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1. Introduction

At the beginning of the Age of Mass Migration (1850-1913), 300 thousand Europeans migrated to New World destinations annually (Hatton and Williamson, 1998, p. 7). In the final decade of that period, a new episode of mass migration began, this time from Mexico to the United States. Between 60 to 100 thousand Mexican immigrants crossed the border in 1908 (Clark, 1908, p. 466). One hundred years later, this figure remained at similar levels, making Mexico-to-US migration the most intense and persistent of the twentieth century (Borjas, 2007).[1]

While extensive research examines the drivers of contemporary Mexican migration (for example, Angelucci, 2015; Chort and De La Rupelle, 2016; Hanson and Spilimbergo, 1999; Munshi, 2003), our knowledge about the factors that initially induced it is limited to few historical studies (see Escamilla-Guerrero, 2020, for a review). This literature generally agrees that railroads were "fundamental" in explaining the surge of mass migration from Mexico. This argument is based on the fact that Mexican migration became notable during the 1890s, coinciding with the completion of the first rail line connecting Central Mexico to the US border (Cardoso, 1980; Durand, 2016; Fogel, 1978). However, identifying the impact of railroads in general, and on migration in particular, is empirically challenging due to the endogeneity of railroads' location—it is unclear whether the arrival of railroads induced mass migration, or whether existing demand for passenger transportation attracted railroad investments.

This chapter examines the impact of railroad access on Mexican mass migration to the United States in the early twentieth century. To overcome the endogeneity of railroad access, I implement an identification strategy based on least cost paths.[2] These paths reflect hypothetical railroad routes designed solely to connect Mexico's historical cities to the US border while minimizing construction costs. Intuitively, I compare two districts, one of which is located closer to a least cost path, and the other of which is farther away. The former, by virtue of its location only, is more likely to be traversed by a rail line, which provides a measure of railroad access that is more randomly assigned and thus exogenous to migration potential.

[1] Gross immigration from Mexico was estimated at 140 thousand (probably less) in 2010 (Passel, Cohn and Gonzalez-Barrera, 2012).

[2] My strategy is similar to those used in recent research addressing the impact of railroads on development outcomes. See, for example, Atack et al. (2010); Banerjee, Duflo and Qian (2020); Berger and Enflo (2017); Fenske, Kala and Wei (2023), which I discuss later.

My main result—based on newly-digitized individual border crossings (Oct 1906 – Sep 1910) and data from the 1910 Population Census of Mexico—shows that districts closer to a least cost path had higher migration rates than those farther away. More specifically, the difference in migration rates between these two district groups was 2.5 migrants per thousand inhabitants. This figure implies that railroad access could explain up to 60 percent of all border crossings. My finding is robust to controlling for differences in location fundamentals, land characteristics, demographic structure, labor markets, landholding patterns, and living standards across districts. Furthermore, the magnitude and precision of my estimate changes little after explicitly accounting for regional droughts (Dell, 2012; Cardoso, 1980) and state fixed effects. The latter controls for unobserved state-specific factors that may have influenced Mexico-to-US migration, including migrant networks (Durand, 2016; McKenzie and Rapoport, 2010).

I contribute to a vast literature studying the impact of railroads (for example, Atack et al., 2010; Donaldson and Hornbeck, 2016; Donaldson, 2018; Fogel, 1962). The majority of this research, however, focuses on development and trade outcomes, overlooking the effect of railroads on migration. The few exceptions provide mixed results for within-country settings (for example, Black et al., 2015; Fenske, Kala and Wei, 2023), leaving unexplored the impact of railroads on international migration. My study fills this gap by estimating the impact of railroad access on Mexico-to-US migration in the early twentieth century, a period that shaped migration patterns persisting until the Immigration Reform and Control Act (IRCA) of 1986 (Durand, 2016).[3]

I also contribute to our understanding of the Mexico-US migration history. My results indicate that railroads were intensively used by Mexican migrants to reach the US border. This finding contrasts with previous literature arguing that, for most Mexicans, a second-class train ticket for an average journey (67 km) was more expensive than walking the same distance, suggesting that railroads' social savings on passenger transportation were negligible (Coatsworth, 1979). However, my results also reveal that approximately 40 percent of immigrants came from districts without direct access to railroads. My findings, therefore, provide a more accurate picture of the role that railroads played in shaping Mexico-to-US migration: railroads were a catalyst for mass migration rather than a determinant, as traditionally believed.

[3]This reform transformed the circular pattern of Mexican migration into a permanent settlement of both legal and undocumented immigrants.

2. Historical Background

From a historical perspective, Mexican migration to the United States started in 1848, when the US-Mexican War ended and Mexico conceded more than half of its territory.[4] As a consequence, thousands of Mexicans who lived in the newly-acquired American territories became the first immigrant network without ever leaving their home (Henderson, 2011; Kosack and Ward, 2020). While the population of Mexican origin grew slowly afterward, it was not until the 1890s that Mexican immigration increased sharply and expanded its geographic range of settlement in the United States (Durand, Massey and Zenteno, 2001; Feliciano, 2001; Gratton and Gutmann, 2000).

To explain the beginning of Mexican mass migration, previous literature has focused on the asymmetric economic conditions between Mexico and the United States at the time. The economic boom of the American Southwest represented greater employment opportunities in agriculture, mining, and railroads for the Mexican population, whose living standards had deteriorated since the 1870s (Gratton and Merchant, 2015; Oñate, 1991; López-Alonso, 2007). Mexicans could also earn at least four times more in the United States due to both the stagnation of wages and depreciation of the peso (Fogel, 1978; Rosenzweig, 1965).[5] In addition, high land concentration by a small elite had perpetuated economic and political inequality since colonial times (Chevalier, 1970; Florescano, 1987; Sellars and Alix-Garcia, 2018; Sokoloff and Engerman, 2000), which further incentivized migration in search of a more prosperous life.

Despite its overall backwardness, Mexico experienced a profound modernization in transportation infrastructure during the late 19th century: the railroad mileage increased from 477 km in 1877 to 19,000 km in 1910, connecting the main population centers to the US border (Moreno-Brid and Ros, 2009). Since trains significantly reduced travelling times, many have argued that access to railways was indispensable for the surge of Mexican mass migration (Cardoso, 1980; Feliciano, 2001; Durand, 2016; Gamio, 1930). This argument is based on the fact that the Mexican and American railroad networks were connected at El Paso, Texas in 1884, shortly before Mexican immigration became notable. Others have documented that stagnant wages and liquidity constraints made train tickets unaffordable for the majority of the Mexican population, limiting the railroad's social savings on passenger transportation and thus questioning its impact on mass migration (Coatsworth, 1979).

[4] The conceded territories were California, Utah, Nevada, and most part of Arizona, New Mexico, and Colorado. The US-Mexican War also formalized the loss of Texas, which had been admitted to the American Union in 1845.
[5] The exchange rate at the time was 2 pesos per US dollar (Clark, 1908).

In sum, substantial differences between Mexico and the United States in employment opportunities, living standards, and wage levels provided the incentives to cross the border. While these forces have been mentioned by previous literature as determinants of the flow, it is unclear to what extent they induced mass migration, as they were in place since the mid-nineteenth century. Similar to European mass migration, improvements in transportation technology likely played a pivotal role in the history of Mexico-US migration.[6] With the dramatic expansion of railroads, migration costs fell, making it feasible for populations farther from the border to migrate to the United States. Moreover, the absence of restrictive immigration policies allowed Mexicans to respond to the increasing labor demand in the American Southwest, where existing migrant networks could have provided assistance upon arrival.[7]

2.1 The Mexican Railroad Network

The construction of railroads in Mexico was significantly delayed by episodes of war and political instability. It was not until 1873 that the first major rail line connecting the port of Veracruz to Mexico City was finally inaugurated. The country's rugged topography proved exceptionally challenging and costly for railroad development. To finance the construction of additional railroads, the Mexican government issued concessions and granted subsidies to international companies, predominantly American (Donly, 1920).

As a result of this policy and the strategic interest of American companies to connect Mexican and US markets, three trunk lines were built running from Central Mexico to the US border (Woodruff and Zenteno, 2007).[8] These trunk lines connected major cities and economic centers along their routes, dramatically reducing travel times from several weeks to around 45-60 hours, depending on the route (De Cardona, 1892). Complementing the main trunk lines, multiple branch lines were also part of the network. Built by local elites and entrepreneurs to serve individual interests (Coatsworth, 1974), these shorter railroads connected large estates, mines, and small towns to the trunk lines, primarily to facilitate the transport of goods, though some of these short rail lines were also used for mail delivery and passenger transportation (Pletcher, 1950).

[6] See Abramitzky and Boustan (2017) and Hatton and Williamson (1998) for reviews on Europe-to-US mass migration.

[7] Before 1910, Mexicans were not considered immigrants who sought to settle permanently, but temporary aliens who moved back and forth supplying labor without facing immigration restrictions (Fogel, 1978; Samora, 1982).

[8] The three trunk lines are the following. The Mexican Central Railway, connecting Mexico City with El Paso, Texas. The Mexican International Railroad, connecting Durango City to Eagle Pass via Torreon. The Mexican National Railroad, connecting Mexico City to Laredo via San Luis Potosi (Donly, 1920). See Figure A.1 for guidance.

3. Conceptual Framework and Related Literature

Railroads revolutionized transportation around the world in the 19th century. From Europe and Asia to the Americas, railroads were built to promote market integration and economic development, as well as to improve passenger transportation. This has motivated a large body of literature evaluating the short- and long-run effects of railroads on diverse economic outcomes. These include trade (Bignon, Esteves and Herranz-Loncán, 2015; Donaldson, 2018), innovation (Andersson, Berger and Prawitz, 2023), land values (Donaldson and Hornbeck, 2016), economic growth (Banerjee, Duflo and Qian, 2020; Fogel, 1962; Herranz-Loncán, 2006), urbanization (Atack et al., 2010; Berger and Enflo, 2017), and state capacity (Cermeño, Enflo and Lindvall, 2022), among others, with findings ranging from negligible to large effects across settings.

Similarly, the impact of railroads on migration is far to be obvious. On the one hand, railroads can substantially reduce the costs and uncertainty associated with migration by shortening journey times and facilitating information access (Hatton and Williamson, 1998; Leunig, 2006), allowing a larger share of the population to migrate. On the other hand, railroad access can induce industrialization and give rise to cities offering higher living standards and better economic prospects (Berger, 2019; Fenske, Kala and Wei, 2023), which would deter outmigration and increase immigration (Sequeira, Nunn and Qian, 2020). It is also possible that in some contexts the fixed cost of migration (transportation and unemployment risk) is small (Imbert and Papp, 2020), implying that railroad access can have no effect on migration.

There is, however, little empirical evidence on how transportation infrastructure, in general, and railroads, in particular, shape migration. Morten and Oliveira (2024) show that access to highways increased migration rates within Brazil from 1960 to 2000, which explain about one fourth of the welfare gains associated with the expansion of highways. Black et al. (2015) also find that during the Great Migration (1910-1970), railroad access significantly influenced migration, with African Americans from the US South often moving to locations along the rail lines. In contrast, Fenske, Kala and Wei (2023) show that migration did not respond to railroad access in India over the period 1881-1931. Note that these findings capture effects on internal migration, leaving unexplored the impact of transportation infrastructure on migration between countries.

4. Data

My analysis is based on data digitized by Escamilla-Guerrero (2020) and Escamilla-Guerrero, Kosack and Ward (2023), which consist of 35,159 individual records of Mexican-born immigrants arriving at 12 entrance ports along the Mexico-US border from October 1906 to September 1910.[9] The original source of these data are the Mexican Border Crossing Records (MBCRs)—immigration forms used by American officials to systematically record the flow of immigrants and their characteristics. To obtain detailed information on railroad access at the local level, I digitize a map of the Mexican railroad network ca. 1906 (FNM, 1914). In addition, I digitize data from the 1910 Population Census of Mexico (Secretaría de Agricultura y Fomento, 1910). The census provides a rich set of socioeconomic variables at the district level, which capture the main incentives to migrate. I also use complementary data from a variety of sources to control for additional features that may affect the migration decision.

4.1 Immigration

The MBCRs report rich demographic and socioeconomic data for each immigrant, including their localities of birth.[10] I classify places of birth into districts using the 1910 Census Catalogue of Localities and the Mexican Historical Archive of Localities (AHL), both maintained by Mexico's National Institute of Statistics and Geography (INEGI). I collapse the individual-level data to calculate migration rates by district for each of the 12-month periods covered by the data: October 1906 - September 1907 ... October 1909 - September 1910.[11] I collapse the individual-level data to calculate migration rates by district for each of the four 12-month periods covered by the data: October 1906 - September 1907 ... October 1909 - September 1910. I calculate migration rates (per 1,000 inhabitants) as the number of migrants over the district population level according to the 1910 Census. I then compute the mean migration rate across periods, my main outcome variable.

4.2 Railroads

By the mid-1900s, three rail lines connected Central Mexico to the US border. Yet, not every district had direct access to trains, making long-distance journeys costly and tedious since most roads were not

[9] The data exclude duplicate entries and records with incomplete geographic information. Border crossings were not systematically recorded before this period (Escamilla-Guerrero, 2020). Although the available data extend to December 1920, I limit the analysis to September 1910 to avoid capturing migration responses induced by conflict events during the Mexican Revolution (November 1910 - February 1917).

[10] In 1910, 93 percent of the Mexican population lived in their municipality of birth (Sobrino, 2010), making location of birth a reasonable proxy for location of last residence.

[11] Estimating migration rates for 12-month periods accounts for seasonal migration patterns. Clark (1908) documents that border crossings increased during planting and harvest seasons.

accessible to carts (Bignon, Esteves and Herranz-Loncán, 2015). To identify districts with direct access to railroads, I estimate the distance from the centroid of each district to the nearest railroad. I then create an indicator variable that equals one if such a distance is less than 40 km and zero otherwise. This criterion is based on Coatsworth (1979), who documents that people were used to walking 30 km per day, but about twice this distance could be covered using stagecoaches or pack animals. Therefore, back-of-the-envelope calculations suggest that a 40 km distance could have been covered in 3 to 5 hours through a combination of walking and stagecoach travel.[12] Considering that the average district area was 5.2 thousand km^2, a 40 km criterion should be a sensible proxy for *direct* access to railroads.

4.3 District Characteristics

I collect data on a number of district characteristics that may have affected migration, many of which have been found to influence mass migration in contemporaneous settings (see Hatton and Ward, 2024, for a review). I create a battery of variables to control for geographic conditions and market access. These variables include altitude, latitude, longitude, surface area, distance to the border, distance to the nearest historical city, distance to the nearest port, and land suitability for staple crops—beans, carrot, coffee, maize, potato, tomato, and wheat (Food and Agriculture Organization, 2021).

To control for push and pull labor market factors, I use the working-age population share of unemployed in Mexico from the 1910 census and the US-Mexico wage gap. I calculate the latter as follows. First, I calculate mean minimum wages in Mexico using national minimum wages in agriculture, manufactures, and mining (Rosenzweig, 1965), weighted by the working-age population share of agricultural peons, industrial workers, and miners in each district (Secretaría de Agricultura y Fomento, 1910).[13] Second, I compute the mean wage for Mexican immigrants across US border states—California, Arizona, New Mexico, and Texas—following Kosack and Ward (2020) and using full-count US census data (Bureau of the Census, 1910).[14] I focus on these states for two reasons: first, approximately 86 percent of the Mexican-origin population resided there in 1910 (Gratton and Gutmann, 2000; Gratton and Merchant, 2015); second, the destinations reported by immigrants often reflect ports of entry rather than final destinations. I then use these variables to calculate the wage ratio between the United States and Mexico for each district.

[12] Coatsworth (1979) documents that stagecoaches could move at 15 km per hour given the state of roads in Mexico.
[13] See Table A.1 for wages in Mexico by economic sector.
[14] I consider Mexican-born individuals with less than five years in the United States.

I also use data from the 1910 census to capture the districts' demographic structure. These variables consist of the population share of individuals in prime migration age (16-35), the working-age (16-60) population share of agricultural peons, the population share of indigenous-language speakers, and sex ratio. I also employ three variables to control for living standards. These variables include the share of illiterate among the population aged 11 and older, the dwellings share of huts (dwellings made of clay and straw), and urban density. To capture differences in landholding patterns across districts, I use data from Sellars and Alix-Garcia (2018)—the number of large estates (haciendas and ranches) and the population share living in large estates. Finally, I collect data on droughts from the Mexican Drought Atlas (Stahle et al., 2016), which provides detailed spatial data on severe droughts in Mexican history (1400-2012).

4.4 Summary Statistics

Panel A of Figure 1 shows the railroad network of Mexico in 1906—that is, at the beginning of my period of analysis (Oct 19106 - Sep 1910). It also presents the location of the entry ports observed in the immigration data. There are two points to note. First, the railroad routes were largely influenced by terrain ruggedness. The multiple high-altitude mountain systems made the construction of railroads costly and, in some cases, virtually impossible (Donly, 1920). Consequently, despite having the third-longest railroad network in Latin America (Bignon, Esteves and Herranz-Loncán, 2015), many regions of Mexico had no direct access to this transportation technology. Second, with few exceptions, all entry ports were terminus stations connected to the American railroad network, making trains the fastest mean of transportation to travel to the United States at the time.[15] Panel B shows that migration varied significantly across districts, with rates ranging from 0 to 32 per thousand inhabitants. Migration was particularly intense near the border, but many districts in the West-Central region had equally high rates. There was also migration from the Center and Southeast regions, though relatively low and concentrated in specific districts (see Figure A.1 for guidance). A common feature is the correlation between railroads and migration: districts crossed by or close to a railroad have higher migration rates than those farther away.

Table 1 presents characteristics of districts by railroad access status as previously defined. It shows that districts with railroad access differed from their counterparts without access in several aspects (Column 4). However, some of these differences are dwarfed when comparing districts within states (Column 5), which is desirable given Mexico's large territory and rich socioeconomic diversity. I find no economically meaningful differences in geographic or labor market characteristics, nor in the share of population

[15] A journey by train from central Mexico to the border took 45 to 60 hours depending on the route (De Cardona, 1892), while using alternative means of transportation took several weeks (Coatsworth, 1979).

in prime migration age. However, districts with railroad access had fewer agricultural peons, fewer native-language speakers, and lower land concentration. These places also had larger populations, better living standards, and higher migration rates.[16] This preliminary analysis shows that railroads connected districts where labor mobility was less constrained by landholding patterns and poverty, illustrating the main empirical problem that I face: the endogeneity of railroads' location. While districts with railroad access had significantly higher migration rates, this could have been the result of preexisting higher demand for passenger transportation that attracted railroad investments.

5. Empirical Strategy

To overcome the endogeneity of railroad access, I implement an identification strategy based on least cost paths (LCPs). The LCPs reflect a hypothetical network as it would have been designed by state planners aiming to connect Mexico's main destinations to the United States, while minimizing construction costs. I construct the LCPs as follows. I first use the 1790 Colonial Population Census (Castro Aranda, 2010) and a map of Mexico created in 1847 (Disturnell, 1847) to identify the target destinations of the LCPs: historical cities of Mexico and historical crossing points along the Mexico-US border. I then connect the target destinations using straight lines, following a decision rule similar to that employed by Banerjee, Duflo and Qian (2020). I draw a straight line from each city to the nearest city or border crossing point. If there are two or more target destinations where the differences in distances is less than 100 km, I draw a line to all of them. I extend the line past the target until it hits a natural barrier to avoid endogeneity arising from stopping the line in termini cities. To account for high construction costs due to terrain ruggedness, I avoid drawing lines crossing mountain systems with an altitude greater than 1,500 meters.

My LCPs approach relies on three elements for identification. First, by using historical cities—observed approximately 80 years before the arrival of railroads—as target destinations, the LCPs capture potential transportation routes that existed since the colonial period.[17] Second, districts along these routes are more likely to be traversed by a rail line solely due to their location, which provides a measure of railroad access that is more randomly assigned and thus exogenous to migration potential. Finally, given

[16] Productivity in the vast majority of haciendas and ranches was based on labor exploitation and coercive mechanisms of debt bondage that restricted migration (Moreno-Brid and Ros, 2009; Sellars and Alix-Garcia, 2018). In places with low land concentration, (temporary) international migration becomes a mechanism to acquire land or extend a family smallholding (Hatton and Williamson, 1998).

[17] Since Mexico's urbanization patterns remained largely unchanged from colonial times until the mid-20th century (Alix-Garcia and Sellars, 2020), transportation routes are unlikely to have undergone significant changes during this period.

that pre-rail overland transportation was very precarious, the LCPs are unlikely to capture access to other types of transportation infrastructure.[18]

Figure 2 displays my LCPs approach and the existing railroad network ca 1906. It is clear that railroads, particularly trunk lines, were built in locations nearby the least cost paths. Moreover, a binscatter plot of the relationship between distance to the railroad network and distance to the LCPs confirms that proximity to an LCP is strongly correlated to the construction of railroads (see Figure A.2).

5.1 Estimating Equation

To evaluate the effect of railroad access on migration to the United States, I estimate the following equation:

$$mig_i = \alpha + \beta \cdot lcp_i + \mathbf{X}_i' \cdot \mathbf{B} + \varepsilon_i, \tag{1}$$

where mig_i is the mean migration rate in district i, lcp_i is an indicator for districts located within 40 km from the nearest least cost path, and $\mathbf{X}_i$ is a vector of standardized district characteristics that I use to account for factors that may influence migration. More specifically, these variables control for differences in location fundamentals (latitude, longitude, the interaction between latitude and longitude, and both linear and quadratic distances to the US border and nearest port), land characteristics (altitude, surface area, and land suitability for staple crops), demographic structure (individuals in prime migration age, agricultural peons, indigenous-language speakers, and sex ratio), labor markets (unemployed population and US-Mexico wage gap), landholding patterns (number of large estates and population living in large estates), and living standards (literacy, housing deprivation, and urban density) across districts.

Note that due to the construction method of the LCPs, districts closer to an LCP will also be in closer proximity to a target destination (either a historical city or a historical border crossing point). Therefore, I control for distance to the nearest target destination in all specifications. The β coefficients are interpreted as the difference in mean migration rates between districts close to the LCPs and those farther away. Since railroads were more likely to be built in districts closer to the LCPs, migration rates from these places are expected to be higher, conditional on the vector of controls. For comparison purposes, I also estimate Equation 1 using the existing network to identify districts with and without direct access to railroads. I estimate all models using OLS and report robust standard errors for inference.

[18] Most roads were not accessible to carts and a large share of freight transport depended exclusively on pack animals (Bignon, Esteves and Herranz-Loncán, 2015, p. 1279).

6. Results

Table 2 presents estimates of the effect of railroad access on migration, using both my LCPs strategy (Panel A) and the existing railroad network (Panel B). My results show that districts located within 40 km from an LCP had higher migration rates than those farther away. Conditional on the baseline controls, the difference in annual migration rates between closer and distant districts was 1.17 per thousand (Column 1), about 2.6 times the mean migration rate in distant districts (0.45). However, half of this difference disappears when controlling for market access and migration costs, i.e., factors related to geographic location (Column 2). Adding controls for land characteristics, demographic structure, labor market conditions, landholding patterns, and living standards further adjusts the difference in migration rates downward—albeit by small margins—with estimates ranging from 0.47 to 0.61 per thousand (Columns 3-7).[19] This is equivalent to approximately 1.8 to 2.5 more migrants per thousand inhabitants throughout my period of analysis (Oct 1906 - Sep 1910). Using these figures as reference, back-of-the-envelope calculations suggest that railroad access could explain up to 60 percent of all border crossings.[20]

Estimates for the existing railroad network are smaller in magnitude and less precise across specifications. This is likely influenced by the endogenous component of railroad access, particularly reflected in the branch lines of the network. As argued previously, many branch lines were constructed to serve particular interests, connecting places with insufficient demand for transportation and low migration potential. In fact, in 1908 the Ministry of Finance evaluated the state of the railroad network, concluding that "Unnecessary railroads were developed ... railroads starting in the desert and ending in the same desert ... lines that never could be and never were exploited." It also mentions that "Hundreds of miles of parallel track were built, where there was not sufficient traffic for one line alone" (Cuéllar, 1936). Therefore, estimates based on the existing railroad network would tend to be downward biased. I find similar results when using a 50 km criterion to identify districts with railroad access (see Table A.2).

Overall, my analysis suggests that railroad access, proxied by LCPs reflecting historical transportation routes, had a large impact on Mexican migration to the United States. My estimates show that railroads were intensively used by migrants to reach the US border, contrasting with the view that train tickets were unaffordable to average laborer (Coatsworth, 1979). While my results are more in line with literature arguing that railroads were indispensable for the surge of Mexican mass migration (Durand, 2016; Gamio,

[19] These migration rates associated with railroad access were higher than migration rates to the United States from European countries such as Germany or the Netherlands during the 1900s.(Hatton and Williamson, 1998).
[20] I multiply the difference in migration rates by the population in districts within a 40 km from an LCP.

1930), they also show that about 40 percent of the migration flow originated in districts without direct access to railroads. Hence, my findings provide a more accurate picture of the role that railroads had in shaping Mexico-to-US migration. Railroads were a catalyst for mass migration, particularly in districts along historical transportation routes, where migration to the United States is likely to have predated the arrival of railways.

6.1 Robustness Checks

As part of the analysis, I implement a series of robustness checks. There is a large body of literature showing that changes in temperature and rainfall can significantly influence international migration, particularly from rural locations, as productivity is likely to be negatively impacted (see, for example, Cattaneo and Peri, 2016; Hunter, Murray and Riosmena, 2013; Rosenzweig and Udry, 2014). Cardoso (1980) and Clark (1908) document that droughts affected Mexico in 1907 and 1908, which caused severe crop losses in some areas (Contreras, 2005). To identify droughts at the district level, I use the Mexican Drought Atlas (Stahle et al., 2016). These data consist of reconstructions of the self-calibrating Palmer Drought Severity Index (PDSI) on a 0.5° latitude/longitude grid centered over Mexico. The index spans from -6 (dry) to +6 (wet), with values below -4.0 representing extreme droughts and values above +4.0 representing extreme wet spells. Figure 3 shows that several districts traversed by the LCPs also experienced moderate droughts during my period of analysis (1906-1910). It is, therefore, plausible that my results confound the effect of contemporaneous droughts. However, the magnitude of the coefficient on the LCPs reduces by 12 percent only and remains statistically significant (Column 8), suggesting that local temperature shocks do not explain my main result.[21]

It is also well documented that migrant networks can provide financial assistance and information, lowering the costs for future migrants (Hatton, 1995; McKenzie and Rapoport, 2007; Munshi, 2003). In my setting, for instance, networks could have provided assistance in the form of prepaid train tickets, which would confound the effect of railroad access. Controlling explicitly for the so-called friends and relatives effects is difficult, as there are no comprehensive data capturing the sources of Mexican migration before 1906.[22] However, McKenzie and Rapoport (2010) show that migrant networks in Mexico have been historically stronger in a handful of states that today continue to be among the main migrant sources, reflecting the persistence of chain migration. To account for the effect of migrant networks that existed

[21] To account for delayed effects of droughts, I use PDSI values for each of the 12-month periods covered by the immigration data: October 1906 - September 1907 ... October 1909 - September 1910.

[22] The reporting of alien arrivals at the Mexico-US border started in few locations ca. 1903 and implemented systematically across entrance ports (border towns) in 1906 (Escamilla-Guerrero, 2020).

before my period of analysis, I estimate Equation 1 including state fixed effects, which control for any unobserved state-specific factor that may have influenced Mexico-to-US migration. Table 2 shows that my result holds after controlling for state fixed effects (Column 9), confirming that differences in migrant networks across states are not driving the migration effect associated to proximity to an LCP.

6.2 Bias from Unobservables

Regardless of the richness of the control variables I use, my estimates may still be biased by unobservable factors correlated with railroad access and migration to the United States. To assess the extent of this potential bias, I follow Altonji, Elder and Taber (2005). This approach leverages the effect of observed control variables, reflecting selection on observables, to determine the potential bias from unobservables. In practice, I use the estimated coefficients on my variable of interest (lcp_i) to calculate the ratio $\hat{\beta}^F / (\hat{\beta}^R - \hat{\beta}^F)$, where F and R denote two models, one of which includes a full set of controls, and the other of which includes a restricted set of controls. This ratio provides a measure of how much greater selection on unobservables (numerator), relative to selection on observables (denominator), must be to explain away the full estimated effect.[23] Consider the estimated coefficients reported in Columns 2 (0.614 - restricted set of controls) and 9 (0.508 - full set of controls) of Table 2. The ratio implies that selection on unobservables would have to be 4.8 times greater than selection on observables to explain my results. Therefore, in my view, it is unlikely that my findings are significantly influenced by unobservable factors.

7. Conclusion

In this chapter, I examine the impact of railroad access on Mexican migration to the United States in the beginnings of the flow (1890-1910). This setting provides an excellent environment to better understand how transportation infrastructure shapes international migration. During this period, Mexican railroads expanded dramatically and were connected to the US railroad network, coinciding with the surge of Mexican mass migration. Moreover, the US open border policy for Mexican immigration allows to identify immigration responses to improvements in transportation technology.[24] I find that districts closer to a rail line had higher migration rates than those farther away. This effect, however, only explains approximately 60 percent of all border crossings, suggesting that railroads were a catalyst for mass

[23] Intuitively, if adding observed controls significantly changes the coefficient of interest, then unobserved factors might also have a substantial impact. Conversely, if observed controls have little effect, it suggests unobserved variables may be less influential.

[24] Before 1910, Mexicans were not considered immigrants who sought to settle permanently, but temporary aliens who moved back and forth supplying labor without facing immigration restrictions (Fogel, 1978; Samora, 1982).

migration rather than a determinant, as traditionally believed. In 1890, Mexicans living in the United States represented 0.8% of the foreign-born population. One hundred years later, this figure increased to 21.7% (Feliciano, 2001, p. 388). Future research could examine to what extent railroad access in the early twentieth century influenced the persistence of Mexican mass migration over time.

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Tables and Figures

Table 1: District Characteristics

	1	2	3	4	5
	All Districts	Access to Railways	No access to Railways	Difference	Conditional Difference
Geography					
Distance (km) to border	651.47	604.16	746.82	−142.66***	−14.91
Altitude (m)	1,228.84	1,380.30	923.55	456.76***	203.62***
Area (sq km)	5,137.72	3,976.57	7,478.15	−3,501.58***	−934.12
Maize suitability index	922.72	1,005.04	756.79	248.25***	62.00
Population Structure					
Population (thousands)	39.28	44.03	29.70	14.33***	13.58***
Population share aged 16-35 years	0.34	0.34	0.34	−0.00	0.00
Working-age population share of agric. peons	0.31	0.30	0.32	−0.02*	−0.03***
Population share of native-language speakers	0.13	0.11	0.18	−0.07**	−0.06**
Sex ratio	1.02	0.99	1.07	−0.08	−0.01
Labor Markets					
US-Mexico wage gap	3.92	3.90	3.94	−0.04	−0.03
Working-age population share of unemployed	0.02	0.02	0.03	−0.01	0.00
Land Ownership					
Number of large estates	96.96	90.25	110.49	−20.24	−19.08*
Population share living in large estates	0.31	0.30	0.32	−0.02	−0.06***
Living Standards					
Urban density	6.64	9.58	0.73	8.85***	3.94***
Population share of illiterate	0.69	0.67	0.73	−0.06***	−0.05***
Dwellings share of huts	0.52	0.52	0.54	−0.02	−0.10***
Infrastructure					
Number of train stations	4.47	6.32	0.73	5.59***	7.48***
Number of telegraph offices	0.79	0.82	0.73	0.08	0.38***
Migration to the United States					
Mean migration rate per 1000	0.91	1.14	0.45	0.69***	0.46**
Observations	386	258	128	386	386

Source: Mexican Border Crossing Records (MBCRs), Secretaría de Agricultura y Fomento (1910), (Food and Agriculture Organization, 2021), and (Sellars and Alix-Garcia, 2018).

Note: The table presents means of district characteristics. I estimate differences (column 4) and differences conditional on state fixed effects (column 5) between districts with and without railroad access—within a 40 km distance from the nearest railroad line. * = Significant at 10% level; ** = Significant at 5% level; *** = Significant at 1% level.

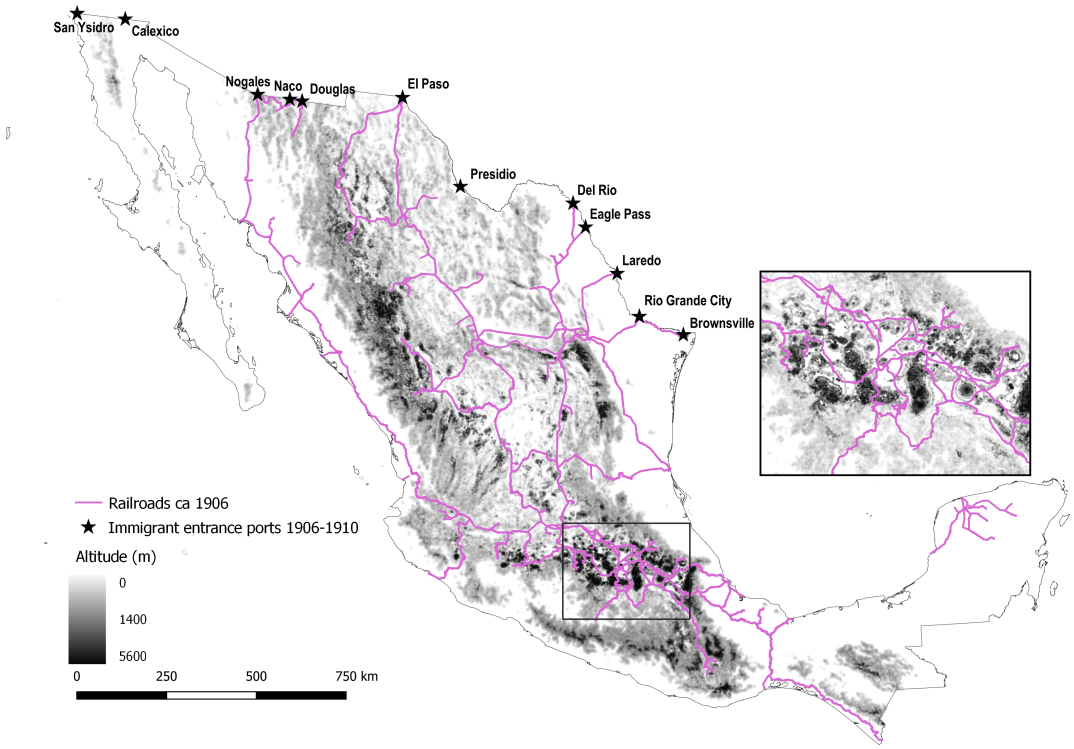
Table 2: Railroad Access and Migration

	1	2	3	4	5	6	7	8	9
Panel A. Least Cost Path									
lcp = 1	1.175***	0.614***	0.503**	0.514**	0.557**	0.497**	0.471**	0.409**	0.508**
	(0.315)	(0.235)	(0.206)	(0.216)	(0.218)	(0.209)	(0.206)	(0.201)	(0.241)
Observations	386	386	386	386	386	386	386	386	386
R-squared	0.047	0.366	0.383	0.385	0.391	0.418	0.422	0.435	0.463
Panel B. Railroad Network									
railroad = 1	0.863***	0.399**	0.388**	0.433**	0.483**	0.379**	0.402**	0.284	0.275
	(0.261)	(0.195)	(0.188)	(0.201)	(0.205)	(0.185)	(0.186)	(0.182)	(0.207)
Observations	386	386	386	386	386	386	386	386	386
R-squared	0.028	0.360	0.381	0.384	0.390	0.415	0.421	0.433	0.460
Controls									
Baseline	✓	✓	✓	✓	✓	✓	✓	✓	✓
Location fundamentals		✓	✓	✓	✓	✓	✓	✓	✓
Land characteristics			✓	✓	✓	✓	✓	✓	✓
Demographic structure				✓	✓	✓	✓	✓	✓
Labor market					✓	✓	✓	✓	✓
Landholding						✓	✓	✓	✓
Living standards							✓	✓	✓
Droughts								✓	✓
State FE									✓

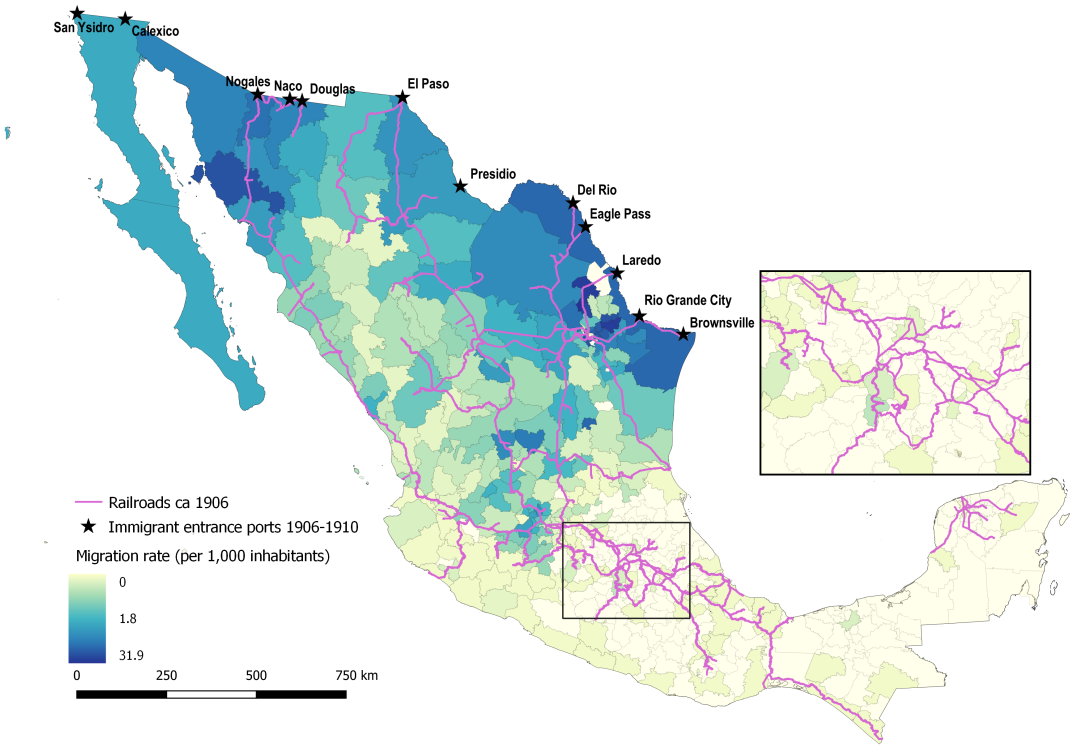
Source: Mexican Border Crossing Records (MBCRs) and Secretaría de Agricultura y Fomento (1910).
Note: *lcp* is an indicator variable for districts within 40 km from the nearest least cost path. *railroad* is an indicator variable for districts within 40 km from the nearest rail line. The control variables included are the following: *baseline* (linear and quadratic distances to the nearest historical city); *location fundamentals* (latitude, longitude, the interaction between latitude and longitude, and both linear and quadratic distances to the US border and nearest port); *land characteristics* (altitude, surface area, and land suitability for staple crops); *demographic structure* (individuals in prime migration age, agricultural peons, indigenous-language speakers, and sex ratio); *labor markets* (unemployed population and US-Mexico wage gap); *landholding* (number of large estates and population living in large estates); and *living standards* (literacy, housing deprivation, and urban density). All continuous control variables are standardized. * = Significant at 10% level; ** = Significant at 5% level; *** = Significant at 1% level.

Figure 1: Railroads and Migration to the United States

Panel A. Railway Network and Ruggedness

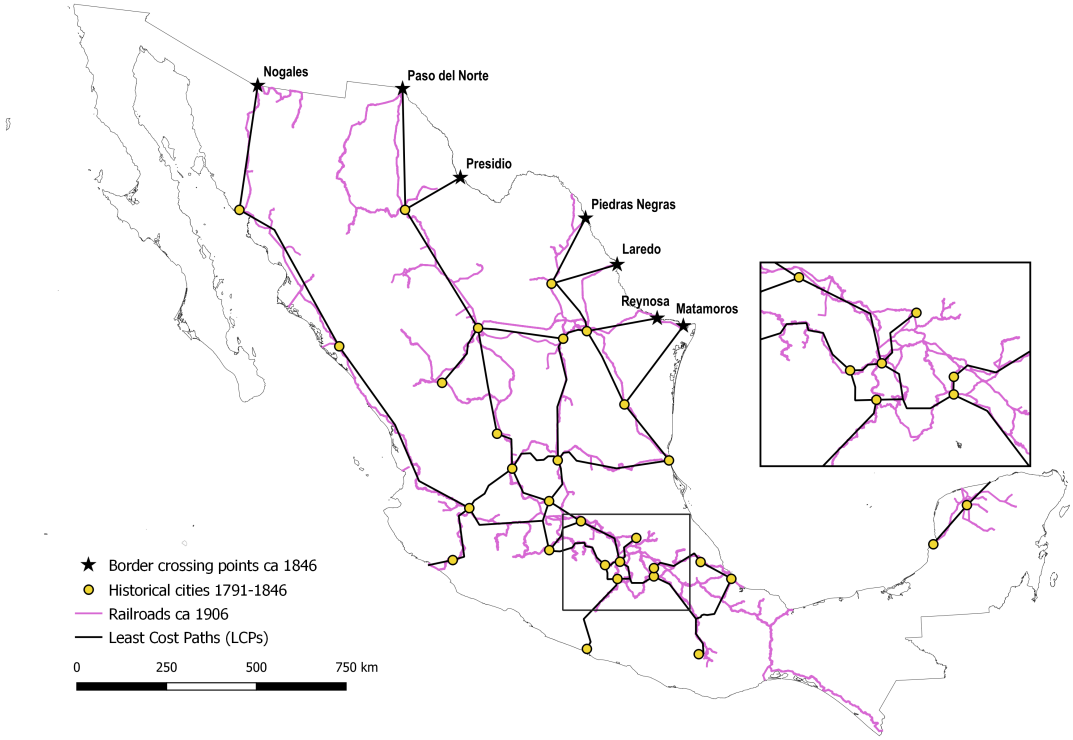


Panel B. Migration Rates by District



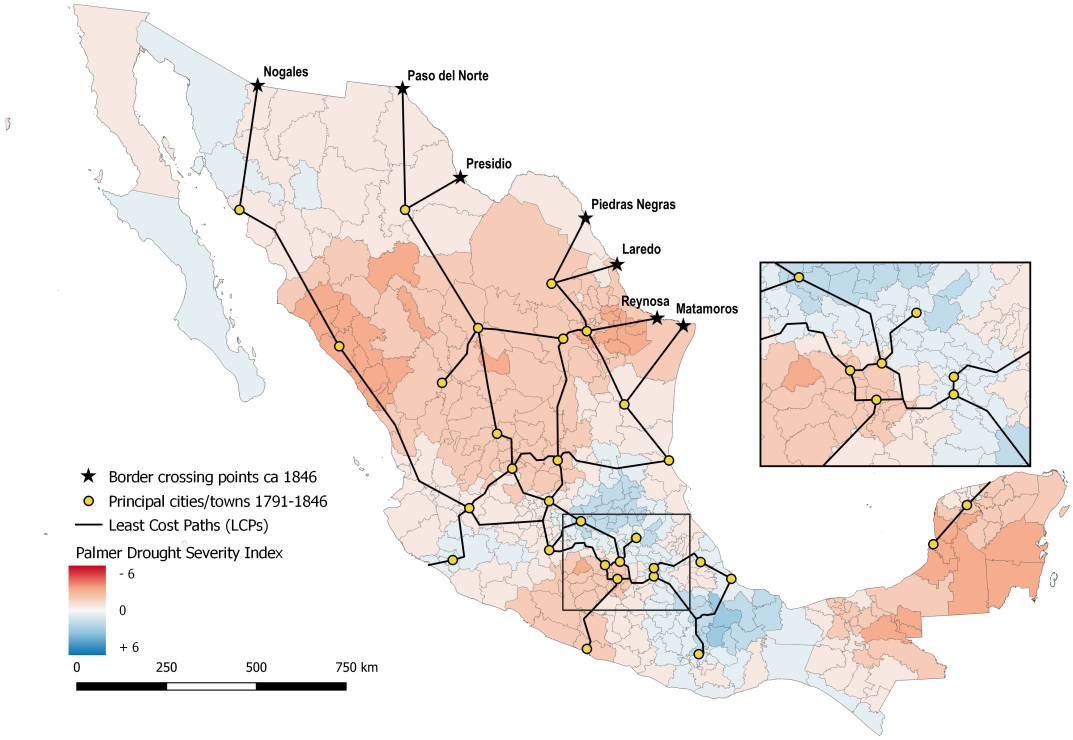
Source: Mexican Border Crossing Records (MBCRs), Secretaría de Agricultura y Fomento (1910), and FNM (1914).
Notes: The figure shows the terrain ruggedness of Mexico and the railroad network ca 1906 (Panel A). The polygons display migration rates per 1000 inhabitants by district (Panel B).

Figure 2: Least Cost Paths



Source: Castro Aranda (2010), Disturnell (1847), and FNM (1914).
Notes: The figure shows the location of target destinations (historical cities and historical border crossing points) used to construct the least cost paths.

Figure 3: Droughts



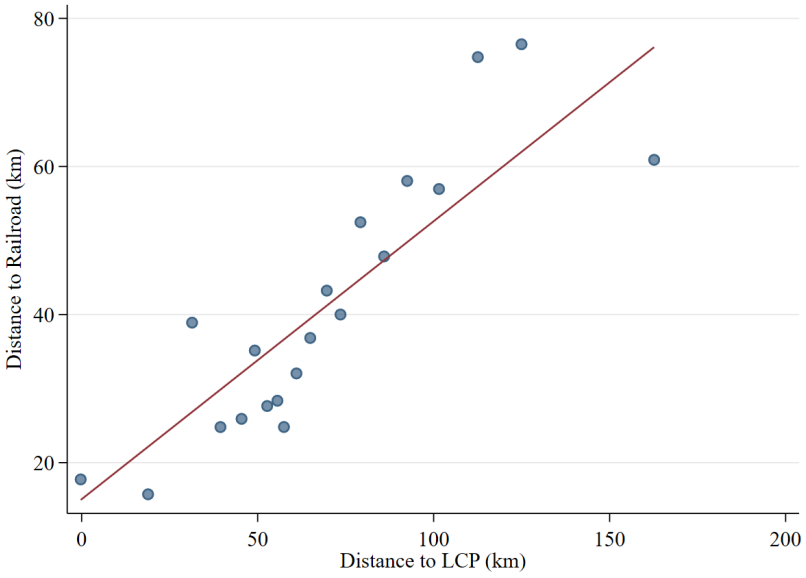
Source: Stahle et al. (2016) and FNM (1914).
Notes: The polygons display mean values of a Palmer Drought Severity Index by district. The index spans from -6 (dry) to +6 (wet), with values below -4.0 representing extreme droughts and values above +4.0 representing extreme wet spells.

Online Appendix

Figure A.1: Map for Guidance

Source: Adapted from Durand (2016, p. 28).
Notes: Before 1910, the state of Nayarit was called Tepic, and the states of Baja California and Baja California Sur constituted a single territory.

Figure A.2: Railroads and Least Cost Paths



Source: Author's estimates.
Notes: The figure shows a binscatter plot—conditional on state fixed effects—of the relationship between distance to the railroad network and distance to the least cost paths.

Table A.1: Minimum wage in Mexico by economic activity, 1877–1911.
Cents per day (US dollars)

	All Sectors		**Agriculture**		**Manufactures**		**Mining**	
Year	*Current prices*	*1900 prices*	*Current prices*	*1900 prices*	*Current prices*	*1900 prices*	*Current prices*	*1900 prices*
1877	11	16	11	16	11	16	11	16
1885	11	14	11	13	14	17	13	15
1892	15	14	14	13	16	13	16	15
1898	17	19	15	18	19	25	20	23
1902	18	16	17	16	20	18	23	21
1911	24	15	22	13	29	18	59	36

Source: Rosenzweig (1965, p. 447).
Notes: Real wages stagnated during the Porfirian period (1877–1911), especially in agriculture. The exception are wages in the mining sector that grew from 1898. Yet, for most of the Mexican population, wage stagnation translated into large wage differentials between Mexico and the United States.

Table A.2: Railroad Access and Migration
Alternative Treatment Definition

	1	2	3	4	5	6	7	8	9
Panel A. Least Cost Path									
lcp = 1	1.121***	0.607**	0.502**	0.524**	0.561**	0.523**	0.530**	0.468**	0.621**
	(0.308)	(0.243)	(0.212)	(0.225)	(0.228)	(0.222)	(0.220)	(0.219)	(0.272)
Observations	386	386	386	386	386	386	386	386	386
R-squared	0.042	0.365	0.383	0.385	0.391	0.418	0.423	0.436	0.465
Panel B. Railroad Network									
railroad = 1	0.835***	0.282	0.270	0.315	0.328*	0.264	0.284	0.186	0.232
	(0.254)	(0.183)	(0.184)	(0.199)	(0.196)	(0.188)	(0.188)	(0.202)	(0.246)
Observations	386	386	386	386	386	386	386	386	386
R-squared	0.025	0.358	0.379	0.381	0.386	0.414	0.419	0.432	0.459
Controls									
Baseline	✓	✓	✓	✓	✓	✓	✓	✓	✓
Location fundamentals		✓	✓	✓	✓	✓	✓	✓	✓
Land characteristics			✓	✓	✓	✓	✓	✓	✓
Demographic structure				✓	✓	✓	✓	✓	✓
Labor market					✓	✓	✓	✓	✓
Landholding						✓	✓	✓	✓
Living standards							✓	✓	✓
Droughts								✓	✓
State FE									✓

Source: Mexican Border Crossing Records (MBCRs) and Secretaría de Agricultura y Fomento (1910).
Note: *lcp* is an indicator variable for districts within 50 km from the nearest least cost path. *railroad* is an indicator variable for districts within 50 km from the nearest rail line. The control variables included are the following: *baseline* (linear and quadratic distances to the nearest historical city); *location fundamentals* (latitude, longitude, the interaction between latitude and longitude, and both linear and quadratic distances to the US border and nearest port); *land characteristics* (altitude, surface area, and land suitability for staple crops); *demographic structure* (individuals in prime migration age, agricultural peons, indigenous-language speakers, and sex ratio); *labor markets* (unemployed population and US-Mexico wage gap); *landholding* (number of large estates and population living in large estates); and *living standards* (literacy, housing deprivation, and urban density). All continuous control variables are standardized. * = Significant at 10% level; ** = Significant at 5% level; *** = Significant at 1% level.

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