of the cost of going from a given origin to a given destination that takes into account the cost of crossing a pedestrian wall or a vehicular fence as well as the substitutability between different routes. Standard errors are reported in parentheses. Spatial cluster is origin-cluster (1 degree x 1 degree) x destination cluster (1 degree x 1 degree). Stars indicate statistical significance: *p<0.10 **p<0.05 ***p<0.01.

Appendix Table 12: 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 migration costs	-4.345	-4.345	-4.345	-4.345	-4.345	-4.345
	0.800***	0.779***	0.863***	1.423***	0.775***	1.097***
N	154518	154518	154518	154518	154518	154518
First-stage F stat	48721.19	77720.45	18709.35	2449.03	84746.67	1240.08
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
SE clustered at:	spatial pair (1x1)	spatial pair (0.5x0.5)	spatial pair (2x2)	two-way spatial (1x1)	pair	state-pair-yr

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.

Appendix Table 13: Model Fit: Estimated effect of the border wall expansion vs. actual changes

	Mex. low skill	Mex. high skill	U.S. low skill	U.S. high skill	Mex. vs U.S. low skill	Mex. vs U.S. high skill
	(1)	(2)	(3)	(4)	(5)	(6)
Dep var: Log observed change						
Panel (a): Changes in population						
Log estimated change	66.196***	116.666	246.605	-281.244	69.168***	10354.868***
	(18.427)	(116.105)	(184.681)	(236.642)	(20.072)	(2643.716)
N	3308	3308	977	977	977	977
F-statistic	12.90	1.01	1.78	1.41	11.87	15.34
Panel (b): Changes in wages						
Log estimated change	295.527	667.274	-76.496***	111.278***	400.526	-16872.130
	(366.687)	(432.115)	(26.360)	(33.692)	(491.589)	(40543.015)
N	3308	3308	977	977	977	977
F-statistic	0.65	2.38	8.42	10.91	0.66	0.17
Country FE	✓	✓	✓	✓	✓	✓
State FE	✓	✓	✓	✓	✓	✓
Sample	All locations	All locations	U.S. only	U.S. only	U.S. only	U.S. only

Notes: Each observation is the log difference between the pre- and post- periods in a given location. Each regression compares the estimated change (in log points) in either population (in panel (a)) or wages (in panel (b)) from the border wall expansion to the observed change in the data before and after the wall expansion. The sample for Mexican workers include all locations in both the U.S. and Mexico, whereas the sample for U.S. workers (or the relative change in Mexican and U.S. workers) only include U.S. locations. Robust standard errors reported in parentheses; stars indicate statistical signifiance: * p<0.1, ** p<0.05, *** p<0.01.

D Theoretical Framework

In this appendix, we describe in more detail the general equilibrium framework presented in section 5. The framework embeds the labor market structure featuring imperfectly substitutable labor types differing in skill and nativity developed in the immigration literature[45] into a general equilibrium "quantitative" spatial framework[46] where outcomes are intertwined across labor markets through the costly movement of 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.

D.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 homogeneous good using a nested constant elasticity of substitution (CES) production function:

$$Q_i = \left(\sum_{s \in \{h,l\}} \left(\left(\sum_{n \in \{M,U\}} A_i^{n,s} \left(L_i^{n,s} \right)^{\frac{\rho_s - 1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s - 1}} \right)^{\frac{\rho - 1}{\rho}} \right)^{\frac{\rho}{\rho - 1}}, \tag{15}$$

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.[47]

Production occurs under perfect competition and a worker in location i of nationality

---

[45] 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).

[46] See, for example, the works of Allen and Arkolakis (2014); Tombe and Zhu (2019); Burstein, Hanson, Tian, and Vogel (2019); Monte, Redding, and Rossi-Hansberg (2019); Redding (2016) and the excellent review article of Redding and Rossi-Hansberg (2017).

[47] 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)).

n and skill s is paid a wage $w_i^{n,s}$ equal to her marginal product:

$$w_i^{n,s} = Q_i^{\frac{1}{\rho}} \times \left(\left(\sum_{n \in \{M,U\}} A_i^{n,s} \left(L_i^{n,s} \right)^{\frac{\rho_S - 1}{\rho_S}} \right)^{\frac{\rho_S}{\rho_S - 1}} \right)^{\left(\frac{1}{\rho_S} - \frac{1}{\rho} \right)} \times A_i^{n,s} \times \left(L_i^{n,s} \right)^{-\frac{1}{\rho_S}}. \tag{16}$$

The movement of people across locations is 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:

$$U_i^{n,s}(\nu) = \max_{j \in \mathcal{N}} \frac{w_j^{n,s}}{\mu_{ij}^{n,s}} \varepsilon_{ij}^{n,s}(\nu), \tag{17}$$

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 $\left\{ \mu_{ij}^{n,s} \right\}_{i,j,\in \mathcal{N} \times \mathcal{N}}^{n \in \{U,M\}, s \in \{h,l\}}$ 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 $\{\rho, \rho^s, \theta^{n,s}\}_{n \in \{U,M\}, s \in \{h,l\}}$ 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*.

D.2 Calculating the general equilibrium effects of any police

Suppose there is any policy shock that changes any combination of migration costs, productivities, and/or amenities from $\left\{ \mu_{od}^{n,s}, A_d^{n,s}, u_d^{n,s} \right\}$ to $\left\{ \widetilde{\mu_{od}^{n,s}}, \widetilde{A_d^{n,s}}, \widetilde{u_d^{n,s}} \right\}$; what are the economic effects of this shock?

For any variable x, define $\hat{x} \equiv \frac{\tilde{x}}{x}$. From equations 16, we have that:

$$
\begin{aligned}
\hat{w}_d^{n,s} =& \hat{Q}_d^{\frac{1}{\rho}} \times \left(\left(\frac{\sum_{n\in\{M,U\}} \widetilde{A_d^{n,s}} \left(\widetilde{L_d^{n,s}} \right)^{\frac{\rho_s-1}{\rho_s}}}{\sum_{n\in\{M,U\}} A_d^{n,s} \left(L_d^{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 \hat{A}_d^{n,s} \times \left(\hat{L}_d^{n,s} \right)^{-\frac{1}{\rho_s}} \\
=& \hat{Q}_d^{\frac{1}{\rho}} \times \left(\left(\sum_{n\in\{M,U\}} \frac{A_d^{n,s} \left(L_d^{n,s} \right)^{\frac{\rho_s-1}{\rho_s}}}{\sum_{n\in\{M,U\}} A_d^{n,s} \left(L_d^{n,s} \right)^{\frac{\rho_s-1}{\rho_s}}} \hat{A}_d^{n,s} \left(\hat{L}_d^{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 \hat{A}_d^{n,s} \times \left(\hat{L}_d^{n,s} \right)^{-\frac{1}{\rho_s}} \\
=& \hat{Q}_d^{\frac{1}{\rho}} \times \\
\times& \left(\left(\sum_{\substack{n\in \\ \{M,U\}}} \frac{Q_d \left(\sum_{\substack{n\in \\ \{M,U\}}} A_d^{n,s} \left(L_d^{n,s} \right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{1}{\rho_s}-\frac{1}{\rho}\right)} A \left(L_d^{n,s} \right)^{\frac{\rho_s-1}{\rho_s}}}{\sum_{\substack{n\in \\ \{M,U\}}} Q_d \left(\sum_{\substack{n\in \\ \{M,U\}}} A_d^{n,s} \left(L_d^{n,s} \right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{1}{\rho_s}-\frac{1}{\rho}\right)} A_d^{n,s} \left(L_d^{n,s} \right)^{\frac{\rho_s-1}{\rho_s}}} \hat{A}_d^{n,s} \left(\hat{L}_d^{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& \hat{A}_d^{n,s} \times \left(\hat{L}_d^{n,s} \right)^{-\frac{1}{\rho_s}} \\
=& \hat{Q}_d^{\frac{1}{\rho}} \times \\
& \times \left(\left(\sum_{n\in\{M,U\}} \left(\frac{w_d^{n,s} L_d^{n,s}}{w_d^{MEX,s} L_d^{MEX,s} + w_d^{US,s} L_d^{US,s}} \right) \hat{A}_d^{n,s} \left(\hat{L}_d^{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 \\
& \times \hat{A}_d^{n,s} \times \left(\hat{L}_d^{n,s} \right)^{-\frac{1}{\rho_s}} \\
=& \hat{Q}_d^{\frac{1}{\rho}} \times \left(\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{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 \hat{A}_d^{n,s} \times \left(\hat{L}_d^{n,s} \right)^{-\frac{1}{\rho_s}}, \qquad (18)
\end{aligned}
$$

where $y_d^{n,s} \equiv \frac{w_d^{n,s} L_d^{n,s}}{w_d^{MEX,s} L_d^{MEX,s} + w_d^{US,s} L_d^{US,s}}$ is the share of income earned by workers of skill s that is paid to workers of nativity n in location d.

Moreover, notice that:

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

Therefore:

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

Therefore:

$$\begin{aligned}
\sum_n w_i^{n,s}L_i^{n,s} &= Q_i^{\frac{1}{\rho}} \times \left(\left(\sum_{n\in\{M,U\}} A_i^{n,s}\left(L_i^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{\rho_s}{\rho_s-1}}\right)^{\left(\frac{1}{\rho_s}-\frac{1}{\rho}\right)} \sum_n \left(A_i^{n,s}\left(L_i^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right) \\
&= Q_i^{\frac{1}{\rho}} \times \left(\sum_{n\in\{M,U\}} A_i^{n,s}\left(L_i^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{1}{\rho_s}-\frac{1}{\rho}\right)+1} \\
&= Q_i^{\frac{1}{\rho}} \times \left(\sum_{n\in\{M,U\}} A_i^{n,s}\left(L_i^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{\rho-1}{\rho}\right)} \qquad (19)
\end{aligned}$$

Using equations 17 and 19, we have that:

$$
\begin{aligned}
\hat{Q}_d =& \frac{Q'_d}{Q_d} \\
=& \frac{\left(\sum_{s\in\{h,l\}}\left(\left(\sum_{n\in\{M,U\}}\widetilde{A_i^{n,s}}\left(\widetilde{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}}}{\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}}} \\
=& \Bigg[\sum_{s\in\{h,l\}}\frac{1}{\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}}}\times \\
&\times\left(\left(\sum_{n\in\{M,U\}}\widetilde{A_i^{n,s}}\left(\widetilde{L_i^{n,s}}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{\rho_s}{\rho_s-1}}\right)\Bigg]^{\frac{\rho}{\rho-1}} \\
=& \Bigg[\sum_{s\in\{h,l\}}\frac{\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}}}{\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}}}\times \\
&\times\left(\left(\frac{\sum_{n\in\{M,U\}}\widetilde{A_i^{n,s}}\left(\widetilde{L_i^{n,s}}\right)^{\frac{\rho_s-1}{\rho_s}}}{\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}}\Bigg]^{\frac{\rho}{\rho-1}} \\
=& \Bigg[\sum_{s\in\{h,l\}}\left(\frac{\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}}}{\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)\times \\
&\times\left(\left(\sum_{n\in\{M,U\}}\left(\frac{A_i^{n,s}\left(L_i^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}}{\sum_{n\in\{M,U\}}A_i^{n,s}\left(L_i^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}}\right)\hat{A}_i^{n,s}\left(\hat{L}_i^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{\rho_s}{\rho_s-1}}\right)^{\frac{\rho-1}{\rho}}\Bigg]^{\frac{\rho}{\rho-1}}
\end{aligned}
$$

$$
\begin{aligned}
&= \Bigg[\sum_{s\in\{h,l\}} \left(\frac{\left(\left(\sum_{n\in\{M,U\}} A_i^{n,s} \left(L_i^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s-1}} \right)^{\frac{\rho-1}{\rho}}}{\sum_{s\in\{h,l\}} \left(\left(\sum_{n\in\{M,U\}} A_i^{n,s} \left(L_i^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s-1}} \right)^{\frac{\rho-1}{\rho}}} \right) \times \\
&\quad \times \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)} \Bigg]^{\frac{\rho}{\rho-1}} \\
&= \left(\sum_{s\in\{h,l\}} \left(\frac{\sum_{n\in\{M,U\}} w_i^{n,s} L_i^{n,s}}{\sum_{s\in\{h,l\}} \sum_{n\in\{M,U\}} w_i^{n,s} L_i^{n,s}} \right) \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)} \right)^{\frac{\rho}{\rho-1}} \\
&= \left(\sum_{s\in\{h,l\}} \eta_d^s \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)} \right)^{\frac{\rho}{\rho-1}} ,
\end{aligned}
\tag{20}
$$

where $\eta_d^s \equiv \frac{\sum_{n\in\{M,U\}} w_i^{n,s} L_i^{n,s}}{\sum_{s\in\{h,l\}} \sum_{n\in\{M,U\}} w_i^{n,s} L_i^{n,s}}$ is the fraction of labor income in location d paid to workers of skill s.

Now combining equations 18 and 20:

$$
\begin{aligned}
\hat{w}_d^{n,s} = {} & \left(\sum_{s\in\{h,l\}} \eta_d^s \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)} \right)^{\frac{1}{\rho-1}} \times \\
& \times \left(\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s-1}} \right)^{\left(\frac{1}{\rho_s}-\frac{1}{\rho}\right)} \times \hat{A}_d^{n,s} \times \left(\hat{L}_d^{n,s}\right)^{-\frac{1}{\rho_s}} ,
\end{aligned}
\tag{21}
$$

Notice that

$$
\begin{aligned}
\left(\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s-1}} \right)^{\left(\frac{1}{\rho_s}-\frac{1}{\rho}\right)} &= \left(\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{\rho-1}{\rho}\right)} \right)^{\frac{\rho}{\rho-1}\left(\frac{1}{\rho_s}-\frac{1}{\rho}\right)} \\
&= \left(\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{\rho-1}{\rho}\right)} \right)^{\left(\frac{\rho}{\rho_s}-1\right)\frac{1}{\rho-1}}
\end{aligned}
$$

Therefore, equation 21 simplifies to:

$$
\begin{aligned}
\hat{w}_d^{n,s} = & \left(\sum_{s\in\{h,l\}} \eta_d^s \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)}\right)^{\frac{1}{\rho-1}} \times \\
& \times \left(\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{\rho-1}{\rho}\right)}\right)^{\left(\frac{\rho}{\rho_s}-1\right)\frac{1}{\rho-1}} \times \hat{A}_d^{n,s} \times \left(\hat{L}_d^{n,s}\right)^{-\frac{1}{\rho_s}} \\
= & \left(\frac{\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{\rho-1}{\rho}\right)}}{\sum_{s\in\{h,l\}} \eta_d^s \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)}}\right)^{-\frac{1}{\rho-1}} \times \\
& \times \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{1}{\rho_s-1}} \times \hat{A}_d^{n,s} \times \left(\hat{L}_d^{n,s}\right)^{-\frac{1}{\rho_s}} \\
= & \left(\frac{\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{\rho-1}{\rho}\right)}}{\sum_{s\in\{h,l\}} \eta_d^s \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)}}\right)^{-\frac{1}{\rho-1}} \times \\
& \times \left(\frac{\hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}}{\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}}\right)^{-\frac{1}{\rho_s-1}} \left(\hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{1}{\rho_s-1}} \times \hat{A}_d^{n,s} \times \left(\hat{L}_d^{n,s}\right)^{-\frac{1}{\rho_s}} \\
= & \left(\frac{\left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{\rho-1}{\rho}\right)}}{\sum_{s\in\{h,l\}} \eta_d^s \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}\right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)}}\right)^{-\frac{1}{\rho-1}} \times \\
& \times \left(\frac{\hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}}{\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}}}\right)^{-\frac{1}{\rho_s-1}} \times \left(\hat{A}_d^{n,s}\right)^{\frac{\rho_s}{\rho_s-1}}
\end{aligned}
$$

Finally, the change in the value of residing in destination d for a worker of nationality n and skill s can be written as:

$$
\begin{aligned}
\hat{V}_d^{n,s} =& \hat{w}_d^{n,s} \cdot \hat{u}_d^{n,s} \\
=& \left(\frac{ \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\frac{\rho_s}{\rho_s-1}\left(\frac{\rho-1}{\rho}\right)} }{ \sum_{s\in\{h,l\}} \eta_d^s \left(\sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} \right)^{\left(\frac{\rho_s}{\rho_s-1}\right)\left(\frac{\rho-1}{\rho}\right)} } \right)^{-\frac{1}{\rho-1}} \times \\
& \times \left(\frac{ \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} }{ \sum_{n\in\{M,U\}} y_d^{n,s} \hat{A}_d^{n,s} \left(\hat{L}_d^{n,s}\right)^{\frac{\rho_s-1}{\rho_s}} } \right)^{-\frac{1}{\rho_s-1}} \times \left(\hat{A}_d^{n,s}\right)^{\frac{\rho_s}{\rho_s-1}} \hat{u}_d^{n,s}
\end{aligned}
,
$$

which is the decomposition presented in equation 14 of the main text.