Long-Distance Trade and Long-Term Persistence*

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Abstract

Do changes in the location of trading opportunities lead to changes in the location of eonomic activity? This paper explores this question using a staggered lifting of restrictions on direct trade with Europe across the Spanish Empire. I combine a difference-in-differences approach with a dynamic spatial equilibrium framework and detailed georeferenced data on maritime travel from historical logbooks to examine this issue. I show that the reform improved market integration and induced urban growth. The effect was larger in places that were initially less populated. Moreover, I find that modern-day settlement patterns depend less on historical settlement patterns in areas subjected to the reform. Taken together, the findings show that the persistence of historical trading locations depend on the sequencing of urban growth and changes in international trade costs.

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1 Introduction

Understanding what determines the location of economic activity is a fundamental issue on the research agenda in economics. There is wide recognition that historical patterns of trade can play an important role by shaping the emergence and growth of cities. Many of the largest cities in the world had their growth initiated by access to long-distance trade in the past, although they have long ceased being important trading locations. Do historical patterns of trade dictate the location and size of cities today even if patterns of trade have changed markedly over time? Does the location of economic activity adapt to changes in the location of trading opportunities? If so, under what conditions?

To study these questions, I exploit a large-scale historical experiment: the expansion of direct trade with Europe in the Spanish Empire. Early Spanish commercial policy restricted the direct trade of goods with Europe. However, driven by political developments in Europe and dynastic changes in Spain, these restrictions were gradually lifted in the second half of the 18th century. While only four ports were permitted to trade goods directly with Europe in 1765, this number had increased to 45 by the beginning of the 19th century. By this time, no major ports in the empire were subjected to restrictions on the direct trade of goods with Europe (see Figure 1). The reform reduced trade costs in different years and different locations, generating variation that is well suited to study these questions for several reasons. First, while I show that the reform caused large and spatially heterogeneous variation in international trade costs, these changes were limited to the costs of trading goods. Second, the geographic scope of the reform allows us to consider its heterogeneous effects while keeping other long-run determinants of growth, such as formal institutions and legal origins fixed. Finally, compared to studies of single countries or regions, the geographic scope of this setting is compelling in terms of external validity.

I study the long-run impact of the reform in three steps. First, I construct a comprehensive panel of cities, settlements, and trade for the Spanish Empire in the 18th century. To quantify how the reform affected empire-wide shipping times, I construct a directed network of trade costs. For maritime shipping, I estimate accurate sailing speeds from historical maritime logbooks and georeferenced data on wind patterns. To model travel on land I account for a range of geographic factors shaping mobility historically, such as the slope, elevation, landcover, as well the location of roads and ports. I validate the resulting shipping times with various historical and contemporary sources. As there are many potential routes between any two cities, I use the route that minimizes shipping cost, subject to the restrictions on direct trade with Europe that were in place in a given decade. This results in time-varying bilateral trade cost matrices between all cities and settlements in the sample. These time-varying measures of bilateral shipping times are then matched with data on geographical characteristics, agricultural productivity, urban populations, and the locations of settlements to construct a balanced panel covering Spanish America during the 18th and 19th centuries.

I then use this dataset to study the reduced form effect of the reform on city emergence and growth. At the heart of the research design is a difference-in-differences approach, which compares changes in population growth in cities where trade costs changed differentially because of the reform. The identification assumption is that changes in population growth in such localities would have been the same in the absence of the reform. I challenge this assumption in several ways and provide evidence in support of a causal interpretation of the estimates. I document four main results. First, I show that the reform improved market integration between Europe and America which in turn increased the volume of trade. While the shipping time was 6 days lower on average, the decrease ranges from 0 to 27 days.[1] Next, I find that improved access to maritime trade increased urban growth and induced the formation of new settlements. In the preferred specification, a one standard deviation reduction in the shipping time (6.5 days) increases the urban population growth rate by around 8 percentage points. The effects are concentrated in less populous cities and regions. Consistent with these patterns, I show that the correlation between historical and contemporary population density is lower in areas more intensively treated by the reform. Taken together, the findings provide evidence that the location of economic activity adapted to the change in the location of trading opportunities. However, this happened to a larger extent in locations with smaller internal markets and therefore weakened the persistence of pre-reform settlement patterns.

To explore potential mechanisms driving the reduced form findings, I interpret the findings through the lens of a parsimonious dynamic spatial general equilibrium model that I calibrate to match the observed data.[2] The population can move freely among cities that differ in their productivity, their access to trade, and their availability of arable land which determines the urban carrying capacity. To accommodate the long adjustment process documented in the reduced form, agglomeration economies are dynamic and depend on both contemporaneous and historical population following (Allen and Donaldson, 2020). The model therefore permits path dependence, where initial conditions determine the allocation in the long run. The parameters of the model are chosen to rationalize key moments of the data, such as the model simulated impact of the reform to the reduced form estimates. The identification relies on the assumption that *changes* in the value of geographical fundamentals were uncorrelated with changes in population during the reform period, conditional on a large set of controls. While this is an untestable assumption in practice, the reduced form evidence, and in particular, the absence of pre-trends, provides support for it.

Since the dynamic agglomeration economies are found to be positive, a key insight of the framework is that the population size depends on the historical path of trade costs and the model can therefore account for the reduced form findings. The reform induced population growth in cities that experienced reductions in trade costs through lowering the price of traded goods. However, the effect depends on the pre-reform market size of the city and had smaller effects on the cost of living in locations with a larger home market. Moreover, historical trade costs have a persistent impact, but not as a result of multiple equilibria or path dependence. Rather, the persistence is driven by a slow adjustment process to a new equilibrium. Finally, the model accounts for the reform attenuating the relationship between historical and contemporary population density. In particular, changes in trade costs attenuate the persistence of historical settlement patterns through disproportionally increasing economic growth in less populous locations. In conclusion, the findings show that city growth adapts to changes in the location of trading opportunities, but support the view that the adjustment is contingent on the city size as these changes occur. An important determinant of the

[1] The calculated travel times are validated with several historical and contemporary datasets. For example, I provide evidence that the calculated sailing times are highly correlated with mail dispatch times and recorded travel times in the 18th century.

[2] More generally, the model builds on recent quantitative models of trade and geography, which accommodate a large number of locations that are asymmetric in their locational characteristics and frictions to trade and migration (Redding and Rossi-Hansberg, 2017).

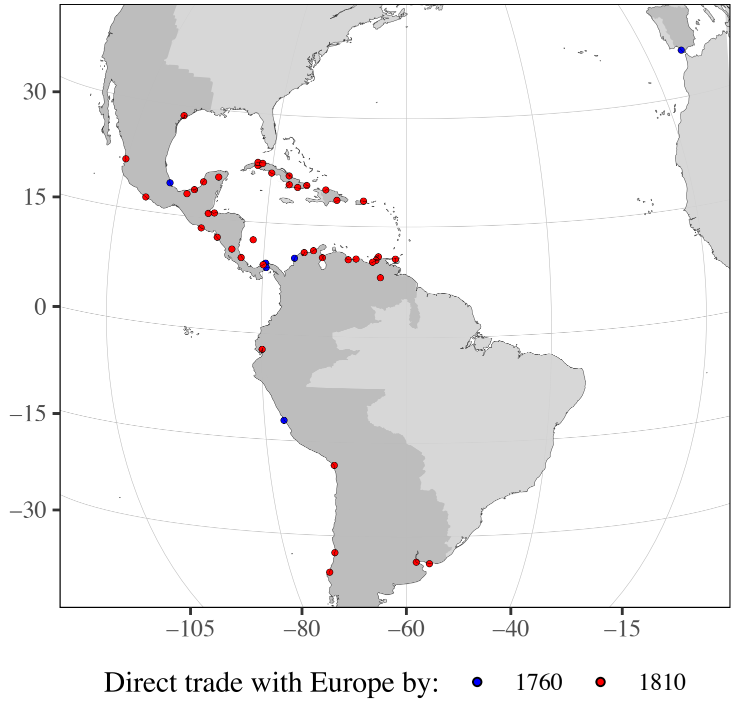

Figure 1: This map depicts the extent of the territory claimed by the Spanish Empire in 1790 with its ports marked according to status. Ports marked in blue were licensed for direct trade with Europe prior to 1765 (Callao, Cartagena, Veracruz, and Panama), while those marked in red were licensed to trade with Europe in 1810.

persistence of historical trading opportunities is therefore the sequencing of economic growth and changes trade costs.

This paper contributes to the literature on the determinants of persistence in urban economics and economic geography. Persistence in the location of economic activity is consistent with both the importance of natural advantages (Davis and Weinstein, 2002; Maloney and Valencia, 2016; Bosker and Buringh, 2017; Alix-Garcia and Sellars, 2020; Bakker et al., 2021) and multiple spatial equilibria (Krugman, 1991; Redding, Sturm and Wolf, 2010; Bleakley and Lin, 2012; Michaels and Rauch, 2018). While persistence in the spatial distribution of economic activity remains well-documented, little is known about what drives the degree of persistence across different locations. This is puzzling since Henderson et al. (2018) show that the importance of historical locational fundamentals differs substantially across countries. This paper contributes to the literature by exploring the drivers of persistence in the location of economic activity and by establishing a relationship between persistence and international trade costs. The paper therefore builds on a literature emphasizing the importance of international trade in shaping the economic geography within countries. Earlier contributions emphasized the role of trade openness in determining spatial concentration in stylized settings (Henderson, 1982; Ades and Glaeser, 1995; Krugman and Elizondo, 1996), while later studies have explored the effect of trade on a range of outcomes in models accommodating rich geographies (Fajgelbaum and Redding, 2014; Coşar and Fajgelbaum, 2016; Nagy, 2018). This paper builds on this literature by exploring the effects of changes in the trading environment on the location of economic activity in the very long run and by quantifying the role of trade in shaping persistence in the location of economic activity.

This paper also contributes to the literature exploring the long-term economic impacts of historical institutions, (Acemoglu, Johnson and Robinson, 2001, 2002; Nunn, 2008; Dell, 2010) and the economic legacy of the Spanish Empire in particular (Grafe and Irigoin, 2006, 2012; Bruhn and Gallego, 2011; Engerman et al., 2012; Valencia Caicedo, 2019). Acemoglu, Johnson and Robinson (2002) establish a negative relationship between population densities in 1500 and today at the country level. They show that lower initial population density necessitated institutions that enabled broader participation in the economy. These institutions were in turn more conducive to sustained economic growth and therefore contributed to a divergence between areas with different population densities in 1500 beginning in the second half of the 18th century. Other important contributions emphasize the role of migration from Europe in generating this reversal (Chanda, Cook and Putterman, 2014; Easterly and Levine, 2016). This paper complements these findings by highlighting the role of trade-related institutions. The results are consistent with the view that the *reversal of fortune* in the Americas is rooted in institutional change but also highlight the importance of the factors that shaped institutions governing trade, such as the transition from Habsburg to Bourbon rule in Spain, in addition to more localized differences in property rights, of which Acemoglu, Johnson and Robinson (2002) emphasize the importance. More broadly, this paper provides evidence of the impact of trade-related institutions on long-run economic development, which has received little attention in the literature (Jha, 2013; Jia, 2014; Alvarez-Villa and Guardado, 2020).

Finally, the findings contribute to the empirical literature on the effects of international trade on economic development. The literature using reduced-form approaches have documented sizeable impacts of trade on national income (Frankel and Romer, 1999; Feyrer, 2009, 2019; Maurer and Rauch, 2019), while papers relying on structural approaches find more modest effects (Arkolakis, Costinot and Rodríguez-Clare, 2012). However, studying the diffusion of steamship technology in the late 19th century, Pascali (2017) finds little evidence of improved trade integration on economic development, except in countries with inclusive institutions. This is consistent with increased access to trade inducing some countries to specialize in sectors that have fewer growth-enhancing externalities (Grossman and Helpman, 1990), are more volatile (Blattman, Hwang and Williamson, 2007), have weaker economies of scale (Matsuyama, 1992; Krugman and Venables, 1995), or negative effects on institutions (Acemoglu, Johnson and Robinson, 2005; Puga and Trefler, 2014). The findings in this paper complement this literature by providing evidence that trade can promote economic development *within* countries even in contexts with highly extractive institutions. Relatedly, the paper contributes to the debate on the sources of the growth of world trade in the 19th century (Estevadeordal, Frantz and Taylor, 2003). In particular, the paper provides empirical evidence on the importance of institutions governing trade and supports the view that the relaxation of mercantilist policies contributed to market integration in the early 19th century (O'Rourke and Williamson, 2002; O'Rourke, 2006).

This paper is structured as follows. Section 2 presents the historical background. Section 3 presents the data sources. Section 3 provides details the calculation of trade costs. Section 5 elaborates on the reduced-form research design, results, and mechanisms. Section 6 presents the model and the results of the quantitative exercise. Section 7 concludes.

2 Historical Background

This section provides the historical background for the analysis. I outline the institutional setting, the motivation for the trade reform as well as the historical relationship between trade and economic development within the Spanish Empire in America.

The Spanish commercial system. A central aim of commercial policy in the 18th century was to promote state wealth acquisition through trade surpluses (Findlay and O'Rourke, 2007). In the Spanish context this was achieved through a range of policies restricting trade. First, trade was restricted to four ports in the Americas (Cartagena de Indias, El Callao, Portobello/Nombre de Dios, and Veracruz) and only Seville/Cádiz in Europe. Further, the frequency of travel and the routes were restricted.[3] Third, participation in Atlantic trade was restricted to Spanish merchants. Finally, there were high tax rates on imports and exports.[4] These measures effectively monopolized trade in the merchant guilds in Seville (later Cadiz), Mexico City, and Lima. These cities in turn managed trade with other locations in their respective viceroyalties, typically transported by third parties using mule trains (*recuas*) or wagons (*carros*) depending on road conditions. The system limited trade with Europe across large parts of the Spanish empire in America, however, there was still limited maritime communication and trade with locations too remote to the large trade routes. In addition to dispatch ships (*avisos*), ships sailing under special permission of the crown (*registros*) occasionally supplied ports that were too remote relative to the large trade routes. However, this was never done at a sufficiently large scale (Walker, 1979) and increased the reliance on contraband trade which was sizeable (Christelow, 1942). While as a rule, there were no restrictions on inter-regional trade (Elliott, 2006, p. 111), there were cases where inter-regional was discouraged.[5]

Mercantilist restrictions and high trade costs ensured that trade was limited to non-competing goods with a high value-to-weight ratio. Important exports during the period beyond precious metals were hides, tallow, sugar, indigo, and cochineal (Rahn Phillips, 1990).[6] However, the measures facilitated naval defense of convoys and limited imports to the Americas, thus limiting the flow of bullion to other places than the Iberian Peninsula while keeping prices for Spanish exports artificially high. It also facilitated the managing of risk in a context where long shipping times and costly communication made it difficult to predict demand (Baskes, 2013). As a result, in addition to remittances directly controlled by the crown, private remittances to Spain were substantial (Cuenca-Esteban, 2008). However, a likely consequence of Spanish mercantilist policies before the liberalization

[3]Typically, only two fleets left Spain every year: the New Spain *flota* destined for Veracruz, and the *Tierra Firme galeones* destined for Cartagena and Portobello. In the Pacific, shipping was conducted by *Armada del Sur*, which carried goods from the trade fairs in Portobello to Pacific ports in South America (Walker, 1979). Moreover, the Manilla galleon would sail between Acapulco and Manilla. Official information was carried by *aviso* ships, which were light carriers operating separately from the commercial system and were not permitted or equipped to carry freight.

[4]The duties typically depended on the origin of the goods, with lower rates on goods originating from Spain.

[5]For example, there were policies in place to limit trade between the Viceroyalties of Peru and New Spain to reduce the demand for the goods of the Manilla Galleon in Peru. Another example is the erection of a customs barrier in Córdoba (Argentina) in 1618 (Scobie, 1971, p. 53)

[6]The slave trade was subject to different rules. Trade of slaves was allowed for British ships from early to the mid 18th century as a result of the treaty of Utrecht, the *asiento* (Walker, 1979).

in the late 18th century was the underdevelopment of peripheral areas in America (Fisher, 1997, p. 73).

Reforming transatlantic trade. Beginning in the 18th century, Spanish policymakers were induced by geopolitical considerations, originating mainly in Europe, to overhaul the external trading system (Elliott, 2006). In the immediate aftermath of Spain's defeat in the Seven Years' War, a special *junta* was appointed under Charles III to "review ways to address the backwardness of Spain's commerce with its colonies and foreign nations" Stein and Stein (2003). Drawing on ideas for reforming the system of government in America that had been circulating for a long time, the *junta* proposed the abolition of the Cádiz monopoly as well as the fleet system. Further, it proposed opening 14 ports on the Iberian Peninsula as well as 35 ports in the Americas (Fisher, 1997).[7] Several ports in the Caribbean were opened already in 1765 (see Table 3).[8] Further, reform was slowed by the Esquilache riots in 1766 and the liberalization measures culminated in the decree of free trade in 1778, which opened several of the remaining ports.[9] In the 1780s, the remaining ports followed. Spanish communication with the Americas was disrupted during the Napoleonic wars (O'Rourke, 2006). Out of necessity, trade with neutral nations was therefore allowed. This marked the end of Spain's ability to enforce protected trade with the colonies. By the beginning of the 19th century, Spanish America enjoyed *de facto* although not *de jure* unrestricted trade with foreigners (Fisher, 1998). As a result, direct trade with Britain, not mediated through Spain, grew in importance (Prados de la Escosura and Casares, 1983). Independence was mostly followed by high tariffs, mainly driven by the revenue needs of post-independence governments (Coatsworth and Williamson, 2004).

The historical literature emphasizes the role of European interstate competition and the resulting increased need for a modernized imperial defense as motivating the reform. Thus, the drive to reform the Spanish commercial system can be understood as being motivated by the intense interstate competition between the European states of the 18th century (Kuethe and Andrien, 2014). Highlighted in the historical literature as an important impetus for the reform was the "humiliating" capture of Havana and Manila by the British during the Seven Years' war. This opened a window of opportunity for reform-minded policymakers in Spain who now could justify reforming the commercial system with concerns about the territorial integrity of the empire in what has been described in the historical literature as a "defensive modernization" (Stein and Stein, 2003). The reform was therefore implemented rapidly after the Seven Years' War (Fisher, 1997). Furthermore, the commercial expansion of Havana during the British occupation showcased the economic potential of the Spanish colonies. As a result, the timing of the reform is mainly driven by intensified interstate competition in Europe, rather than economic development in the Americas directly. Moreover, the reform was implemented from above, and no significant ports in which the policies were applied were excluded. This is also apparent from the fact that the policies were resisted by powerful interests

[7] The ports that were opened on the Iberian peninsula in this period was Malaga, Almería, Cartagena, Alicante, Tortosa, Barcelona, Santander, Gijón, La Coruña, Palma de Mallorca, Santa Cruz de Tenerife. While the reform is believed to have a role in promoting the rise of the Barcelona textile industry, in the early 19th century, around 80 percent of Spanish trade with the Americas still went through the port of Cádiz (Fisher, 1997).

[8] Santo Domingo, Puerto Rico, Margarita, and Trinidad were opened for direct trade with Spain in 1765.

[9] This was with the exception of Venezuela (Caracas), where it was believed the Caracas companies tobacco monopoly was worth protecting, and New Spain. Even so, especially Veracruz was affected by the changes before the late 1780s due to the abolition of the convoy system and the increased prevalence of register ships.

in the Spanish Empire (Baskes, 2013). Finally, the decision of which ports to open is unlikely to be driven by the perceived commercial potential of its hinterland. This is best illustrated by considering the case of New Spain. As the most important colony of the Spanish empire in America, it was believed New Spain would have diverted too much trade away from other regions (Fisher, 1997). Also avoiding confrontation with merchants in New Spain whose resources were a key source of revenue for the crown was important. As a result, New Spain was not subject to the reform until the late 1780s.

"Free trade" and economic development. It is generally agreed upon that the reform increased trade. This was recognized by contemporaries as well as in the historical literature.[10] The magnitudes in the economic history literature are contested however (Cuenca-Esteban, 2008). Colonial imports to Spain increased tenfold and exports from Spain to the colonies fourfold according to Fisher (1985), while more modest estimates are found in Cuenca-Esteban (2008), also suggesting large effects (see Figure 2). However, while the reform stimulated trade, the terms of trade in many ports presumably remained depressed (Francis, 2017). Fisher (1993) provides data on the composition of Spanish imports from Spanish America between 1782 and 1796 for the ports of Cadiz and Barcelona (which accounted for around 88 percent of imports from Spanish America). Precious metals still accounted for 56.4 percent of imports through this period. The other commodities were typically high-value agricultural commodities (tobacco 13.6, cacao 7.8, sugar 5.5, indigo 5.2, cochineal 4.2, hides 3.4 and cotton 0.4 percent Fisher (1993)) (see Figure 3). Cadiz remained the dominant port for trade with Spanish America between 1778 and 1796 (76.4 percent of total exports and 84.2 percent of imports).[11]

Some accounts highlight that the lower trade costs induced by the reform promoted agricultural development. "...for the first time, the metropolis succeeded in unleashing the agricultural potential of its American possessions whilst also promoting the continued expansion of mining production. The relationship between this economic growth and the liberalization of trade is abundantly clear", (Fisher, 1997, p. 197). Moreover, lower trade costs induced by unrestricted sailing potentially allowed for specialization in a wider range of commodities, such as more perishable goods. However, bullion remained an important export commodity (Fisher, 1997, p. 38). Moreover, it has been argued that the population and economies of previously stagnant peripheral colonies in Spanish America grew rapidly (Mahoney, 2010). In summary, the historical literature suggests the restrictions imposed on trade in goods with the Americas stunted economic development, and efforts induced by European interstate competition to relax these marked the beginning of a process that would have large effects on trade and affect economic development in the second half of the 18th century.

[10] Floridablanca (minister under Charles III) wrote about a fortunate revolution (*feliz revolución*) when referring to Spanish export growth after 1778. When referring to Veracruz, a recent immigrant described that the city went from "gloomy and ugly" to "elegant and growing" (Stein and Stein, 2003).

[11] The remaining important ports were Barcelona (9.6 and 3.8 percent), Malaga (4.8 and 1.3 percent), Santander (3.3 and 2.6 percent), and La Coruña (3 and 6.8 percent) (Fisher, 1993, p.20 and p.25).

3 Data

To quantitatively assess the impact of the reform, I construct a dataset containing geographical, demographic, and economic data of the Spanish Empire in the 18th and 19th centuries.[12] The main dataset covers the 100 year-period 1710-1810, roughly corresponding to the Spanish Empire under the Bourbon dynasty. I restrict the sample to locations that were claimed by Spain throughout the period.[13] Summary statistics of the main variables can be found in Table 1 and 2.

Population. As a starting point, I use city-level population data from Buringh (2013). Following Bairoch (1988) they apply a threshold rule and collect data on cities with a population exceeding 5,000 inhabitants in 1850 or 20,000 inhabitants in 2000. I restrict the sample to cities with data recorded for 1750, the last measurement before the reform, which constitutes 297 cities. Following Arroyo Abad and Zanden (2016), I supplement and expand this data source by digitizing population data from the historical literature. Details on the sources and approach are provided in the Appendix. I further supplement the dataset territorial gazetteer of around 15,000 places that existed in the Spanish Empire during the 18th and early 19th-century (Stangl, 2019*b*). The dataset is based on official records as well as various secondary sources.[14] It contains the founding, legal status, position in the ecclesiastical hierarchy, as well as the longitude and latitude of each settlement. In the main analysis, I restrict the sample to places with the status of city, town, or village to capture the location of population centers.[15] Altogether, the final dataset contains 2,125 places spanning 1710 and 1810, and henceforth, I refer to these as settlements. Data on pre-colonial population density is from Denevan (1992), which combine the most recent available geographical, anthropological, and archaeological findings (Maloney and Valencia, 2016).[16] For New Spain and Peru, more detailed data is available for the colonial period. For these locations, I digitize data on population and tributary density from Gerhard (1993*a*,*b*,*c*) and Cook (1981). Finally, I include data on contemporary population density from the Gridded Population of the World, which is distributed by the (CIESIN) at Columbia University.

Sailing and trade. To estimate the sailing speeds, I combine information on maritime logbooks with data on wind patterns. To calculate average sailing speeds I use logbooks from the CLIWOC database (Climatological Database for the World's Oceans) (García-Herrera et al., 2005). The data was

[12]The contemporary countries partly or entirely contained in the sample are Argentina, Brazil, Chile, Bolivia, Peru, Uruguay, Ecuador, Colombia, Paraguay, Venezuela, Panama, El Salvador, Honduras, Costa Rica, Guatemala, Mexico, Nicaragua, Cuba, the United States, and the Dominican Republic.

[13]This mainly excludes parts of what today are Brazil, Louisiana, and Florida. These locations had limited trade with Spain throughout the period.

[14]"Sources include archival material like census tables, mission reports, visitations of dioceses and provinces, but also more ephemeral documents like petitions of some city council which was mostly not written for giving geographic information but may touch one specific detail or incidentally exposes some relevant information. Non-archival contemporary sources include mostly highly systematic sources for information like so-called "Foreigner Guides" (printed calendar-manuals which included also lists of office holders of many parts of the Empire), maps, or geographical descriptions both printed and manuscripts." (Stangl, 2018).

[15]This avoids common pitfalls associated with using population thresholds for defining a settlement. The status of city was the highest legal status afforded a population center in Spanish America and was typically granted by the crown. Below the city in the hierarchy was the town (*villa*). In some cases, settlements were abandoned (such as Buenos Aires) or moved (such as Guatemala). In these cases, the date of founding is the founding of the first city in both cases. The location of the place is determined by the functional center. For example, a place served as a marketplace, the dataset includes the location of the marketplace. A place with a primarily religious function records the location of the church and so on.

[16]The data used in this paper have been made available by Bruhn and Gallego (2011) and Maloney and Valencia (2016).

originally compiled for studying historical oceanic climate conditions and contains around 280,000 logbook entries for Spanish, Dutch, French, English, and Swedish ships between 1750 and 1850. The logbook entries contain the daily longitude and latitude, wind speed and direction as well as several voyage-level characteristics such as the ship name, origin, and destination, captain name, and ship type.[17] Information on the average velocity and direction of the sea-surface winds by 0.5° $\times$ 0.5° cells for each week between 2011 and 2017 is from the US National Oceanic and Atmospheric Administration (NOAA).[18]

I digitized data on trade flows come from two separate sources. First, data on trade between Spain and America at the port-level is primarily from Fisher (1985) and Fisher (1993). These data have been compiled from primary sources, mainly from the General Archive of the Indies in Seville. It contains data on the share of Spanish foreign exports to the 19 largest American ports as well as the total value (measured in *reales de vellón* in constant prices). Moreover, it contains data on the composition of trade and the number of ships arriving at Cadiz from a range of American ports. I also digitize data on prices in Spain (Castille) using data from Hamilton (1947) and use price data from GPIH.[19] Data on the slave trade is from Behrendt et al. (1999).

Geography and infrastructure. I use data on agricultural suitability measures from FAO's Global Agro-Ecological Zones under rain-fed, low-input agriculture for six important staple and export crops. The staple food in Mexico and the Andean countries was maize while wheat was the important staple in Chile and Argentina. Important export crops were cotton, tobacco, sugarcane, and cacao which constituted around 27.3 of total exports from Spanish America to Spain in this period (Fisher, 1993). I supplement these data with the maximum attainable caloric yield using data from Galor and Özak (2015, 2016). The potential caloric yield is chosen because the relative caloric content is economically important in a pre-industrial context, moreover it isolates features of the natural environment affecting attainable yields, but that are exogenous to human intervention. Information on urban nominal wages (measured in grams of silver) is from Arroyo Abad, Davies and van Zanden (2012). Furthermore, I calculate the terrain ruggedness index, average slope, and elevation. Information on climatic variation is from Hijmans et al. (2005).

I collect data on the location and trading status of each port is from the decree *Reglamento y aranceles reales para el comercio libre de España a Indias de 12. de octubre de 1778* (Ramíres Bibiano and Ortíz de la Tabla, 1978), as well as Fisher (1997). I validate these sources with various other secondary sources. The list of ports can be found in Table 3. Further, I include the location of the principal mining centers (*Reales de Minas*) in the 18th century from Fisher (1997).[20] Together, mining, cotton, tobacco, sugarcane, and cacao exports make up around 83.7 of all exports from Spanish America to Spain in the period. Finally, I use mail routes to proxy for the location of roads (Stangl, 2019*a*). I include controls on potential vegetation to proxy for different geographical fundamentals as well as using landcover to calculate travel speeds (Ramankutty and Foley, 1999). Navigable rivers played a less important role in trade than in Europe and the United States. Therefore, I only control for

[17] In the case of Spanish ships these are *paquebote*, *fregata*, and *navio*.

[18] For cells covering land, the wind speed is set to zero to prevent routes from crossing land.

[19] Available at `https://gpih.ucdavis.edu/`.

[20] I identify in total 78 locations across the Spanish Empire mined for silver, mercury, gold, salt, emeralds, copper, platinum, or iron.

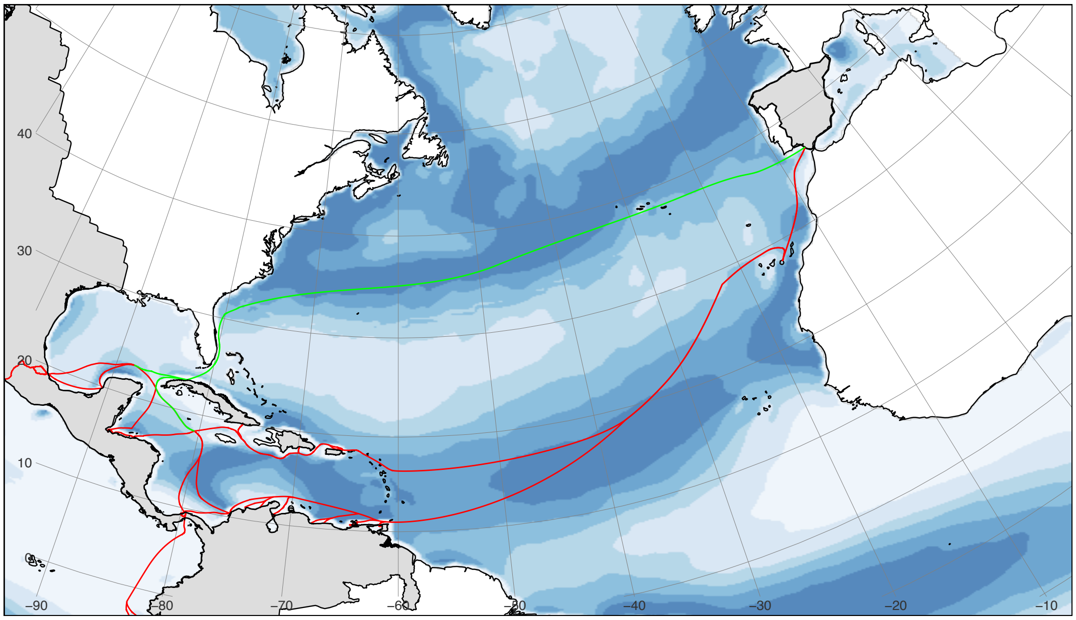

Figure 6: The figure depicts the cost surface of maritime travel between 1750 and 1850. The map plots the average cost for each 1°×1° grid-cell where darker colors indicate higher predicted sailing speed. Grey areas denote territory claimed by the Spanish Empire in 1790. The cost surface is calculated from predicting sailing speeds from wind direction and speed. The estimated relationship is the extrapolated on gridded data of wind direction and wind speeds covering the world oceans. The red and green lines denote historical trade routes. Red denotes the westward journey while green denotes the eastward journey. Source: NOAA and CLIWOC.

time-varying effects of distance to waterways and fresh-water access by using data from Natural Earth.

4 Shipping Times and Trade Costs

I compute trade costs between locations in the Spanish Empire in the 18th century. While trade costs in this context are a function of a range of factors, I exploit that trade costs have been widely documented to be affected by distance both in contemporary and historical settings (Flückiger et al., 2019; Barjamovic et al., 2019). I leverage this by constructing a directed graph, where nodes denote localities and edges the shipping times to all adjacent nodes (measured in days). Shipping times are calculated based on predetermined first-order determinants of mobility in Spanish America, such as wind patterns, elevation, and infrastructure constructed before the reform. Using the graph, I calculate time minimizing trade routes each decade, accounting for which ports were allowed to trade directly with Europe. This section further elaborates on the procedure.

4.1 Estimating Trade Costs

Maritime transportation. I estimate the sailing speed by using information from maritime logbooks in the 18th and early 19th centuries. From each logbook entry, I extract information on recorded wind speed, wind direction, and travel direction. I follow Kelly and Ó Gráda (2019) and remove observations for which either the inferred speed is implausibly high (above 10 knots), or are located in coastal areas. Figure 4 panel (a) shows the distribution of recorded wind directions and panel (b) travel speeds. The figure shows that the average sailing speed was around 5 knots and that most sailings took place in the direction of the wind or at 90 degrees where sails work most efficiently (Pascali, 2017; Kelly and Ó Gráda, 2019). To estimate the relationship between wind direction, wind speed, and sailing speed, I consider the following equation,

$$S_i = e^{f(\theta_i, ws_i)+\epsilon_i}, \tag{1}$$

where ws_i measures the wind speed in grid-cell i, θ_i measures the deviation of the angle between the wind direction and direction of travel, S_i denotes the sailing speed, and ϵ_i is an error term. Given a large number of features, Equation 1 is estimated using an elastic net where tuning parameters are chosen optimally using 10-fold cross-validation (Zou and Hastie, 2005). The full sample ($N = 37,141$) is then split into a training sample (80 percent of the sample) and a validation sample. I fit the model on a training sample and then test its performance in a validation sample. The model predicts sailing speed accurately (with a mean absolute error of 1.48 in the preferred model). Next, I average weekly high-resolution data on wind speed and wind direction from NOAA over the period 2011-2017. For every node in the graph, I then calculate the predicted sailing time between all adjacent nodes using $\hat{S}_i$.[21]

Overland transportation. Mules were the most common means of bulk transportation for most of the colonial period up to the second half of the 19th century. For the case of New Spain, there were typically groups of 50 pack animals (*recuas*) with one individual (*arriero*) per five animals, each carrying a load of around 113 kilograms (Hassig, 1993). I calculate the costs faced by shipping with pack animals using geographical features, drawing on least-cost analysis tools from archaeology (White, 2015). The pace will depend on whether travel occurs on road, the slope of the terrain, the elevation, and the land cover. The predicted speed of travel between node i and j is given by W_{ij} and based on the Tobler function (Tobler, 1993),

$$W_{ij} = \kappa_i \times 6.096 \times e^{-3.5|\text{sl}_{ij}+0.05|-\gamma \text{elev}_i} \tag{2}$$

where sl_{ij} measures the slope between cells i and j, κ_i is a coefficient determined by the landcover in cell i, and elev_i denotes the elevation in meters ($\gamma = -0.0001072$).[22] As a consequence, travel on flat terrain at sea level the predicted speed is around 5 kilometers per hour. To adjust for differences in landcover, I rely on coefficients from Weiss et al. (2018). Five terrain types have a natural mapping between historical land cover data and the terrain coefficients.[23] I rely on data on official routes for mail in the Spanish Empire during the Bourbon period to proxy the location of roads. Travel on a road is affected by the slope and elevation, but not the landcover. The walking speed is then used to

[21] The graph is weighted again to account for the fact that the distance between the nodes of the graph varies due to their relative position as well as curvature of the earth.

[22] While Equation 3 models walking speed, the use of pack-animals will not have affected the speed much since these were typically accompanied by humans on foot (Verhagen, Joyce and Groenhuijzen, 2019).

[23] These are tropical forests, temperate forests, desert, savanna, and shrubland. The terrain factors are 0.324 in a tropical forest, 0.648 in a temperate forest, 0.97 in a savanna, 0.6 in shrubland, and 0.6 in deserts. Inland water can be crossed at half the speed (Herzog, 2014).

construct the time required to travel between all nodes.[24]

Least-cost path problem. Once the duration of passing between all adjacent cells is known, I calculate the bilateral travel time between all cells by searching for the cost-minimizing route of getting from a cell i to any other cell j along the graph. Since there will be many alternative routes to ship a good between localities i and j, I assume goods shipping follows the time-minimizing route according to the Dijkstra algorithm (Dijkstra, 1959) (see Figure 5 for an example). Beyond sailing speed, the turnaround time in port shapes the total sailing time of a route. Since it is not clear whether turnaround times improved over time (Rönnbäck, 2012), I assume these are constant at zero as a starting point. Moreover, I model Europe as a point-like country centered on Cadiz containing the population mass of Spain, the United Kingdom, and France in 1700. I choose Cadiz because the majority of legal trade with Europe was channeled through this port throughout the period.[25] This approach results in a $R \times R$ dimensional matrix of bilateral travel times between all the cells, $\mathbf{T}_t[T_{ij} \geq 1]$. I calculate one matrix for every decade, accounting for which ports were open to direct trade with Europe in a given decade, and I refer to $\mathbf{T}_t$ as the travel time matrix in decade t.[26]

Shipping time elasticity. Finally, I calculate the elasticity of the value of trade with respect to shipping time. I estimate the following equation,

$$\ln X_{jt} = \alpha_r + \gamma_t + \beta \ln \mathrm{T}_j + \epsilon_{jt}, \tag{3}$$

where X_{jt} is the value of exports from Spain and port j in year t. α_r accounts for regional heterogeneity that is unlikely to be driven by shipping time, for example route-specific factors such as risk caused by weather variability or privateering along the route.[27] Finally, γ_t accounts for year-specific factors affecting trade during the period, such as interstate conflict. A challenge is that missing data on bilateral trade between American ports prevent me from fully accounting for multilateral resistance terms, which arise in a large class of trade models (Anderson and Wincoop, 2003). However, since trade in this context was a closed system, trade with third countries is less of a concern in the current context.

4.2 Assessing the Shipping Times

I validate the estimated shipping times in different ways. First, I find a close correspondence between predicted trade routes and the location of known historical trade routes.[28] An example is illustrated in Figure 6. I quantitatively assess the quality of the estimates in three ways. First, I

[24] Özak (2018) develops a *Human Mobility Index* to calculate pre-modern travel times. This measure is not appropriate in this context because I use context-specific features such as the location of paths and maritime technology available during the period.

[25] For the case of Great Britain the share of direct trade with Latin America became the most dominant towards the end of the colonial period, starting in the early 18th century (Prados de la Escosura and Casares, 1983).

[26] In the baseline case R = 5,573.

[27] The decline in piracy and privateering has been highlighted as an important source of productivity growth in shipping in the first half of the 18th century (North, 1968). These factors had become less important towards the end of the 18th century (Hillmann and Gathmann, 2011).

[28] For example, Pacific and Atlantic ports are connected by the Panama isthmus, Mexico City is connected to maritime trade through Veracruz and Acapulco, and Potosi and Arica with Callao.

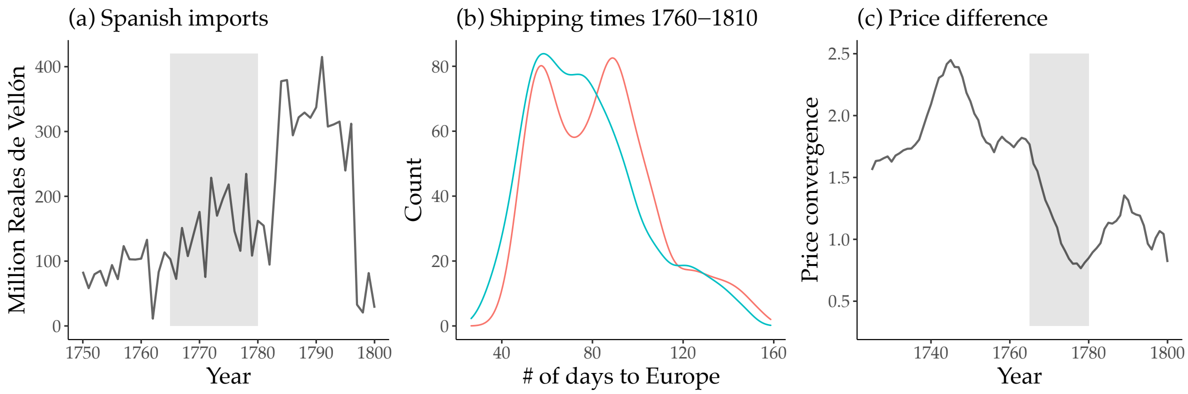

Figure 10: Panel (a) depicts the value of private non-bullion imports to Spain from American ports between 1750 and 1800 at constant prices. The shaded area denote the main reform period. Data for 1780 is missing in the original data source (imputed with average for the whole period). Data are from Cuenca-Esteban (2008). Panel (b) depicts the number of days' travel from a grid-cell to Europe in 1760 (red) and 1810 (green) for the grid cells in the sample. Panel (c) depicts the difference in the average log price for commodities (salt, sugar, cinnamon) in Spain (Castille) and cities in Spanish America (Buenos Aires, Potosí, Lima, Bogotá, Santiago de Chile, Mexico City).

compare the results to measures sailing times according to a database of bilateral sailing times.[29] For each port, I calculate the sailing time from Europe (Cadiz) to all the ports in the dataset for which the website records information. The average speed of 5 knots is used, the average speed of Spanish freight ships in 1750 (Kelly and Ó Gráda, 2019). For shipping on land, I compare the calculated shipping times with walking times using the Human Mobility Index Özak (2018) as well as google maps. Finally, I assess the correlation between predicted travel time and the duration of mail dispatches between major ports in Spanish America (Baskes, 2013). Figure 7 shows that these alternative shipping time measures are highly correlated with the measure developed in this paper. Furthermore, I assess the correlation between historical and contemporary wind patterns. There is a strong correlation between wind speed and direction in these two datasets. A remaining concern is that changes in maritime technology changed the relationship between distance and trade costs over the period. However, improvements in maritime technology were unlikely to be the most important determinant of productivity gains in shipping before the 19th-century (North, 1968; Harley, 1988; Menard, 1991).[30] Since maritime productivity gains were limited, potential measurement error in travel times is unlikely to be changing over time. Taken together, the exercises show that the determinants of trade costs emphasized in the estimation were important in the context.

5 Reduced-Form Evidence

In this section, I use the calculated changes in trade costs to examine the effects of trade on the location of economic activity and economic development. I document four main results.

[29] A database of bilateral sailing times between major ports around the world. Data available at `seadistances.org`.

[30] This view has recently been challenged by (Kelly and Ó Gráda, 2019). However, they show that Spanish sailing speeds remained stagnant throughout the period of this study.

5.1 Results

Fact 1: *Lower shipping times promoted market integration.* To assess the effect of the reform on market integration, I first consider the evolution of trade during the reform period. The value of Spanish non-bullion imports from the Americas is shown in Figure 2a. While there is no secular increase in imports before 1765, there is a positive trend coinciding with the reform. After the largest wave of port openings in 1778, the value of trade increased nearly fourfold.[31] Exports from Spain exhibit similar patterns as is displayed in Figure 2. How was this increase distributed across different ports? Figure 9 displays the number of ships and the total value of imports to Spain originating in treated ($\Delta T > 0$) and untreated ($\Delta T = 0$) ports. There is an increase in the number of ships and the value of imports originating in both treated and non-treated ports, however, the increase is substantially larger for the treated ports. Before the reform, the number of ships arriving in the treated ports was limited (see e.g. Walker, 1979, p. 230, for the number of register ships arriving in Spanish America 1701-1740). The effects are unlikely to be driven by changes in contraband for three reasons. First, smuggling is less likely to be an issue when considering imports to Cadiz which was the port most closely monitored by the crown (Fisher, 1985, p. 32). Second, estimates of the extent of smuggling are too small to account for the large increase in trade. Finally, the increase not only in the value of trade but also in the number of ships is not consistent with smuggling explaining the increased trade volume.

What drove this rapid increase in trade? It remains possible that the growth is partly driven by increases, income, or productivity that happened to coincide with the reform in treated ports. Figure 2b presents the change in shipping time between 1760 and 1810 induced by opening ports for direct trade with Europe. The red curve denotes the shipping times in 1760, while the green curve the distribution of shipping times in 1810. As can be seen from the figure, there is an overall shift to the left in the distribution of shipping times. The shipping time is 6 days lower on average. The reduction ranges from 27 days shorter shipping to no changes for several locations. These reductions are relative to a pre-reform average of around 83 days. As a result, the reduction in shipping times and trade costs induced by the reform is economically significant.[32] Table 4 shows the relationship between shipping times and the value of exports from Spain between 1797 and 1820. Across all the specifications, there is a negative relationship between the shipping time and the value of trade. As a result, the reductions in shipping times induced by the reform are consistent with an increase in trade with Europe. To further corroborate that improved market integration was a key driver for the trade growth, I leverage information on price differentials for various commodities (salt, sugar, cinnamon) in Spain and various cities in Spanish America. Figure 2c shows the average log price differential calculated in five-year periods over the 18th century. For these commodities, there is a reduction in the price differential also coinciding with the reform. A t-test for the average price differentials being different before and after 1765 rejects the equality at conventional levels of significance. Taken together, the timing of the increases in trade, the substantial reduction in trade costs, and price convergence provide evidence that the disproportional growth in trade among treated ports is driven by market integration.

[31] The slightly delayed response is explained by the Spanish involvement in the American Revolutionary War which disrupted trade.

[32] Figure 11 shows the spatial distribution of the changes in trade costs.

reform promoted market integration.

Fact 2: *Lower shipping times induced urban growth.* Next, I explore how the change in shipping time to Europe affected urban population growth. Consider a specification of the following form,

$$\ln L_{it} - \ln L_{it'} = \gamma_t + \beta \Delta T_i + \phi x_{it} + \epsilon_{it}, \tag{4}$$

where L_{it} is the population in city i at time t , ΔT_i measures the change in the number of days of travel from the city to Europe, x_{it} is a vector controlling for geography, climatic characteristics, disease environment, and historical resource availability, and ϵ_{it} is an error term potentially spatially correlated across nearby locations. To control for mean reversion and differences in population growth depending on city size (Duranton and Puga, 2014), I control for the initial population in some of the specifications.[33] In the baseline specification, standard errors are clustered at the level of the closest port.[34] The coefficient β captures the effect of a one standard deviation change in ΔT_i on the population growth in city i. The key identification assumption is that *changes* population growth in locations with different *changes* in trade costs would have been the same in the absence of the reform. I challenge this assumption in several ways below. Furthermore, proxying 18th and 19th-century geographical characteristics with contemporary data sources requires further assumptions. Throughout, I assume that the variables have remained fixed or changed with the same factor across different locations. While measurement error in the outcome variable remains a possibility, classical measurement error does not lead to bias in the estimate of β. To account for non-classical measurement error that potentially varies across time and location, I include various location fixed-effects as robustness checks.

Table 5 shows the relationship between shipping times and city growth. Panel (a) presents the effect of changes in shipping time on population growth between 1750 and 1800. Across a wide range of specifications, there is a negative relationship between shipping time to Europe and population growth. Cities with larger reductions in shipping time grow faster on average. In the preferred specification in Column (3), containing both viceroyalty fixed effects in addition to the full set of controls, I find that one standard deviation larger reduction in the shipping time to Europe (6.5 days) leads to an around 8 percentage point increase in urban population growth ($\beta = 0.079$). The estimated coefficients range from 0.079 and 0.12. Panel (b) shows the estimates for the 1750 to 1850 period for which the estimates are nearly twice as large. Reassuringly, the estimates for 1700 to 1750 are significantly smaller and statistically insignificant.

Economic expansion, an increased military presence, and missionary activity also led to the formation of new settlements during the 18th-century (Morse, 1974). Did the changes in shipping time also induce growth on the extensive margin? To explore this I estimate Equation 4 with the number of settlements as the per grid-cell as the dependent variable. Aggregating the number of

[33]To proxy for the disease environment, I construct an indicator variable that takes value 1 if the average elevation is below 1500m and control for distance to the coastline. There is no data on the disease environment at high geographical resolution available for Spanish America in the 18th century. However, as pointed out in Bruhn and Gallego (2011), Hong (2007) shows that the main predictors of deaths due to malaria in North American frontier forts in the 19th century are variables related to climate and elevation, which I do control for in a flexible manner.

[34]I also account for spatial dependence in the error term by explicitly allowing for spatial correlation (Conley, 1999). The distance kernel chosen has a cutoff of 5,000km. This correction matters little for the size of the standard errors, as can be seen in the appendix.

Table 5: *Shipping time and urban population growth*

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it'}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.116***	0.114***	0.122***	0.079**
	(0.034)	(0.040)	(0.041)	(0.035)
N	297	297	297	297
R^2	0.048	0.065	0.073	0.248
Panel (b): Population growth 1850-1750				
Change in shipping time	0.222***	0.194***	0.201***	0.130***
	(0.045)	(0.053)	(0.058)	(0.046)
N	297	297	297	297
R^2	0.076	0.097	0.123	0.327
Panel (c): Population growth 1750-1700				
Change in shipping time	0.035	0.012	0.008	0.008
	(0.036)	(0.040)	(0.036)	(0.035)
N	245	245	245	245
R^2	0.006	0.038	0.059	0.059
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Population (1750)				✓

Note: The table reports OLS estimates. Shipping time is standardized. The unit of observation is a city in a certain year. **Dependent variable:** The change in the natural logarithm of city population. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. ***p < .01, **p < .05, * p < .1

settlements by the grid-cell reduces measurement error in the recorded location and makes the variable less sensitive to the grid-cell size. Table 6 shows the relationship between shipping times and the formation of new settlements. Panel (a) presents the results estimated between 1750 and 1800. The estimates are positive and significant but smaller in magnitude than the effect on city growth. One standard deviation higher reduction in the sailing time increases the number of settlements in a grid-cell by 0.044 in the baseline specification. Again, it is reassuring that the change between 1700 and 1750 is unrelated to the change in sailing time which is consistent with the identification assumption. Taken together, the estimates are consistent with cheaper access to goods produced in other locations making locations more attractive.

Fact 3: *Lower shipping times had a smaller effect on urban growth in larger cities.* The change in trade costs induced by the reform affected cities that differed substantially in terms of population size. In smaller cities, the own market is potentially less important relative to markets in other cities and as a result, the change in external trade cost has a larger impact in smaller cities (Redding and Sturm, 2008). To explore this, I interact the initial population size with the change in trade costs using the baseline specification in Equation 4. The results are presented in in Table 7. Across all specifications, the interaction between changes in shipping time and the pre-reform city population is negative. While there is a positive effect of lower shipping time for the cities with the average population size, a one standard deviation increase in the population size, reduced the marginal impact of a change in the shipping time to zero. I find no effect of the interaction with growth on the extensive margin. To further explore the role of the own market size in mediating the effect, I split the sample into a colonial center, semiperiphery, and periphery following Mahoney (2010).[35] The core and semiperiphery are by far the largest internal markets. The results are reported in Table 8 and show that the average effect is driven by cities in the periphery, further suggesting that the effect is mediated by the internal market size.

An alternative interpretation could be that the resource availability is more constrained in larger cities, therefore limiting how much the population size adjusts to lower trade costs. However, in Columns (2)-(3) I control for different measures of the local resource availability. Since the negative interaction remains across these specifications the findings are not consistent with this mechanism. Measurement error in the city population size is a concern when population size enters as an explanatory variable. To address this, I use a more stringent fixed effect specification in Column (4) which also controls for unobserved time-variant heterogeneity at the *audiencia* level. Also, in this specification, the estimated coefficient between changes in shipping time and the population size is negative and significant. Finally, it is reassuring that there is no effect on population growth, both for the interaction and the un-interacted terms, for the period 1700 to 1750. This is again consistent with the assumptions underlying the causal interpretation of the estimates. In sum, the result is therefore consistent with the pre-reform population size being important in mediating the effect of the change in trade costs.

Fact 4: *There is a high degree of persistence in of the pre-reform settlement pattern, but it is lower in areas more exposed to the reform.* To explore the persistence of historical settlement patterns, I estimate the elasticity of contemporary with respect to historical population size. Consider the following equation,

$$\ln L_{it} = \alpha_c + \beta \ln L_{it'} + \phi x_i + \epsilon_{it}, \tag{5}$$

where L_{it} denotes contemporary population size, $L_{it'}$ the population size at time t', x_i a vector of control variables, and ϵ_{it} is an error term potentially correlated across nearby locations. Standard errors are therefore clustered at the country level in the main specifications.[36] To account for differences in measurement error across locations, the specifications contain country fixed-effects as captured by α_c. β is the elasticity of contemporary population size with respect to the pre-reform population size. To explore the role of the reform in affecting the persistence of historical settlement patterns, I estimate Equation 5 separately for locations that were differentially exposed to the reform. I therefore make the assumption that the locations that experienced different changes in shipping time would have had similar elasticities β in the absence of the reform, conditional on the set of controls.

[35]The colonial core consists of Mexico, Peru, Bolivia, the colonial semiperiphery consists of Guatemala, Ecuador, Colombia, while the periphery consists of Uruguay, Argentina, Chile, Paraguay, El Salvador, Honduras, Nicaragua, Costa Rica (Mahoney, 2010, p. 50)

[36]To address concerns about spatially correlated errors, I also calculated the Conley standard errors (Conley, 1999).

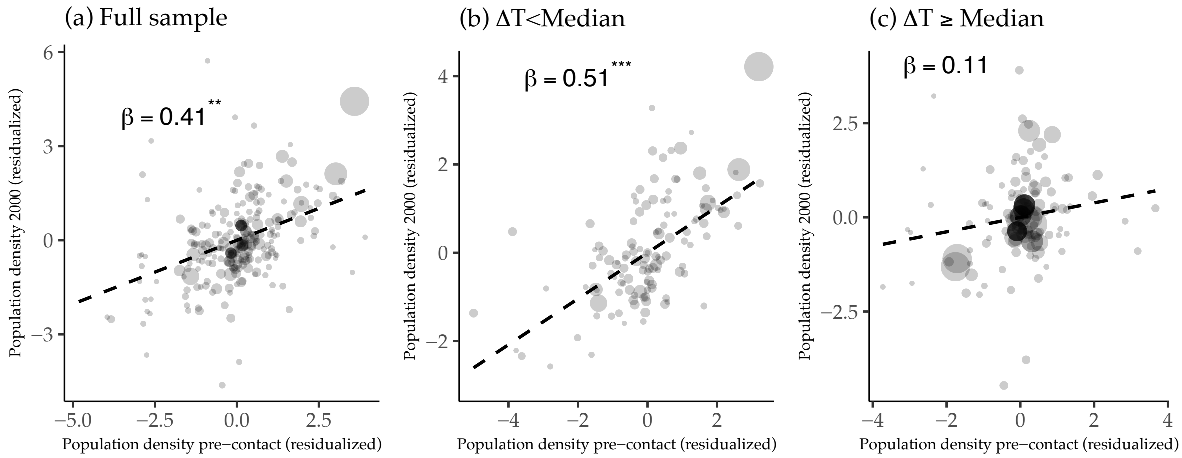

Figure 12: The figure depicts the relationship between pre-contact population density and the population density in year 2000 at the province level. The left figure depicts the relationship for the full sample. The middle figure depicts the relationship for provinces with below median change in the distance to Europe between 1760 and 1810. The right figure depicts the relationship for the sample above median reduction in shipping time to Europe between 1760 and 1810. Pre-colonial population density is the number of people per square kilometre pre-contact. The dependent variable is the log of people per square km in 2000. The full sample contains 340 observations. **Geographical controls:** Altitude, ruggedness, rainfall, and inverse distance to the coast (see Maloney and Valencia (2016) for details). **Standard errors** are clustered at the country-level.

Table 9 shows the results for the baseline sample of cities. In the preferred specification in Column (4), the elasticity for the full sample is 0.34. The elasticity for the above-median sample is 0.28 while it is 0.44 for the below-median sample. This pattern is mirrored using data from Denevan (1992). Figure 13 shows the relationship between pre-colonial population density and the current population for the different samples. Figure 13a shows the correlation for all regions in the study region. Consistent with Maloney and Valencia (2016), there is a strong persistence as measured by the positive relationship within-country between pre-colonial population density and population density in 2000. Figure 13b shows the relationship between the two variables for the sample of provinces that experienced low changes in shipping costs after the reform. The figure shows that persistence is more pronounced for this subsample. Finally, Figure 13c shows the relationship to be weak in the subsample of provinces that experienced large changes due to the reform. Table 10 shows that the pattern is robust across several specifications. Moreover, I find that these areas are substantially more concentrated in coastal areas today. Table 11 uses the same approach to compare the differences in coastal access for areas more or less intensively treated by the reform. The table shows that the distribution of the population is more spatially clustered in coastal areas for places more intensively treated by the reform. In sum, the results from Table 11 support the interpretation that the changes in trade costs induced urban growth, increased the coastal population density, and attenuated the persistence of pre-reform settlement patterns. While there is certainly measurement error in the data from Denevan (1992), it is reassuring that I find a similar elasticity using tributary counts from Gerhard (1993*a*,*b*,*c*).

5.2 Assessing the Research Design

The key identification assumption is that, in the absence of the reform, urban population growth would have happened at an equal rate across areas that, under the reform, experienced different reductions in shipping costs. To assess the plausibility of this assumption, I consider the dynamic version of Equation 4 where the change in shipping time is interacted with decade indicators. I estimate the following model

$$\ln L_{it} = \alpha_i + \tau_t + \sum_{s=1710}^{1810} \mathbb{1}[t = s]\Delta T_i \times \tau_s + \phi x_{it} + \epsilon_{it}, \tag{6}$$

where the variables are defined as in Equation 4. Figure 13 shows the estimated coefficients using the baseline specification for both population growth and the formation of new settlements. The plotted coefficients give the estimated difference between differentially exposed localities in year s relative to 1760, which is the last year prior to the reform. Consistent with the identification assumption, Figure 13 shows that there is no significant difference in the change of settlement in areas with high or low exposure to the reform before the reform for either outcome.[37] Table 12 summarizes several alternative specifications. This pattern can also be seen in Figure 10.

In the second half of the 18th century, other administrative, ecclesiastical and military reforms were conducted in Spanish America. A related concern is that these reforms affected city growth in a similar way as the trade reform. One important reform was the separation of the Viceroyalty of *Rio de la Plata* from the Viceroyalty of Peru in the second half of the 18th century. It remains a possibility that this induced economic growth to be reoriented towards Buenos Aires in a way that was correlated with the reduction in travel times. However, when dropping cells in the Viceroyalty of *Rio de la Plata* or the whole of Argentina the estimated coefficients are similar. Moreover, I exploit the fact that the Viceroyalty of *Nueva Granada* with the capital in Bogota separated from the Viceroyalty of Peru already in 1717. I do not find evidence that this reform affected city growth. Next, I use viceroyalty and *audiencia* borders between 1710 and 1750 multiplied with time fixed effects which removes differences in average growth rates across locations that could experience different institutional developments. Further, I control for distance to large cities interacted with time to control for exposure to changes in policies emanating from the capitals.

Even though all large ports were eventually allowed to trade directly with Europe, and even though the historical literature suggests the opposite, it cannot be ruled out that the timing of which ports opened was driven by commercial potential. To mitigate this concern, I restrict the sample to only include areas far away from ports in the estimation, which were unlikely to be targeted by the policy. To account for potentially spatially correlated error terms, I calculate standard errors accounting for spatial correlation in line with Conley (1999). Next, I remove outliers for all the outcome variables. To further address concerns about measurement error, I re-estimate the model for cities in locations with high state capacity. Following Acemoglu, Moscona and Robinson (2016), I measure state capacity by restricting by the location of post offices in 1750.[38] The effects on

[37] I conduct a formal test of the joint significance. In all specifications, the hypothesis that the pre-trend coefficients are zero cannot be rejected.

[38] This draws on the notion of infrastructural power, or "the capacity to actually penetrate society and to implement

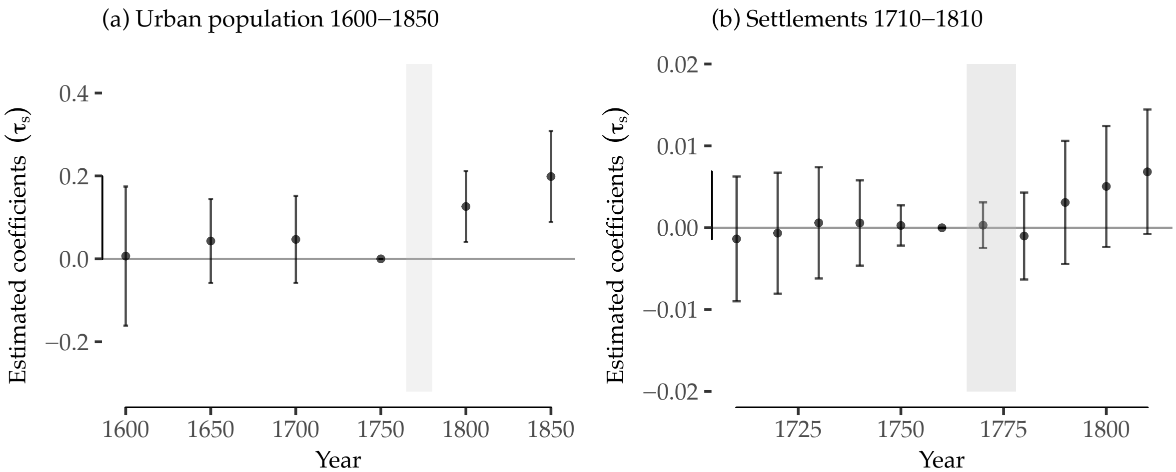

Figure 13: The figure depicts the estimated coefficients of the difference in population growth and the number of settlements according to the reduction in shipping times to Europe induced by the reform. **Dependent variable:** In panel (a) log of city population. In panel (b) number of settlements in grid-cell. **Observations:** In Panel (a) 297 cities for the period 1600-1850 totalling 1,782 observations. In panel (b) 5,014 0.5°×0.5° grid-cells for the period 1710-1810 totalling 55,154 observations (11 × 5,014 = 55,154). **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline, and terrain ruggedness. **Standard errors:** Clustered at the port-level.

urban growth are already positive before independence, however, if trade contributed to political fragmentation of the Spanish Empire (see e.g. Arteaga (2016) and Bonfatti (2017)) conditioning on country fixed effects might induce post-treatment bias. I address this by estimating the model with virtual country fixed effects. Finally, I explore the relationship between increased access to trade on the slave trade. Did the improved trade opportunities induce population growth through the slave trade? Using data from Behrendt et al. (1999), which covers around 80 percent of all voyages of the slave trade, I find little evidence of this mechanism. Most of these further results are reported in the Appendix. Taken together, these exercises provide support for the causal interpretation of the estimates. The findings provide evidence that cheaper access to goods and better export opportunities increased urban growth and that the size of the internal market was important in mediating the effect.

6 A Model of Trade and Urban Growth

In this section I explore potential mechanisms driving the reduced form findings. To do this I interpret the findings through the lens of a parsimonious dynamic spatial general equilibrium model that I calibrate to match the observed data

logistically political decisions" (Mann, 1986, p. 170), as being an important determinant of state capacity.

6.1 Theoretical Framework

Geography. The model consists of $i = 1, ..., R$ cities ($R = 298$ in the baseline case). Cities differ in their productivity A_i, their hinterlands availability of arable land H_i, and in their connectedness to other cities in terms of trade and migration. A_i determines the city's productivity in producing traded goods and the availability of arable land determines the urban carrying capacity (Bairoch, 1988; Hassig, 1993; Duranton, 1999). Inhabitants in each city can trade with and migrate to all other cities subject to a cost. Let τ_{ij} and m_{ij} denote the trade and migration cost between locations i and j respectively. Europe enters the model as a point-like country centered on Cadiz and contains the population mass of Western Europe for each decade.

Preferences. The city's inhabitants have a Cobb-Douglas utility function defined over a composite of location-specific traded goods and a non-traded good (food).[39] This captures that long-distance trade during the 18th century was limited to non-competing goods (Findlay and O'Rourke, 2007). The welfare derived from consumption for an individual living in location i is therefore given by,

$$V_i = w_i \;/\; P_i^{\mu} r_i^{1-\mu}, \tag{7}$$

where μ is the share of expenditure of the traded good, P_i is the price index for the traded goods, w_i is the nominal wage, and r_i is the price of land. Consistent with evidence that real wages responded to market conditions in the context of colonial Mexico and Peru (Allen, Murphy and Schneider, 2012; Arroyo Abad, Davies and van Zanden, 2012), I assume that to a first-order approximation, labor markets were competitive. As a consequence, each household supplies labor inelastically.

Production. Agriculture was the largest sector of the economy (Arroyo Abad and Zanden, 2016), and the availability of arable land and high trade costs played an important role in limiting urban growth.[40] To capture this, I assume there are two sectors in each city, a sector producing the location-specific traded good and an agricultural sector producing food that is non-traded. Production takes place under perfect competition. As a result, the price of the location-specific traded good in location i is given by $p_i = w_i \;/\; A_i$. Since there are iceberg transportation costs, the price faced by an individual in city j for a good produced in i is given by $p_{ij} = \tau_{ij} p_i$. The agricultural sector features constant returns to scale where one unit of land produces one unit of food. Since the land market is competitive and supply exogenous, the land price is pinned down by the demand function for F_i is given by $r_i = (1-\mu)Y_i \;/\; H_i$. Income from land is allocated lump-sum to all inhabitants of the location.

Trade and migration. The model gives rise to a gravity equation for bilateral trade and migration flows between cities. Using the demand function for the traded goods gives the value of trade from location j to location i by

$$X_{ji} = q_{ji} p_{ji} = p_{ji}^{1-\sigma} \mu Y_i P_i^{\sigma-1}. \tag{8}$$

[39] I abstract from differences in agricultural intensification in the hinterland depending on the distance to the city which arises in a von Thünen model.

[40] Mining only employed around 0.04 percent of the population at its peak in the late 18th century (Fisher, 1997, p. 64) (75,000 out of 17 million).

Legal restrictions on labor mobility and coercive labor institutions had lost importance by the end of the 18th century (Arroyo Abad and Maurer, 2019). Moreover, pre-industrial city growth was mainly driven by migration (Cook, 1981; Jedwab, Christiaensen and Gindelsky, 2017). In the context of Spanish America, Mahoney (2010) notes that new areas were being populated after the 1760s, both through international and intra-national migration. While I do not find an impact of increased trade with Europe on the number of ships disembarking slaves, slavery was undoubtedly important in some regions.[41] I assume that factors that made an area attractive for voluntary migration such as higher real wages also increased the inflow of coerced labor. Therefore individuals can migrate to other cities but are subject to a migration cost to maximize their expected utility. Since one period corresponds to roughly a generation in the dataset (50 years), I ignore more complex forward-looking behavior. The utility of an individual moving from region i to region j is given by $V_{ij} = V_j \epsilon_j \ / \ m_{ij}$ where ϵ_j is an iid draw from a Fréchet-distribution with shape parameter θ and captures individual-level heterogeneity in location preferences. Using the properties of the Fréchet-distribution, I show that this structure gives rise to a gravity equation for migration.

Scale economies. In the core areas of Spanish America, urbanization was relatively high in the 18th century, at times exceeding that of Spain (Arroyo Abad and Zanden, 2016). To capture this, the framework allows for agglomeration externalities at the level of the city. A variety of factors drove agglomeration for pre-industrial cities (Jedwab, Johnson and Koyama, 2020). They could reflect factors such as knowledge spillovers, input sharing, physical security, location-specific capital, or knowledge about the local environment. To allow for persistence in the model, I follow Allen and Donaldson (2020) and allow the scale economies to feature dynamic agglomeration economies.[42] In particular, the productivity of the city depends on the size of the city today and in the past with constant elasticities, $A_{it} = \bar{A}_i L_{it}^{\alpha_1} L_{it-1}^{\alpha_2}$. $\bar{A}_i$ is a locational fundamental that is exogenous to the population size.

General equilibrium and steady-state. I define an equilibrium and steady-state of this economy, given a geography that is made up of local fundamentals ($\bar{A}_i$ and H_i), trade costs (τ_i), migration costs (μ_i), and past population distribution L_{i0}. Within each location all firms and individuals optimize and markets clear. In addition, an equilibrium is given by $E_t = \{L_{it}, w_{it}, V_{it}, \Pi_{it}\}_{i \in R}$ such that in each region total sales equals the total income ($w_{it} L_{it} / \mu = \sum_{j \in R} X_{ijt}$), trade is balanced ($w_{it} L_{it} / \mu = \sum_{j \in R} X_{jit}$), the total population equals the population arriving at a location ($L_{it} = \sum_{j \in R} L_{jit}$), and the total population in the last period equals the number of people exiting a location between $t-1$ and t and ($L_{it-1} = \sum_{j \in R} L_{ijt}$). Moreover, a steady-state is an allocation such that $L_{it} = L_{it-1}$ for all cities i, hence a state in which the migration flows between cities cancel out. Intuitively, the existence of the equilibrium and steady-state depends on the strength of the agglomeration force (the local scale economies) relative to the dispersion force (the availability of arable land for food production). Using

[41] The exact magnitude of migration from Europe is contested. Estimates range between 50,000 and 190,000 immigrants in the 18th century (Mahoney, 2010). Cook (1981) writes that migration in colonial Peru was extensive, covered large distances, and was mainly directed to large cities and mining centers. For 1613 numbers on origins of the population of Lima are provided in Cook (1981) and show a significant fraction born outside Lima. 271,000 victims of the transatlantic slave trade disembarked in Spanish America between 1700 and 1760 (Eltis, 2000, p. 9)

[42] As shown in Allen and Donaldson (2020), this can be micro-founded in a variety of ways including the persistence of local knowledge or durable investment in local productivity.

results in Allen and Donaldson (2020) and Allen, Arkolakis and Li (2020), I provide conditions for the existence and uniqueness of the equilibrium and steady-state in the Appendix.

6.2 Estimation and Identification Strategy

In this section I calibrate the model to match the observed data. The model is fully parameterized by seven structural parameters and a tuple of fundamentals given by,

$$\Omega = \left\{\sigma, \theta, \mu, \alpha_1, \alpha_2, \bar{A}_i, H_i, \tau, m\right\}. \tag{9}$$

The empirical strategy to estimate Ω proceeds in four steps. First, I match the trade and migration costs to corresponding reduced form estimates to recover τ and m. Next, the equilibrium conditions are inverted to recover $\{p_{it}^{\sigma-1}, P_{it}^{\sigma-1}, V_{it}^{\theta}, \Pi_{it}^{\theta}\}_{i\in R}$. Third, I estimate the structural version of the reduced form equations to recover α_1 and α_2. Then I choose σ to make the model match the reduced form estimates of the reform. In a final step, productivities are calculated as the residuals of the estimated model. I further elaborate on the steps of this procedure as well as the underlying assumptions for identifying the parameters below.

External parameters. The first set of parameters are matched to parameters estimated without relying on the structure of the model. First, I match μ to the share of GDP derived from land for colonial Mexico and Peru (Arroyo Abad and Zanden, 2016). To the best of my knowledge, there are no estimates for how responsive migration flows are to differences in real wages across cities. I therefore use estimates available for developing countries which typically range between 2 and 4 (Morten and Oliveira, 2018; Bryan and Morten, 2019). Next, I parameterize the bilateral trade and migration costs to depend on travel time. In particular, $\tau_{ijt} = T_{ijt}^{\kappa}$ and $m_{ij} = T_{ijt}^{\lambda}$ where κ and λ are the elasticities of trade and migration costs to travel time respectively. I match the trade elasticity in the model $(1-\sigma)\kappa$ to the estimate in Table 4 and the migration elasticity $-\lambda\theta$ to the corresponding estimate in Table 4. Finally, H_i is calculated as the share of arable land within 100km of the city using data from Galor and Özak (2015, 2016).[43]

Model inversion. Given information on the city population sizes and urban nominal wages, the endogenous variables that would rationalize the observed population and wages can be recovered. Inverting the equilibrium conditions gives the following system of equations,

$$p_{it}^{\sigma-1} = \sum_{j\in R} \hat{T}_{ijt} \left(\frac{Y_{jt}}{Y_{it}}\right) P_{jt}^{\sigma-1} \tag{10}$$

$$P_{it}^{\sigma-1} = \sum_{j\in R} \hat{T}_{jit} \left(p_{jt}^{\sigma-1}\right)^{-1} \tag{11}$$

[43] Hassig (1993) operates with a hinterland spanning between 21 to 28 kilometers for a Mesoamerican city relying on tlameme transportation (human carriers). With the introduction of European modes of transportation this increased. Using information comparative trade costs of tlameme and mule transportation, I assume that the hinterland expanded by a factor of 4 (Hassig (1993), p. 216).

Table 13: Model parameters

Parameter	Value	Description
α_1	0.074***	Productivity spillover
α_2	0.026**	Historical productivity spillover
$\kappa(1-\sigma)$	−3.13**	Elasticity of trade wrt. time
$-\lambda\theta$	−2.8*	Elasticity of migration wrt. time
σ	10.8	Elasticity of substitution
θ	3	Migration elasticity $\theta \in [2,4]$
μ	0.45	Share of income not from agriculture

Note: The table reports the parameters baseline calibration of the model. α_1, α_2, and σ are estimated directly from the data the 297 cities in the main sample. μ, and θ are taken from the literature. **Controls:** Elevation, crop suitability, the location of active mines, and distance to the coastline, and terrain ruggedness. **Standard errors:** Clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, $^{*}\ p < .1$

$$V_{it}^{-\theta} = \sum_{j\in R} \hat{M}_{jit} \left(\frac{L_{jt-1}}{L_{it}}\right) \Pi_j^{-\theta} = 0 \tag{12}$$

$$\Pi_i^{-\theta} = \sum_{j\in R} \hat{M}_{ijt} V_{jt}^{\theta} \tag{13}$$

where $\hat{T}_{ij} = T_{ij}^{\kappa(1-\sigma)}$ and $\hat{M}_{ij} = T_{ij}^{-\lambda\theta}$. It follows from Allen and Donaldson (2020) that given data on $\{L_{it}, L_{it-1}, w_{it}\}_{i\in R}$, the system uniquely solves for the endogenous variables $\{p_{it}^{\sigma-1}, P_{it}^{\sigma-1}, V_{it}^{\theta}, \Pi_{it}^{\theta}\}_{i\in R}$.

Estimating the scale elasticities. The historical scale elasticity can be identified using the equilibrium conditions. Combining the equilibrium conditions, taking logs and first differences to remove the influence of locational fundamentals and time-invariant factors gives,

$$\nu \Delta \ln L_{it} = -\sigma \Delta \ln \Lambda_{it} - \mu(2\sigma - 1)\Delta \ln P_{it} + \alpha_2 \mu(\sigma - 1)\Delta \ln L_{it-1}, \tag{14}$$

where $\nu = \mu + \sigma(1-\mu) + \sigma / \theta + \alpha_1\mu(1-\sigma)$. An important assumption is therefore that changes in locational fundamentals are small throughout the reform period, and can therefore be differenced out. Under this assumption, $\alpha_2\mu(\sigma-1) / \nu$ can be recovered from estimating the equation using ordinary least squares. To explore the validity of the underlying assumption, I consider the stability of the estimated coefficient to the inclusion of the controls used in the reduced form analysis (which flexibly control for time-varying changes in the value of locational fundamentals). Further, I leverage the market clearing condition for the traded good to identify $(1-\sigma)\alpha_1$. σ is identified by simulating the model and matching the impact of the reform to the coefficient in the baseline specification of the reduced form exercise. Finally, again using the market clearing condition for the traded commodity, $\bar{A}_i$ is recovered as the residual.

Results. Table 13 contains the parameters in the baseline calibration of the model. The contemporaneous and lagged agglomeration spillovers, α_1 and α_2 are found to be 0.074 and 0.026 respectively and estimated precisely. As a result, a one percent increase in the contemporaneous population size, increases the productivity of the location by 0.074 percent, while an increase in the historical population size increases the productivity of the location by 0.026 percent. This is similar to the agglomeration elasticities at the city level documented in the literature (Combes and Gobillon, 2015; Allen and Donaldson, 2020). The travel time elasticities of trade and migration are also found to be in line with estimates in the literature and are precisely estimated. A one percent increase in the travel time reduces the value of bilateral trade by around three percent and bilateral migration flows by around 2 percent. Finally, for the model to reproduce the impact of changes in trade costs documented in the reduced form, the elasticity of substitution is found to be 10.8 (this can be seen in Figure 14). The estimated value of σ is high but not uncommonly so. For example, Eaton and Kortum (2002) find values between 3 and 12. While the model permits path dependence, where initial conditions determine the allocation in the long run, I find that there exists a unique equilibrium and steady-state of the model under this calibration.

6.3 Long-Distance Trade and Long-Term Persistence

To study the long-run implications of the model, consider the behavior of the economy along its growth path. Using the indirect utility function, the market clearing conditions, assuming that trade costs are quasi-symmetric, and iterating backwards gives the following relationship for the city size in equilibrium,

$$\begin{aligned}\ln L_{it} = \kappa_i' + \left(\frac{\alpha_2\mu(\sigma-1)}{\nu}\right)^T \ln L_{i0} - \frac{\sigma}{\nu}\sum_{k=0}^{T-1}\left(\frac{\alpha_2\mu(\sigma-1)}{\nu}\right)^k \ln \Lambda_{it-k} \\ -\frac{\mu(2\sigma-1)}{\nu}\sum_{k=0}^{T-1}\left(\frac{\alpha_2\mu(\sigma-1)}{\nu}\right)^k \ln P_{it-k}.\end{aligned} \tag{15}$$

The equation gives the equilibrium population size of city i as a function of the history of the city, or the full path of endogenous and exogenous variables. Intuitively, the equilibrium size of the city is larger if it has a history of high productivity, availability of arable land (both captured by κ_i'), larger historical population size (L_{i0}), and better historical access to trading opportunities (P_{ik}). As can be seen, the local price index summarises the role of trade costs in city growth and as a result, all changes in trade costs affect the urban growth through this term. Equation 15 can be interpreted as the structural version of Equation 4 and 5. The derivations are provided in the Appendix.

Consider first the impact of a change in historical trade cost to Europe at time k on the population size of the city i at time t. Note, that the elasticity of city size at time t to a change in the price index at time k is given by $-\left(\mu(2\sigma-1)\,/\,\nu\right)\left(\alpha_2\mu(\sigma-1)\,/\,\nu\right)^k < 0$. Since the price index is increasing in the trade cost to Europe in period k (τ_{iek}), $\partial P_{ik}\,/\,\partial\tau_{iek} > 0$, it follows that lower historical trade costs to Europe increases the population size in period t which is consistent with Fact 2. As a result, historical trade costs matter for the location of economic activity in the long run. However, since $(\alpha_2\mu(\sigma-1)\,/\,\nu) < 1$ it follows that $\lim_{t\to\infty}\partial L_{it}\,/\,\partial\tau_{iet} = 0$. Hence, the impact of historical trading opportunities dissipates over time. The results are therefore not consistent with the persistence of historical trade costs being induced by multiple equilibria and lock-in effects. Rather, the data are more consistent with persistence being generated by a slow process of adjustment to a new equilibrium. This is ultimately a result of weak agglomeration forces relative to the importance of land in production. Furthermore, consistent with Fact 3, the impact of a change in the historical trade cost is attenuated by the internal market size. Since $\partial P_{ik} \, / \, \partial L_{ik} < 0$, it follows that, $\partial^2 \ln \, L_{it} \, / \, \partial \tau_{iek} \partial L_{ik} > 0$. As a result, the historical location of trading opportunities is more important in cities that are historically larger. In other words, the model shows that the persistence of historical trading opportunities depends on initial urbanization patterns as a location experiences changes in trade costs.

Finally, consider the variation in the persistence of historical settlement patterns documented in Fact 4. The model can be used to explore the determinants of the persistence of historical settlement patterns. Since the coefficient $\alpha_2 \mu(\sigma - 1) \, / \, \nu$ is informative about whether the equilibrium spatial distribution of economic activity is uniquely pinned down by locational fundamentals (in which case shocks to L_{i0} will dissipate over time) or whether there are multiple equilibria (in which case shocks to L_{i0} can accumulate over time), the elasticity of L_{i0} on L_{it} is of interest. From Equation 15, it is clear that this elasticity is given by $(\alpha_2 \mu(\sigma - 1) \, / \, \nu)^T$. However, Equation 15 shows that to recover this parameter, the whole historical path of trade costs needs to be controlled for. Since changes in trade costs have larger effects in smaller locations, this generates a correlation between the effect of changes in historical trade costs and the historical population size. As a result, the changes in trade costs attenuate the relationship between historical and contemporary population density and can therefore account for Fact 4. The estimated persistence elasticity will be biased towards zero in locations that experienced changes in trade costs, as illustrated in Figure 13. More generally, since the time horizon needed to recover $(\alpha_2 \mu(\sigma - 1) \, / \, \nu)^T$ is long, changes in trade costs are typically unobserved and substantial. This highlights the difficulty in estimating the persistence elasticity. Since the effect of trade costs is larger for historically small locations, changes in trade costs attenuate the persistence in the location of economic activity. As a result, changes in trade costs are a force pushing towards reversals rather than persistence in the location of economic activity by having a larger effect on economic growth in smaller locations.

7 Conclusion

There is wide recognition of the central importance of access to trade in shaping the location of economic activity. However, also historical patterns of trade can play a key role in determining city location and growth. Situated on an island, the growth of Mexico City was greatly facilitated by lake-based canoe trade which enabled it to a large economic hinterland compared to other Mesoamerican cities (Hassig, 1993). Physical changes to the landscape have resulted in the disappearance of the lakes, yet the primacy of Mexico City persisted to this day. In contrast, the growth of Argentina which depended on trade with upper Peru for much of the colonial period, reoriented towards the Atlantic starting in the second half of the 18th-century (Scobie, 1971). Do historical patterns of trade dictate the location and size of cities today even if patterns of trade have changed markedly over time? Or does the location of economic activity adapt to changes in the location of trading opportunities?

To explore these questions, I study the reorganization of long-distance trade during the second half of the 18th century. Using a difference-in-differences design that relies on comparing areas within the same region that differentially reduced its trade costs with Europe, I estimate the impact of lower trade costs on the location of settlements and population growth. I find that a statistically and economically significant positive effect on population density is associated with reduced shipping times to Europe. To explore the mechanisms, I build a spatial general equilibrium model that I take to the data. I find that the opening of direct trade with Europe increased urban growth and more so in smaller cities. As a result, the persistence of historical trading opportunities depends on initial urbanization patterns as a location experiences changes in trade costs. Furthermore, changes in trade costs can attenuate the persistence of historical settlement patterns by having a larger effect on economic growth in smaller locations.

The empirical context provides a unique setting to study the long-term adjustment to changes in the location of trading opportunities but also has important limitations. First, the estimation of causal effects relies on sizeable and abrupt changes in trade costs which may induce different adjustment processes than more gradual changes. Second, the context is largely pre-industrial. Other mechanisms and magnitudes are might be important in more industrialized contexts with stronger agglomeration economies. These issues are potentially interesting avenues for future research.

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8 Tables

Table 1: Summary statistics of the city-panel

Statistic	N	Mean	St. Dev.	Min	Median	Max
Population	1,566	6,502.42	14,204.01	400.00	2,000.00	200,000.00
Shipping time 1760 (days)	1,782	58.62	17.90	34.86	54.08	145.27
Shipping time 1810 (days)	1,782	53.80	17.32	26.02	51.93	143.18
Δ Shipping time (days)	1,782	4.82	6.61	0.00	1.91	27.32
Elevation	1,782	0.24	0.43	0	0	1
Terrain ruggednes	1,782	263.33	221.74	2.04	215.08	1,033.84
Average crop suitability	1,782	0.00	1.00	−1.52	−0.11	2.76
Mining center	1,782	0.07	0.26	0	0	1
Average temperature (celsius)	1,782	20.98	4.90	4.52	21.92	28.49
Precipitation (mm.)	1,782	1,408.01	1,223.49	3.06	1,088.19	7,292.16
Coffee	1,782	6.75	1.22	3	6.8	8
Tobacco	1,782	6.31	1.16	2.69	6.26	8.08
Cotton	1,782	6.36	1.32	1	6.3	8
Wheat	1,782	6.84	1.49	2.51	7.67	8.18
Maize	1,782	5.74	1.34	2	5.9	8
Sugar cane	1,782	6.64	1.30	3	6.8	8
Distand to coast (km)	1,782	175.68	190.04	2.02	100.89	988.70
Distand to river (km)	1,782	458.61	340.09	1.19	381.30	1,303.24
Distand to port in 1750 (km)	1,782	304.28	370.87	5.45	192.80	2,516.95
Decade	1,782	1,725.00	85.42	1,600	1,725	1,850

Note: The table reports summary statistics of the key variables used in the analysis. The unit of analysis is the city. The dataset is a panel at a 50 year frequency for the period 1600-1850 for 297 cities. *Elevation* is an indicator variable equal one if the elevation is above 1500m. *Crop suitability* is the average suitability for tobacco, cotton, sugar cane, cacao, coffee (standardized).

Table 2: Summary statistics of the grid-cell dataset

Statistic	N	Mean	St. Dev.	Min	Median	Max
#Settlements	55,154	0.21	0.84	0	0	25
Population 1760	55,154	2,098.00	5,707.89	0.00	165.76	118,175.10
Population 1810	55,154	2,469.52	6,824.08	0.00	234.46	142,383.30
Shipping time 1760 (days)	55,154	83.08	25.19	35.49	82.19	158.67
Shipping time 1810 (days)	55,154	77.06	25.04	26.46	73.58	151.90
Δ Shipping time (days)	55,154	6.02	7.68	0.00	4.35	27.32
Elevation	55,154	0.23	0.42	0	0	1
Terrain ruggednes	55,154	188.07	214.44	1.28	96.49	1,139.80
Average crop suitability	55,154	0.00	1.00	−1.86	−0.11	3.23
Mining center	55,154	0.03	0.18	0	0	1
Average temperature (celsius)	55,154	17.93	7.33	−2.12	19.03	28.83
Precipitation (mm.)	55,154	1,162.72	950.92	0.49	890.98	7,482.85
Coffee	55,154	7.02	1.36	2	8	9
Tobacco	55,154	6.67	1.33	2.00	6.78	8.75
Cotton	55,154	6.54	1.64	1	7.0	9
Wheat	55,154	6.64	1.61	1.02	7.31	8.75
Maize	55,154	6.16	1.66	1.00	6.13	8.75
Sugar cane	55,154	6.76	1.44	1	7.8	9
Distand to coast (km)	55,154	412.17	317.95	0.19	336.61	1,471.73
Distand to river (km)	55,154	387.57	436.48	0.02	226.78	2,481.35
Distand to port in 1750 (km)	55,154	812.69	673.36	3.76	621.79	3,157.83
Decade	55,154	1,760.00	31.62	1,710	1,760	1,810

Note: The table reports the main variables used in the analysis. The unit of analysis is at the grid-cell level. The dataset is a balanced panel at a 10 year frequency for the period 1710-1810 for 5,014 grid cells ($5,014 \times 11 = 55,154$). *Elevation* is an indicator variable equal one if the elevation is above 1500m. *Crop suitability* is the average suitability for tobacco, cotton, sugar cane, cacao, coffee (standardized).

Table 3: Ports 1700 - 1810

Port	*Country*	*Direct trade (decade)*	*Longitude*	*Latitude*
Cadiz	Spain	<1700	-6.28	36.53
Acapulco	Mexico	<1700	-99.91	16.85
Portobelo	Panama	<1700	-79.65	9.55
Panama	Panama	<1700	-79.53	8.95
El Callao	Peru	<1700	-77.15	-12.06
Cartagena de Indias	Colombia	<1700	-75.55	10.42
Veracruz	Mexico	<1700	-96.14	19.19
Batabano	Cuba	1765	-82.29	22.72
Isla de Trinidad	Trinidad and Tobago	1765	-61.51	10.65
Isla Margarita	Venezuela	1765	-63.85	10.95
La Habana	Cuba	1765	-82.35	23.14
Monte-Christi	Dominican Republic	1765	-71.64	19.85
San Juan de Puerto Rico	Puerto Rico	1765	-66.12	18.47
Santiago de Cuba	Cuba	1765	-75.82	20.022
Santo Domingo	Dominican Republic	1765	-69.94	18.48
Trinidad	Cuba	1765	-79.98	21.80
Campeche	Mexico	1770	-90.54	19.84
Arica	Chile	1778	-70.32	-18.48
Buenos Aires	Argentina	1778	-58.37	-34.61
Chagres	Panama	1778	-80.00	9.32
Concepcion	Chile	1778	-73.05	-36.83
Guayaquil	Ecuador	1778	-79.88	-2.19
Montevideo	Uruguay	1778	-56.20	-34.91
Nuevitas	Cuba	1778	-77.27	21.55
Omoa	Honduras	1778	-88.04	15.78
Riohacha	Colombia	1778	-72.91	11.55
Santa Marta	Colombia	1778	-74.21	11.24
Cumana	Venezuela	1788	-64.18	10.47
La Cruz	Venezuela	1788	-64.64	10.21
La Guaira	Venezuela	1788	-66.93	10.60
San Blas	Colombia	1789	-105.29	21.53
Maracaibo	Venezuela	1793	-71.62	10.65
Matanzas	Cuba	1793	-81.58	23.05
Villahermosa	Mexico	1793	-92.93	17.99
Acajutla	El Salvador	1796	-89.83	13.59
Isla de Carmen	Mexico	1796	-91.81	18.65
Puerto Cabello	Venezuela	1798	-68.01	10.48
El Realejo	Nicaragua	1796	-87.17	12.54
San Andres	Colombia	1798	-81.71	12.58
Santo Tomas de Castilla	Guatemala	1798	-89.00	15.64
Valparaiso	Chile	1798	-71.60	-33.05
Baracoa	Cuba	1803	-74.50	20.35
Manzanillo	Mexico	1803	-104.28	19.12
Sisal	Mexico	1807	-88.21	20.69
San Bernardo	United States	1808	-96.63	28.62
Matina	Costa Rica	1811	-83.29	10.08
Manta	Ecuador	Independence	-80.91	-0.97
Esmeraldas	Ecuador	Independence	-79.90	0.95
Trujillo	Peru	Independence	-79.00	-8.10
Huacho	Peru	Independence	-77.61	-11.11
Paita	Peru	Independence	-81.11	-5.09
Huarmey	Peru	Independence	-78.15	-10.07
Maldonado	Uruguay	Independence	-54.95	-34.90
Carupano	Venezuela	Independence	-63.25	10.67
Barcelona	Venezuela	Independence	-64.66	10.13
Barranquilla	Colombia	Independence	-74.80	10.96
Buenaventura	Colombia	Independence	-77.35	3.88
Puntarenas	Costa Rica	Independence	-84.83	9.98
Tela	Honduras	Independence	-87.46	15.76
Tuxpan	Mexico	Independence	-97.40	21.86

Table 4: The shipping time elasticity of trade 1797 - 1820

Outcome:	Value of exports (ln)			
	(1)	(2)	(3)	(4)
Panel (a): OLS Estimator				
ln Shipping time	-2.19^{*}	-3.30^{***}	-3.13^{***}	-2.87^{***}
	(1.17)	(0.97)	(1.03)	(1.11)
Panel (b): PPML Estimator				
ln Shipping time	-2.59^{*}	-3.34^{***}	-3.09^{***}	-3.22^{***}
	(1.17)	(0.86)	(0.83)	(0.86)
Observations	211	211	211	211
Year FE		✓	✓	
Region FE		✓	✓	✓
Viceroyalty FE			✓	
Region × Year FE				✓

Note: The table reports the relationship between shipping time and the value of exports from Spain. Shipping time denotes the shipping time to Spain. The value of trade is measured in *reales de vellón*. The sample contains ports with limited direct trade with Spain prior to the reform period. The data is from Fisher (1993). Robust standard errors in paranthesis. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table 6: Shipping time and settlements

Dependent variable:	Formation of a settlements: $S_{it} - S_{it-1}$			
	(1)	(2)	(3)	(4)
Panel (a): Settlement formation 1800-1750				
Change in shipping time	0.019	0.043***	0.044**	0.055***
	(0.016)	(0.014)	(0.018)	(0.016)
N	5,014	5,014	5,014	5,014
R^2	0.001	0.025	0.047	0.075
Panel (b): Settlement formation 1750-1700				
Change in shipping time	−0.016	0.012	0.005	0.024*
	(0.020)	(0.014)	(0.015)	(0.013)
N	5,014	5,014	5,014	5,014
R^2	0.001	0.045	0.078	0.152
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Population (1750)				✓

Note: The table reports OLS estimates. Shipping time is standardized. Shipping time is standardized. The unit of analysis is at a $0.5° \times 0.5°$ grid-cell in a certain decade. **Dependent variable:** Number of settlements in a grid-cell. **Observations:** The dataset is a balanced panel at a 10 year frequency for the period 1710-1810 for 5,014 grid cells. The full dataset contains $11 \times 5{,}014 = 55{,}154$ observations. **Controls:** Elevation, crop suitability, the location of active mines, and distance to the coastline. **Standard errors:** Clustered at the level of the closest port. ***$p < .01$, **$p < .05$, * $p < .1$

Table 7: Shipping time, city size, and population growth

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it-1}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.067*	0.080**	0.080**	0.083
	(0.035)	(0.038)	(0.038)	(0.058)
Population (1750)	−0.238***	−0.243***	−0.253***	−0.241***
	(0.074)	(0.077)	(0.076)	(0.079)
Change in shipping time × Population (1750)	−0.139	−0.154	−0.166	−0.156
	(0.098)	(0.103)	(0.103)	(0.105)
N	297	297	297	297
R^2	0.181	0.198	0.213	0.251
Panel (b): Population growth 1850-1750				
Change in shipping time	0.160***	0.150**	0.143**	0.102
	(0.048)	(0.059)	(0.059)	(0.069)
Population (1750)	−0.315***	−0.319***	−0.347***	−0.321***
	(0.072)	(0.079)	(0.083)	(0.084)
Change in shipping time × Population (1750)	−0.167	−0.196*	−0.231*	−0.231*
	(0.101)	(0.113)	(0.119)	(0.119)
N	297	297	297	297
R^2	0.177	0.194	0.235	0.280
Panel (c): Population growth 1750-1700				
Change in shipping time	0.031	0.011	0.005	−0.015
	(0.037)	(0.039)	(0.035)	(0.057)
Population (1750)	−0.041	−0.043	−0.057	−0.034
	(0.038)	(0.036)	(0.036)	(0.032)
Change in shipping time × Population (1750)	−0.007	−0.021	−0.041	−0.034
	(0.055)	(0.055)	(0.052)	(0.050)
N	245	245	245	245
R^2	0.014	0.045	0.070	0.172
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Audiencia FE				✓

Note: The table reports OLS estimates. Shipping time is standardized. The unit of observation is a city in a certain year. **Dependent variable:** The change in the natural logarithm of city population. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table 8: Shipping time and urban population growth by market size

Dependent variable:	Population growth 1800-1750			
	(1)	(2)	(3)	(4)
Panel (a): Colonial center				
Change in shipping time	0.167	0.058	−0.152	−0.234*
	(0.133)	(0.143)	(0.154)	(0.119)
N	99	99	99	99
R^2	0.013	0.073	0.162	0.322
Panel (b): Colonial semiperiphery				
Change in shipping time	−0.005	−0.098	0.378	−0.132
	(0.129)	(0.104)	(0.404)	(0.280)
N	70	70	70	70
R^2	0.00001	0.031	0.087	0.418
Panel (c): Colonial periphery				
Change in shipping time	0.069**	0.117**	0.173***	0.142**
	(0.027)	(0.048)	(0.056)	(0.061)
N	93	93	93	93
R^2	0.041	0.083	0.134	0.173
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Population (1750)				✓

Note: The table reports OLS estimates. Shipping time is standardized. The unit of observation is a city in a certain year. **Dependent variable:** The change in the natural logarithm of city population. **Samples:** *Core:* Mexico, Peru, Bolivia. *Semiperiphery:* Guatemala, Ecuador, Colombia. *Periphery:* Uruguay, Argentina, Chile, Paraguay, El Salvador, Honduras, Nicaragua, Costa Rica. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. ***$p < .01$, **$p < .05$, * $p < .1$

Table 9: Spatial persistence in high and low exposure areas (city-level)

Dependent variable:	Population 2000 (log)			
	(1)	(2)	(3)	(4)
Panel (a): Full sample				
Population 1750 (log)	0.271***	0.288***	0.331***	0.343***
	(0.072)	(0.068)	(0.044)	(0.045)
N	297	297	297	297
R^2	0.098	0.130	0.261	0.275
Panel (b): ΔT <Median				
Population 1750 (log)	0.379***	0.407***	0.403***	0.438***
	(0.041)	(0.046)	(0.033)	(0.033)
N	151	151	151	151
R^2	0.185	0.220	0.264	0.307
Panel (c): ΔT ≥Median				
Population 1750 (log)	0.167	0.197**	0.270***	0.281***
	(0.127)	(0.091)	(0.085)	(0.079)
N	146	146	146	146
R^2	0.035	0.181	0.286	0.327
Country FE			✓	✓
Controls		✓		✓

Note: The table reports OLS estimates. The unit of analysis is at the city. The full sample contains 299 observations. **Geographical controls:** Altitude, ruggedness, rainfall, and the distance to the coast. **Standard errors** are clustered at the country-level. ***p < .01, **p < .05, * p < .1

Table 10: Spatial persistence in high and low exposure areas (region-level)

Dependent variable:	Population density 2000 (log)			
	(1)	(2)	(3)	(4)
Panel (a): Full sample				
Population density 1500 (log)	0.382***	0.299***	0.505***	0.406***
	(0.103)	(0.100)	(0.143)	(0.138)
N	311	282	311	282
R^2	0.293	0.364	0.442	0.559
Panel (b): ΔT <Median				
Population density 1500 (log)	0.568***	0.495***	0.594***	0.507***
	(0.065)	(0.079)	(0.086)	(0.091)
N	190	172	190	172
R^2	0.478	0.546	0.673	0.729
Panel (c): ΔT ≥Median				
Population density 1500 (log)	0.288***	0.162**	0.226	0.111
	(0.109)	(0.065)	(0.226)	(0.168)
N	108	107	108	107
R^2	0.217	0.443	0.392	0.524
Country FE			✓	✓
Controls		✓		✓

Note: The table reports OLS estimates. The unit of analysis is the province. Pre-colonial population density is the number of indigenous people per square kilometre before the arrival of Columbus from Maloney and Valencia (2016). The dependent variable is the log of people per square km in 2000. The full sample contains 258 observations. **Geographical controls:** Altitude, ruggedness, rainfall, and inverse distance to the coast (see Maloney and Valencia (2016) for details). **Standard errors** are clustered at the country-level. ***$p < .01$, **$p < .05$, * $p < .1$

Table 11: Coastal consentration in high and low exposure areas

Dependent variable:	Population density 2000 (log)			
	(1)	(2)	(3)	(4)
Panel (a): Full sample				
Distance to coast	-4.821^{***}	-3.886^{***}	-6.604^{***}	-6.010^{***}
	(1.347)	(1.420)	(2.167)	(1.870)
N	318	282	318	282
R^2	0.189	0.227	0.400	0.452
Panel (b): ΔT <Median				
Distance to coast	9.766^{***}	10.275^{***}	7.992^{*}	6.739^{**}
	(2.324)	(1.860)	(3.790)	(3.040)
N	193	172	193	172
R^2	0.192	0.259	0.481	0.583
Panel (c): ΔT ≥Median				
Distance to coast	-3.652^{**}	-2.089^{*}	-5.212^{*}	-4.929^{*}
	(1.642)	(1.195)	(2.842)	(2.564)
N	112	107	112	107
R^2	0.185	0.401	0.433	0.500
Country FE			✓	✓
Controls		✓		✓

Note: The table reports OLS estimates. The unit of analysis is the province. Pre-colonial population density is the number of indigenous people per square kilometre before the arrival of Columbus from Maloney and Valencia (2016). The dependent variable is the log of people per square km in 2000. The full sample contains 258 observations. **Geographical controls:** Altitude, ruggedness, rainfall, and inverse distance to the coast (see Maloney and Valencia (2016) for details). **Standard errors** are clustered at the country-level. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table 12: Event-study specification

Dependent variable:	City population (log)			
	(1)	(2)	(3)	(4)
Δ T $\times$ $\mathbb{1}$ $(year = 1600)$	-0.045	-0.061	-0.042	-0.071
	(0.063)	(0.067)	(0.080)	(0.074)
Δ T $\times$ $\mathbb{1}$ $(year = 1650)$	-0.002	0.009	0.025	-0.009
	(0.039)	(0.052)	(0.058)	(0.054)
Δ T $\times$ $\mathbb{1}$ $(year = 1700)$	0.014	0.042	0.043	0.018
	(0.043)	(0.054)	(0.049)	(0.044)
Δ T $\times$ $\mathbb{1}$ $(year = 1800)$	0.122^{***}	0.120^{***}	0.131^{***}	0.097^{**}
	(0.040)	(0.045)	(0.046)	(0.040)
Δ T $\times$ $\mathbb{1}$ $(year = 1850)$	0.230^{***}	0.200^{***}	0.193^{***}	0.134^{**}
	(0.049)	(0.058)	(0.064)	(0.054)
City FE	✓	✓	✓	✓
Controls $\times$ time FE		✓	✓	✓
Viceroyalty $\times$ time FE			✓	✓
Population 1750 $\times$ time FE				✓
Observations	1,566	1,566	1,566	1,566
R-squared	0.829	0.845	0.859	0.874

Note: The table reports OLS estimates. Shipping time is standardized. The unit is a city in a certain year. The omitted year is 1750 (last period prior to the reform). **Dependent variable:** log of city population size. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

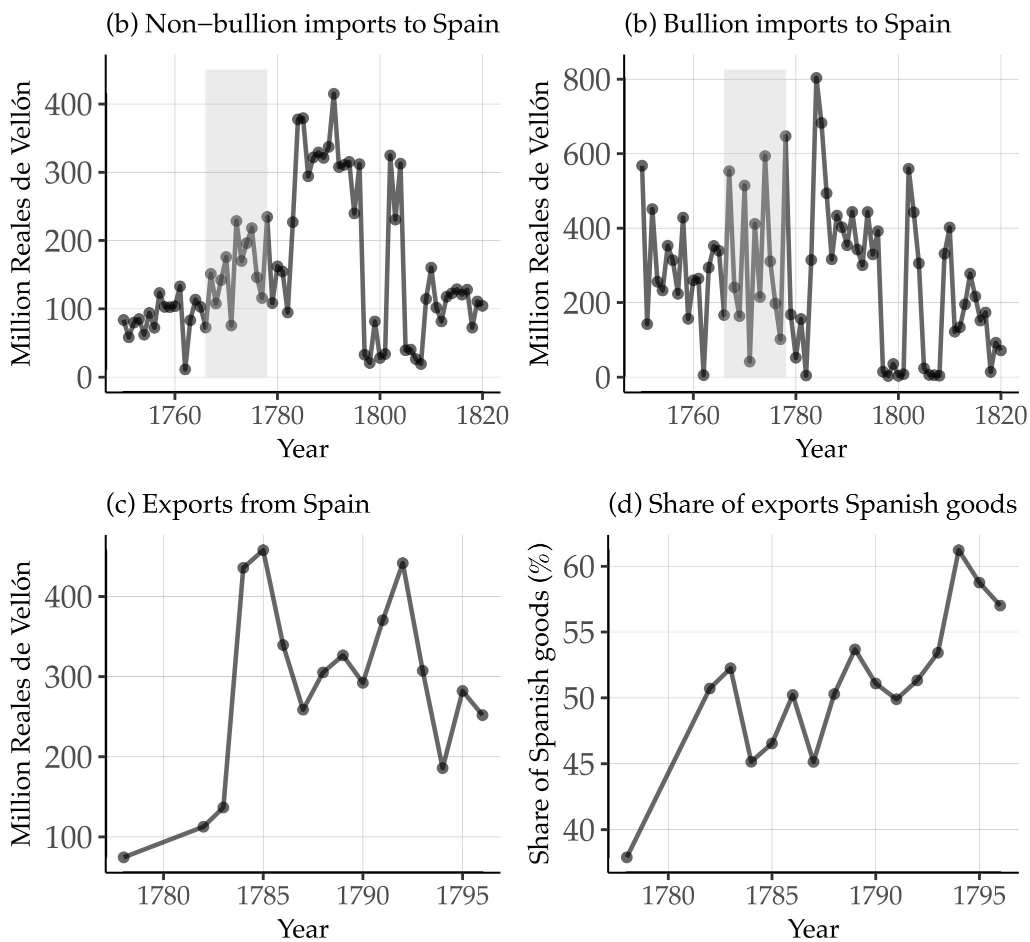

Figure 2: Panel (a) displays the value of private non-bullion imports to Spain (in million reales de vellón) from American ports between 1750 and 1820 at constant prices. Panel (b) displays private bullion imports to Spain for between 1750 and 1820 at constant prices. The shaded area denotes the beginning and end of the main part of the liberalization. The large drop in 1797 is due to the British blockade of Cadiz as part of the Anglo-Spanish War 1796-1808. The lower level after 1807 was due to the Peninsular War as well as the Spanish-American wars of independence. Data for 1780 is missing in the original data source (imputed with average). Panel (c) displays exports from Spain for the years 1782 to 1796. Panel (d) displays the share of Spanish exports originating in Spain for the years 1782 to 1796. Source: Cuenca-Esteban (2008) and Fisher (1985).

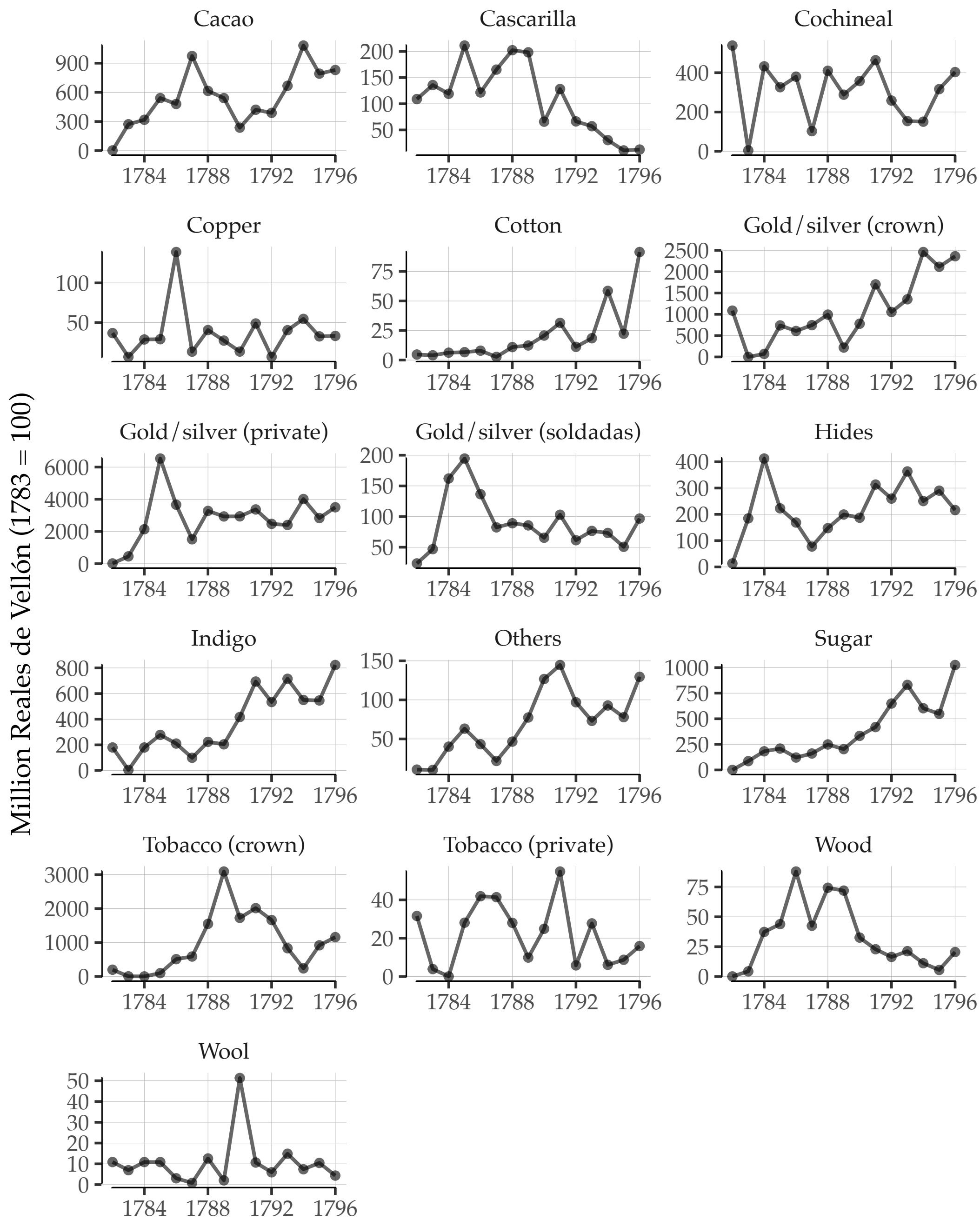

Figure 3: The figure depicts the composition of imports to Cadiz (in million reales de vellón) for for the years 1782 to 1796. Source: Fisher (1985).

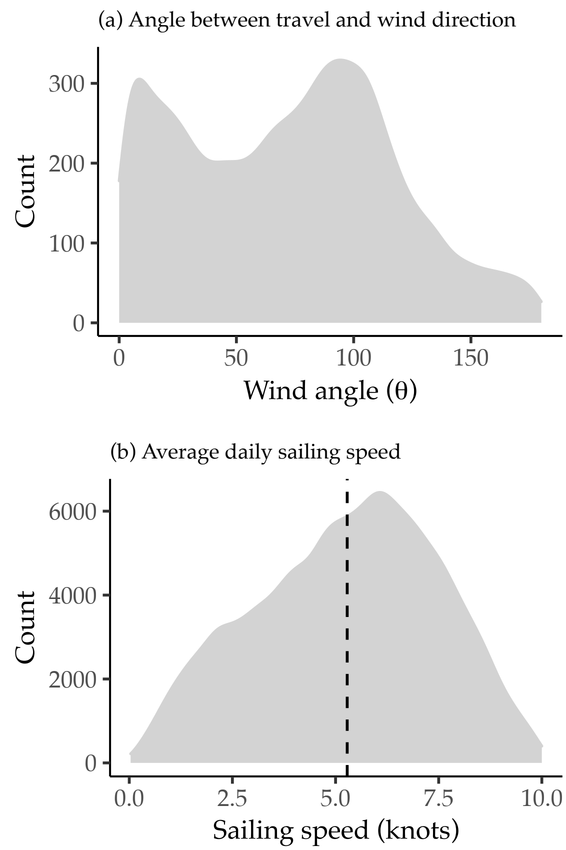

Figure 4: Panel (2) depicts the deviation of the sailing direction and wind direction for the logbook entries. Panel (b) depicts the average daily speed imputed from the logbook entries. The vertical line denotes the average sailing speed in the sample.

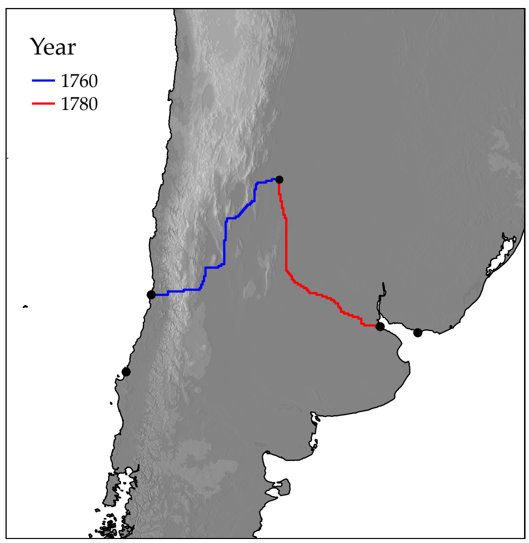

Figure 5: The figure depicts the time minimizing route from a location in current day Argentina to Europe in 1760 (blue) and 1810 (red).

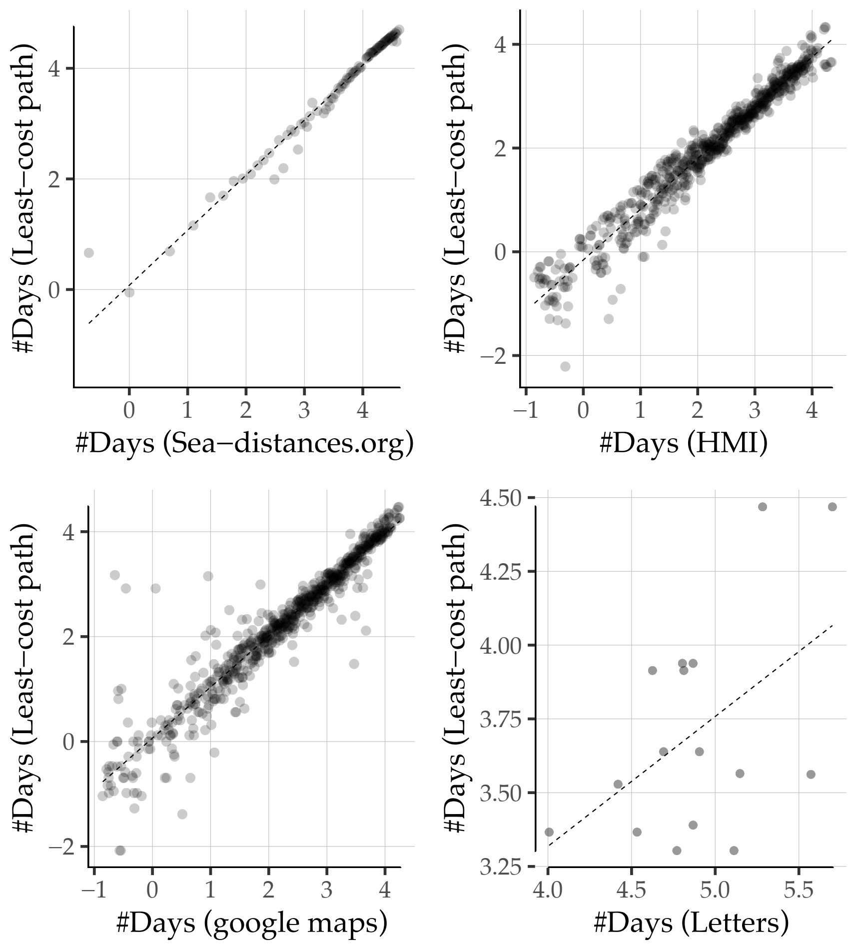

Figure 7: The figures depicts the results from the main validation exercises. The top-left figure depicts the relationship between sailing times produced by the least-cost path on the constructed cost-surface and sailing times from sea-distances.org for voyages between Cadiz and 21 ports in Spanish America. The travel times are set to 4 knots which is the average speed attained over the cost-surface. The top-right figure depicts the relationship between bilateral shipping times between large cities generated by the least-cost path on the constructed cost-surface and the Human Mobility Index developed in Özak (2010, 2018). The bottom-left depicts shows the relationship between bilateral shipping times between major cities generated by the least-cost path on the constructed cost-surface and google maps.

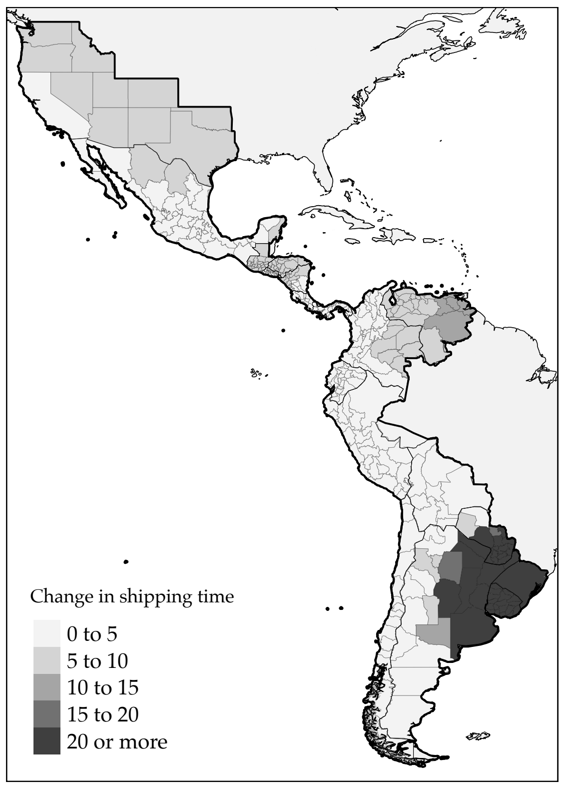

Figure 8: The figure depicts the difference between shipping times in 1760 and 1810 by aggregated to the province-level. Darker colors indicate larger reductions in shipping times. Full lines denote modern country borders.

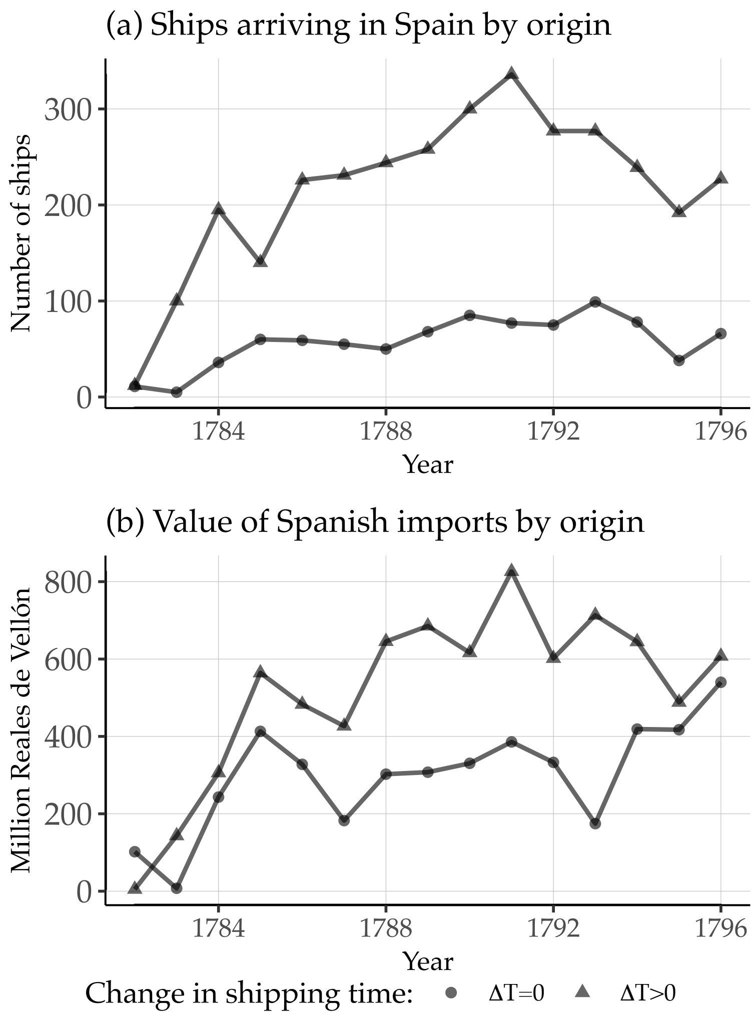

Figure 9: Panel (a) displays the number of ships arriving in Cadiz from ports experiencing changes in shipping time as a result of the reform ($\Delta T > 0$) and ports without changes in the shipping time ($\Delta T = 0$) for the years 1782 to 1796. Panel (b) displays the value of imports arriving in Cadiz (in million reales de vellón) from ports experiencing changes in shipping time as a result of the reform ($\Delta T > 0$) and ports without changes in the shipping time ($\Delta T = 0$) for the years 1782 to 1796. Source: Fisher (1985).

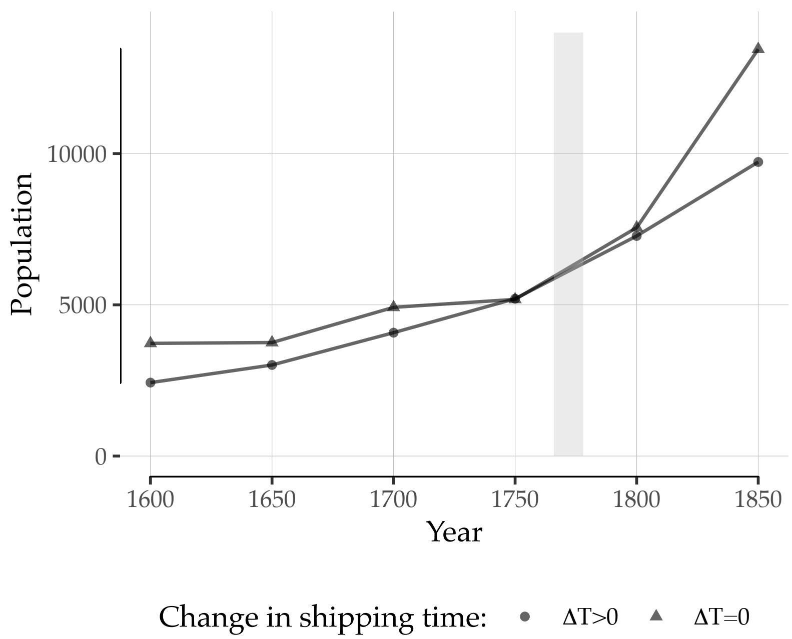

Figure 10: The figure depicts the average population size for cities with changes in the shipping time to Europe and for cities without changes in the shipping time to Europe. The shaded area shows the period of the reform.

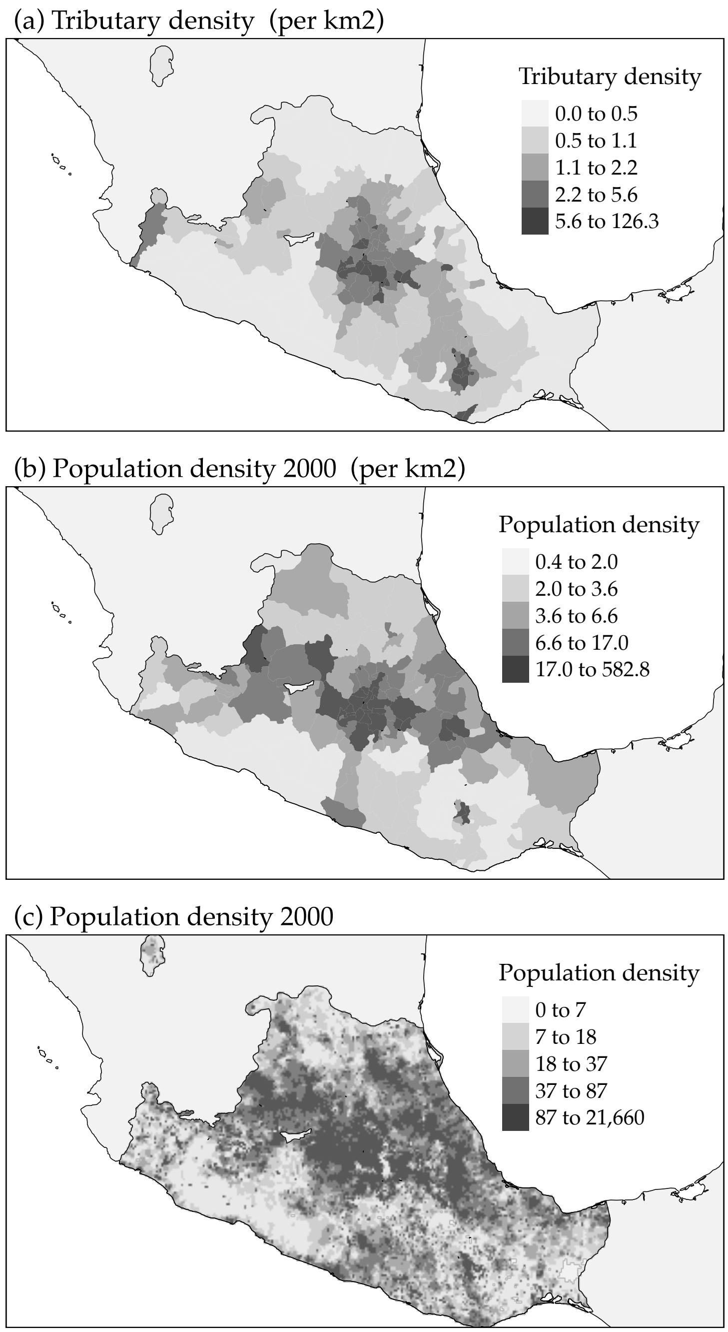

Figure 11: The figure depicts the population density and tributary density for central Mexico. Panel (a) depicts the tributary density by political division for the colonial era. Data are from Gerhard (1993*a*). Panel (b) depicts the population density aggregated to the same political boundaries in 2000. Panel (c) shows the underlying raster containing population density for 2000.

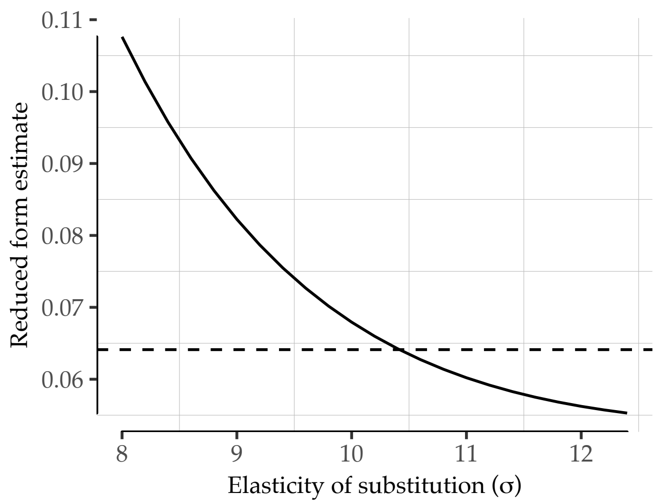

Figure 14: The figure depicts the model-implied impact of the reform for different values of σ. The magnitude of the reduced form estimate is denoted by the horizontal line.

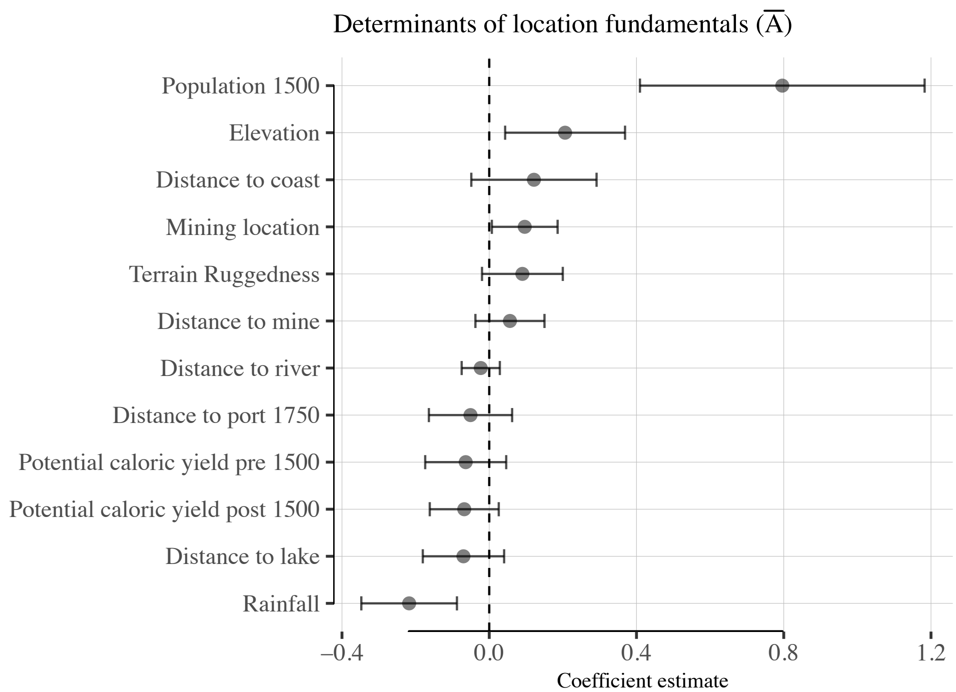

Figure 15: The figure depicts the correlates of the locational fundamentals implied by the model ($\bar{A}$) and 95 percent confidence intervals. Each point is the coefficient of the locational fundamental regressed on each variable. The variables are standardized.

Online Appendix

Contents

A Model Derivation

This section shows the main steps of the derivation of the model, the equilibrium conditions, and the estimation of the parameters.

Preferences. The consumers' problem is standard and I outline the main steps in this section. The utility function is defined over a composite of traded goods that are specific to each location (the Armington assumption) and food that is sourced from the immediate hinterland and is therefore non-traded. These preferences take the Cobb-Douglas form and are defined as follows,

$$U_i = \frac{C_i^{\mu} F_i^{1-\mu}}{\mu^{\mu}(1-\mu)^{1-\mu}}, \tag{A.1}$$

where $C_i = \left(\sum_{j \in N} c_{ji}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}}$ and c_{ji} is the amount of the location j specific good consumed in location i. Since Y_i is the total income in region i, p_{ji} is the price of the j-good in location i, and r_i is the price of land, the demand for food is given by $F_i = (1-\mu)Y_i \ / \ r_i$ and the demand for the traded composite good is given by $C_i = \mu Y_i \ / \ P_i$. To find the demand function for each location-specific good I solve the following problem (where time subscripts are supressed for legibility),

$$\max_{\{c_{ji}\}_{j=1}^{R}} \left(\sum_{j \in R} c_{ji}^{\frac{\sigma-1}{\sigma}}\right)^{\frac{\sigma}{\sigma-1}} \text{ s.t.} \sum_{j \in R} c_{ji} p_{ji} \leq E_i, \tag{A.2}$$

where E_i is the aggregate expenditure on the traded good in region i. As a result, by $c_{ji} = p_{ji} Y_i P_i^{\sigma-1}$ where $P_i = \left(\sum_{j \in N} p_{ji}^{1-\sigma}\right)^{\frac{1}{1-\sigma}}$ and denotes the price index for the traded good. Inserting the demand functions into the utility function gives the indirect utility function for an individual in location i that is provided in the paper,

$$V_i = \frac{w_i}{P_i^{\mu} r_i^{1-\mu}}. \tag{A.3}$$

Production. Production takes place under perfect competition and as a result the price for traded and non-traded goods is equal to its marginal cost. Since a worker in i can produce A_i units of a good and the wage is w_i, the price of the good in location i is given by $p_i = w_i \ / \ A_i$. Since there are iceberg transportation costs, the price faced by an individual in location i is given by $p_{ji} = \tau_{ji} w_j \ / \ A_j$. A_i consists of both an exogenous location specific component ($\bar{A}_i$) and an endogenous component of non-pecuniary externalities not internalized by the production entity which depends on the size of the city i. The productivity of location i at time t is therefore given by $A_{it} = \bar{A}_i L_{it}^{\alpha_1} L_{it-1}^{\alpha_2}$. Finally, the use of land in the production of food features constant returns to scale and is a function of the availability of arable land H_i which is exogenous in each location. As a result, $F_i = H_i$. The land market is perfectly competitive. Since the market for land is competitive and supply exogenous, the price for land is pinned down by the demand function for F_i is given by $r_i = (1-\mu)Y_i \ / \ H_i$.

Trade. Assuming market clearing such that $c_{ji} = q_{ji}$, the value of trade from location j to location i is given by $X_{ji} = q_{ji} p_{ji} = p_{ji}^{1-\sigma} \mu Y_i P_i^{\sigma-1} = \left(\tau_{ji} \frac{w_j}{A_j}\right)^{1-\sigma} \mu Y_i P_i^{\sigma-1}$ where q_{ji} denotes the number of units of the location j goods that arrive in location i. Using the expression for the local productivity A_i and that $\mu Y_i = w_i L_i$ in equilibrium gives the expression in the derivations that follow.

Labor mobility. The utility of an individual moving from region i to region j is given by $V_{ij} = \frac{V_j}{\mu_{ij}} \epsilon_j$ where ϵ_j is an idiosyncratic taste shifter, assumed to be an iid draw from a Fréchet-distribution with shape parameter θ capturing individual level heterogeneity in location preferences. An individual chooses to move from i to j if the realized utility of that location is higher, which happens with probability $Pr\left(V_{ij}\epsilon_j \geq V_{ik}\epsilon_k \forall k \neq j \in R\right)$. Since the idiosyncratic location preferences are iid and there is a continuum of agents in each location this probability corresponds to the share of agents in city i moving to j, denoted π_{ij}. It follows that the conditional probability of moving is,

$$\pi_{ij}|\epsilon_j = Pr\left(\epsilon_k \leq \frac{V_{ij}\epsilon_j}{V_{ik}}\epsilon_k \forall k \neq j \in R\right) = \prod_{k\neq j} Pr\left(\epsilon_k \leq \frac{V_{ij}\epsilon_j}{V_{ik}}\right). \tag{A.4}$$

As a result, the unconditional distribution is given by,

$$\pi_{ij} = \int_0^\infty f(\epsilon_j) \prod_{k\neq j} Pr\left(\epsilon_k \leq \frac{V_{ij}\epsilon_j}{V_{ik}}\right) d\epsilon_j = \int_0^\infty \theta\epsilon_j^{-1-\theta} \exp\{-\epsilon_j^{-\theta}\} \exp\{-V_{ij}^{-\theta}\epsilon_j^{-\theta} \sum_{k\neq j} V_{ik}^{\theta}\} d\epsilon_j \tag{A.5}$$

$$= \int_0^\infty \theta\epsilon_j^{-1-\theta} \exp\{-\epsilon_j^{-\theta}\Phi_j\} d\epsilon_j = \Phi_j^{-1} = \frac{V_{ij}^{\theta}}{\sum_{k\in R} V_{ik}^{\theta}} = \frac{(V_j \,/\, \mu_{ij})^{\theta}}{\sum_{k\in R}(V_k \,/\, \mu_{ik})^{\theta}}, \tag{A.6}$$

which follows after making the substitution defining $x = \epsilon_j^{-\theta}\Phi_j$. The expected utility (prior to the realization of shocks) for an agent living in location i is given by $E[\max_{j\in R} V_{ij}]$. To derive the expression define ψ_{ij} which gives the utility expected to be derived from location j. It follows that $\psi_{ij}|\epsilon_j = V_{ij}\epsilon_j Pr\left(\epsilon_k \leq \frac{V_{ij}\epsilon_j}{V_{ik}}\epsilon_k \forall k \neq j \in R\right) = V_{ij}\epsilon_j \prod_{k\neq j} Pr\left(\epsilon_k \leq \frac{V_{ij}\epsilon_j}{V_{ik}}\epsilon_k\right)$. As a result, the unconditional expectation is given by,

$$\psi_{ij} = \int_0^\infty f(\epsilon_j) V_{ij}\epsilon_j \prod_{k\neq j} Pr\left(\epsilon_k \leq \frac{V_{ij}\epsilon_j}{V_{ik}}\right) d\epsilon_j. \tag{A.7}$$

Again using the distributional assumptions and rearranging gives

$$\psi_{ij} = \theta V_{ij} \int_0^\infty \epsilon_j^{-\theta} \exp\{-\epsilon_j^{-\theta}\Phi_j\}\epsilon_j. \tag{A.8}$$

Substituting with $x = \epsilon_j^{-\theta}\Phi_j$, it follows that $\psi_{ij} = CV_{ij}\Phi_j^{\frac{1-\theta}{\theta}}$. Then summing over ψ_{ij} gives $\Pi_i = \sum_{k\in R}\psi_{ik} = \left(\sum_{k\in R} V_{ik}^{\theta}\right)^{\frac{1}{\theta}}$. The number of people moving from i to j is the $L_{ijt} = \pi_{ij}L_{it-1} = L_{it-1}V_j^{\theta}\Pi_i^{-\theta}\mu_{ij}^{-\theta}$ which is the gravity equation for migration in the model.

Equilibrium. The equilibrium of the model is characterized by the following six equations.

1. $w_iL_i = \sum_{k\in N} X_{ik}$. The expenditure total on goods produced in i equals the revenue in each location, which in turn equals the cost of labor when there are zero profits (goods market clearing).
2. $w_iL_i = \sum_{k\in N} X_{ki}$. Revenue from trade equals total expenditure on goods (balanced trade in each location).
3. $Y_i = \frac{w_iL_i}{\mu}$. Total income in each location equals income derived from land and labor (labor and land market clearing condition).
4. $\sum_{k\in N} L_i = \bar{L}$. The total population size of the economy is fixed.
5. $L_i = \sum_{k\in N} L_{ji}$. The total population equals the number arriving at the location.
6. $L_{it-1} = \sum_{k\in N} L_{ijt}$. The total population equals the number exiting that location.

Since trade is balanced and trade costs are quasi-symmetric, it follows that the origin and destination terms in the gravity equation are proportional (Allen and Arkolakis, 2014). Therefore $w_i^{1-\sigma}A_i^{\sigma-1} \propto w_iL_iP_i^{\sigma-1}$. Using the indirect utility, it follows that $P_i^{\sigma-1} = w_i^{\sigma-1} V_i^{\frac{1-\sigma}{\mu}} H_i^{\frac{(1-\mu)(\sigma-1)}{\mu}} L_i^{\frac{(\mu-1)(\sigma-1)}{\mu}}$. Inserting this gives the following expression for the nominal wage,

$$w_i = A_i^{\tilde{\sigma}} L_i^{\tilde{\sigma}(\frac{1}{1-\sigma}+\frac{1-\mu}{\mu})} V_i^{\frac{\tilde{\sigma}}{\mu}} H_i^{\frac{(\mu-1)\tilde{\sigma}}{\mu}}. \tag{A.9}$$

Using the goods market clearing condition, it follows that

$$w_i L_i = \sum_{j\in R} \tau_{ij}^{1-\sigma} w_i^{1-\sigma} A_i^{\sigma-1} L_j w_j P_j^{\sigma-1} \tag{A.10}$$

$$A_i^{\tilde{\sigma}\sigma+1-\sigma} L_i^{1+\tilde{\sigma}\sigma(\frac{1}{1-\sigma}+\frac{1-\mu}{\mu})} V_i^{\frac{\tilde{\sigma}\sigma}{\mu}} H_i^{\frac{(\mu-1)\tilde{\sigma}\sigma}{\mu}} = \sum_{j\in R} \tau_{ij}^{1-\sigma} A_j^{\tilde{\sigma}\sigma} L_j^{1+\tilde{\sigma}\sigma(\frac{1}{1-\sigma}+\frac{1-\mu}{\mu})} V_j^{\frac{\tilde{\sigma}\sigma}{\mu}+\frac{1-\sigma}{\mu}} H_j^{\frac{\mu-1}{\mu}(\tilde{\sigma}\sigma-\sigma+1)} \tag{A.11}$$

Using the functional form of the agglomeration spillovers then results in the following equations for the equilibrium of the model,

$$L_i^{\tilde{\sigma}\left(1-\sigma\frac{\mu-1}{\mu}-\alpha_1(\sigma-1)\right)} V_i^{\frac{\tilde{\sigma}\sigma}{\mu}} = \bar{A}_i^{\tilde{\sigma}(\sigma-1)} H_i^{\frac{(1-\mu)\tilde{\sigma}\sigma}{\mu}} L_{it-1}^{\alpha_2\tilde{\sigma}(\sigma-1)} \sum_{j\in R} \tau_{ij}^{1-\sigma} \bar{A}_j^{\tilde{\sigma}\sigma} L_j^{\tilde{\sigma}(1+\alpha_1\sigma+\sigma\frac{1-\mu}{\mu})} V_j^{\frac{\tilde{\sigma}(1-\sigma)}{\mu}} H_j^{\frac{\tilde{\sigma}(\mu-1)(1-\sigma)}{\mu}} L_{jt-1}^{\sigma\tilde{\sigma}\alpha_2} \tag{A.12}$$

$$\Pi_i^{\theta} = \sum_{j\in R} \mu_{ij}^{-\theta} V_j^{\theta} \tag{A.13}$$

$$L_i V_i^{-\theta} = \sum_{j\in R} \mu_{ij}^{-\theta} \Pi_j^{-\theta} L_{jt-1} \tag{A.14}$$

Existence and uniqueness. The set of model parameters that guarantee uniqueness and existence of the equilibrium can be derived using the results in Allen and Donaldson (2020) and Allen, Arkolakis and Li (2020). There are $3 \times R$ endogenous variables that need to be solved for. Ordering the endogenous variables as L, V, and Π gives the following matrices of coefficients,

$$\mathbf{B} = \begin{bmatrix} \tilde{\sigma}(1-\sigma\frac{\mu-1}{\mu}-\alpha_1(\sigma-1)) & \frac{\tilde{\sigma}\sigma}{\mu} & 0 \\ 0 & 0 & \theta \\ 1 & -\theta & 0 \end{bmatrix}, \tag{A.15}$$

$$\mathbf{\Gamma} = \begin{bmatrix} \tilde{\sigma}(1+\alpha_1\sigma+\sigma\frac{1-\mu}{\mu}) & \frac{\tilde{\sigma}(1-\sigma)}{\mu} & 0 \\ 0 & \theta & 0 \\ 0 & 0 & -\theta \end{bmatrix}, \tag{A.16}$$

It follows that the inverse of $\mathbf{B}$ is given by,

$$\mathbf{B}^{-1} = \frac{1}{\theta^2 b_{11} + \frac{\tilde{\sigma}\sigma\theta}{\mu}} \begin{bmatrix} \theta^2 & 0 & \frac{\tilde{\sigma}\sigma\theta}{\mu} \\ \theta & 0 & -\theta b_{11} \\ 0 & \theta b_{11} + \frac{\tilde{\sigma}\sigma}{\mu} & 0 \end{bmatrix}, \tag{A.17}$$

where $b_{11} = \tilde{\sigma}(1-\sigma\frac{\mu-1}{\mu}-\alpha_1(\sigma-1))$. As a result,

$$\mathbf{\Gamma B}^{-1} = \frac{1}{b_{11}\theta^2 + \frac{\tilde{\sigma}\sigma\theta}{\mu}} \begin{bmatrix} \theta^2\Gamma_{11} + \frac{\theta\tilde{\sigma}(1-\sigma)}{\mu} & 0 & \Gamma_{11} - \frac{\theta b_{11}(1-\sigma)}{1-\mu} \\ \theta^2 & 0 & -\theta^2 b_{11} \\ 0 & -\theta^2 b_{11} - \frac{\tilde{\sigma}\sigma\theta}{\mu} & 0 \end{bmatrix}. \tag{A.18}$$

As noted in Allen and Donaldson (2020), the spectral norm of the abosulte value of the above matrix is equivalent to the spectral norm of the smaller matrix,

$$\mathbf{A}^p = \left|\frac{1}{\theta^2 b_{11} + \frac{\tilde{\sigma}\sigma\theta}{\mu}}\right| \begin{bmatrix} \left|\theta^2\Gamma_{11} + \frac{\theta\tilde{\sigma}(1-\sigma)}{\mu}\right| & \left|\Gamma_{11} - \frac{\theta b_{11}(1-\sigma)}{1-\mu}\right| \\ \left|\theta^2\right| & \left|-\theta^2 b_{11}\right| \end{bmatrix}. \tag{A.19}$$

Next, consider the long run steady state of the model. There will still be migration in the model in the steady state, but bilateral flows will cancel out leaving the relative size of all locations fixed. The long-run steady state is characterized by $L_{it} = L_{it-1}$ for all i. Using this condition gives the following system of equations for the steady state of the model.

$$L_i^{\tilde{\sigma}\left(1-\sigma\frac{\mu-1}{\mu}-(\alpha_1+\alpha_2)(\sigma-1)\right)} V_i^{\frac{\tilde{\sigma}\sigma}{\mu}} = \bar{A}_i^{\tilde{\sigma}(\sigma-1)} H_i^{\frac{(1-\mu)\tilde{\sigma}\sigma}{\mu}} \sum_{j\in R} \tau_{ij}^{1-\sigma} \bar{A}_j^{\tilde{\sigma}\sigma} L_j^{\tilde{\sigma}\left(1+(\alpha_1+\alpha_2)\sigma+\sigma\frac{1-\mu}{\mu}\right)} V_j^{\frac{\tilde{\sigma}(1-\sigma)}{\mu}} H_j^{\frac{\tilde{\sigma}(\mu-1)(1-\sigma)}{\mu}} \tag{A.20}$$

$$\Pi_i^{\theta} = \sum_{j\in R} \mu_{ij}^{-\theta} V_j^{\theta} \tag{A.21}$$

$$L_i V_i^{-\theta} = \sum_{j\in R} \mu_{ij}^{-\theta} \Pi_j^{-\theta} L_{jt} \tag{A.22}$$

As the equations pinning down the steady state are the same as for the equilibrium except for the parameters, the existence and uniqueness follows directly from the above condition where α_1 is replaced by $\alpha_1 + \alpha_2$.

Reduced form relationships. The deterministic component of indirect utility is given by $V_i = w_i P_i^{-\mu} r_i^{\mu-1}$ where again $r_i = (1-\mu) w_i L_i \,/\, H_i$ and assuming quasi-symmetric trade costs $w_i^{1-\sigma} A_i^{\sigma-1} \propto w_i L_i P_i^{\sigma-1}$. As a result, $V_i^{-\sigma} = w_i^{-\mu\sigma} P_i^{\mu\sigma} L_i^{\sigma(1-\mu)} H_i^{\sigma(1-\mu)}$ and $w_i^{-\sigma\mu} \propto A_i^{\mu(1-\sigma)} L_i^{\mu} P_i^{\mu(\sigma-1)}$. Inserting the latter expression into the former gives and using the specification for the agglomeration economies gives,

$$L_i^{\mu+\sigma(1-\mu)+\frac{\sigma}{\theta}+\alpha_1\mu(1-\sigma)} = \kappa \Lambda_{it}^{-\sigma} \bar{A}_i^{\mu(\sigma-1)} L_{it-1}^{\alpha_2\mu(\sigma-1)} P_{it}^{\mu(1-2\sigma)} H_i^{\sigma(1-\mu)}, \tag{A.23}$$

where $\Lambda_{it} = V_{it}\left(L_{it} \,/\, \bar{L}\right)^{-\frac{1}{\theta}}$. Taking the natural logarithm of this expression gives

$$\nu \ln L_i = \kappa' - \sigma \ln \Lambda_{it} + \mu(\sigma-1)\ln \bar{A}_i + \alpha_2\mu(\sigma-1)\ln L_{it-1} - \mu(2\sigma-1)\ln P_{it}, \tag{A.24}$$

where $\nu = \mu + \sigma(1-\mu) + \frac{\sigma}{\theta} + \alpha_1\mu(1-\sigma)$ and κ_i' is a location-specific constant. Taking first differences gives the expression in the text. Next, the expression can be used recursively to solve for the current population as a function of the full path of endogenous and exogenous variables,

$$\begin{aligned} \ln L_{it} = \kappa_i' + \left(\frac{\alpha_2\mu(\sigma-1)}{\nu}\right)^T \ln L_{i0} - \frac{\sigma}{\nu}\sum_{k=0}^{T-1}\left(\frac{\alpha_2\mu(\sigma-1)}{\nu}\right)^k \ln \Lambda_{it-k} \\ - \frac{\mu(2\sigma-1)}{\nu}\sum_{k=0}^{T-1}\left(\frac{\alpha_2\mu(\sigma-1)}{\nu}\right)^k \ln P_{it-k}. \end{aligned} \tag{A.25}$$

To analyze the comparative statics underlying the reduced form exercise consider the above equation I consider a reduction in the trade cost to Europe in period k for city i (τ_{iek}). It follows that,

$$\frac{\partial \ln L_{it}}{\partial \tau_{iek}} = -\frac{\mu(2\sigma-1)}{\nu}\left(\frac{\alpha_2\mu(\sigma-1)}{\nu}\right)^{t-k} P_{ik}^{\frac{2\sigma-1}{1-\sigma}} \tau_{iek}^{-\sigma} w_{ek}^{1-\sigma} A_e^{\sigma-1} < 0, \tag{A.26}$$

which shows that a lower trade cost to Europe has a persistent and positive effect on the population size in location i. Moreover, since $\alpha_2\mu(\sigma-1) \,/\, \nu < 1$, it follows that $\lim_{t\to\infty} \partial L_{it} \,/\, \partial\tau_{iet} = 0$. Finally, I consider the effect of changes in trade for cities differing in initial market size (L_{ik}). Since $\partial P_{ik} \,/\, \partial L_{ik} < 0$, it follows that, $\partial^2 \ln L_{it} \,/\, \partial\tau_{iek}\partial L_{ik} > 0$.

B Data Sources

Urban population. This dataset on urban population sizes combines a variety of sources. Importantly for this study, the data quality and the number of sources available increased over the colonial period. I therefore restrict the sample to cover the period after 1600. Most of the variation in the data is from after 1750 when more data is available. At contact, numbers mainly come from Spanish reports on military numbers, males in city-states, and written impressions by early settlers and conquistadors. However, once the administrative capacity was in place, the main data source is tribute counts. The motivation for these counts was fiscal and the relationship between total population and tributary count changed over time. In a few cases, I have used conversions between tributary counts and population numbers available in Gerhard (1993*a*). Some of the sources used report population data directly. This is typically the case for the second half of the 18th century. In addition to tributary counts, important sources that form the basis of the data used in the paper are from various civil, fiscal, and ecclesiastical records.

Following, Arroyo Abad and Zanden (2016) the starting point of the dataset is Buringh (2013). The basic criterion to select for inclusion into the database was the availability of historical data on its population size for the period between 1500 and 1800, minimal size of 5.000 inhabitants in 1850 was formulated (similar to what Bairoch (1988) previously applied as one of their inclusion criteria), minimal size of 100.000 inhabitants in 2000 has been used for inclusion into the database. If one of these criteria was met a city was included in the dataset. For these cities, the database is constructed using a variety of secondary sources. I supplement and extend this dataset using a range of sources. Data on central Mexico is from Gerhard (1993*a*). Northern Mexico and the Southwestern United States is from Gerhard (1993*b*). Southern Mexico and parts of Guatemala are from Gerhard (1993*c*). For Peru I use information in Cook (1981). Data on Buenos Aires is from Johnson and Seibert (1979). Information on Colombia is from Pinzón, Mora and Mora (1994). Population numbers for larger cities I use numbers from Morse (1974).

An inevitable issue is that the reporting year often does not coincide with the 50-year bin in which the data is coded in the dataset. For example, for New Granada (present-day Colombia) the first proper census was conducted between 1777 and 1779. For most cases, I assign the observation to the closest 50 year period. Observations in 1790 would for example be assigned to 1800. If there are observations on either of the year of interest, for example, 1790 and 1805, I assume an average growth rate for every year and calculate the predicted population size in 1800. In particular, I use the following formula to extrapolate between yar t and year t', $(L_{t'} - L_t)\ /\ L_t \times \hat{t} \times L_t$, where $\hat{t}$ denotes the number of years from t to the closest year recorded in the sample.

Settlements. Economic expansion, an increased military presence, and missionary activity also led to the formation of new settlements (Morse, 1974). Examples of settlements founded in this period that later grew into larger cities are San Francisco, Albuquerque, San Antonio, Montevideo, Copiapo, and Rancagua (Morse, 1974; Parry, 1990). To capture this, I further supplement the dataset territorial gazetteer of around 15,000 places that existed in the Spanish Empire during the 18th and early 19th-century (Stangl, 2019). The city (*cidudad*) was the highest legal denomination given a settlement in the Spanish Empire. The founding of cities were typically conscious efforts by the crown to ensure territorial control, rather than something which naturally occurred through population growth. Criteria for locations chosen depended on a range of micro-geographic factors such as ease of defense and water supply. Often these were founded in localities where large population centers already were located. Moreover, towns were in some cases upgraded from town status (*villa*) to city status. Few settlements with the status of city were founded during the study period, however, several settlements were founded that later would evolve into large population centers. The town (*villa*) was a legal status granted a settlement in the Spanish Empire. Also, the founding of cities were typically conscious efforts by the crown to ensure territorial control, rather than naturally occurring through population growth. The formation of new towns was frequent throughout the study period. The data come from a variety of sources. "Sources include archival material like census tables, mission reports, visitations of dioceses and provinces, but also more ephemeral documents like petitions of some city council which was mostly not written for giving geographic information but may touch one specific detail or incidentally exposes some relevant information. Non-archival contemporary sources include mostly highly systematic sources for information like so-called"Foreigner Guides" (printed calendar-manuals which included also lists of office holders of many parts of the Empire), maps, or geographical descriptions both printed and manuscripts." (Stangl, 2018). Around 11 percent of cell/decade combinations have a settlement in the main dataset.

Potential vegetation. Global potential vegetation data is from the Center for Sustainability and the Global Environment (SAGE). The data is representative of the world's "potential" vegetation, that is vegetation that would most likely exist now in the absence of human activities. The data consists of a global map of natural vegetation at a 5 min resolution classified into 15 vegetation types. These are:

- Tropical evergreen forest/woodland
- Tropical deciduous forest/woodland
- Temperate nroadleaf evergreen forest/woodland
- Temperate needleleaf evergreen forest/woodland
- Temperate deciduous forest/woodland
- Boreal evergreen forest/woodland
- Boreal deciduous forest/woodland
- Evergreen/deciduous mixed forest/woodland
- Savanna
- Grassland/steppe
- Dense shrubland
- Open shrubland
- Tundra
- Desert
- Polar desert/rock/ice

The data is available at https://nelson.wisc.edu/sage/data-and-models/global-potential-vegetation/index.php. Details about the construction of the data can be found in Ramankutty and Foley (1999).

Agricultural yield. I use a measure of agricultural potential constructed by Galor and Özak (2015, 2016). The data measure the maximum attainable yield measured in calories that can be achieved for a variety of crops. Agricultural productivity is the maximum potential production capacity in tons per hectare over the seventeen crops

- Buckwheat
- Barley
- Chickpea
- Foxtail millet
- Groundnut
- Maize
- Oat
- Pearl millet

- Wetland rice
- Rape
- Rye
- Sunflower
- Soybean
- Sweet potato
- Sorghum
- Wheat
- White potato

Climate and temperature. Data on climate and temperature are from the WorldClim global climate database. The data spans (1960-1990) at 5 minute resolution. See https://www.worldclim.org/data/bioclim.html for the data source. The following variables are included in the analysis:

- Annual Mean Temperature
- Mean Diurnal Range (Mean of monthly (max temp - min temp))
- Isothermality
- Temperature Seasonality (standard deviation ×100)
- Max Temperature of Warmest Month
- Min Temperature of Coldest Month
- Temperature Annual Range
- Mean Temperature of Wettest Quarter
- Mean Temperature of Driest Quarter
- Mean Temperature of Warmest Quarter
- Mean Temperature of Coldest Quarter
- Annual Precipitation
- Precipitation of Wettest Month
- Precipitation of Driest Month
- Precipitation Seasonality (Coefficient of Variation)
- Precipitation of Wettest Quarter
- Precipitation of Driest Quarter
- Precipitation of Warmest Quarter
- Precipitation of Coldest Quarter

Ruggedness, slope, and elevation. The Terrain Ruggedness Index was developed in Elliot, DeGloria and Riley (1999) and follows the the classification:

- 0-80 - level terrain surface.
- 81-116 - nearly level surface.
- 117-161 - slightly rugged surface.
- 162-239 - intermediately rugged surface.
- 240-497 - moderately rugged surface.
- 498-958 - highly rugged surface.

- > 959 - extremely rugged surface.

I measure ruggedness by the average standard deviation of elevation. Plains will score low in this measure, while mountains and valleys will score high.

C Further Historical Background

This section provides a more detailed historical background for the analysis. I discuss the background and the motivation for the trade reform as well as the historical relationship between trade and economic development within the Spanish Empire.

A central aim of commercial policy in the 18th century was to promote state wealth acquisition through trade surpluses (Findlay and O'Rourke, 2007). In the Spanish context, this was achieved through a range of policies restricting trade. First, trade was restricted to four ports in the Americas (Cartagena de Indias, El Callao, Portobello/Nombre de Dios, and Veracruz) and only Seville/Cádiz in Europe. Further, the frequency of travel and the routes were restricted. Typically, only two fleets left Spain every year: the New Spain *flota* destined for Veracruz, and the *Tierra Firme galeones* destined for Cartagena and Portobello. In the Pacific, shipping was conducted by *Armada del Sur*, which carried goods from the trade fairs in Portobello to Pacific ports in South America (Walker, 1979). Moreover, the Manilla galleon would sail between Acapulco and Manilla. Official information was carried by *aviso* ships, which were light carriers operating separately from the commercial system and were not permitted or equipped to carry freight. Third, participation in Atlantic trade was restricted to Spanish merchants. Finally, there were high tax rates on imports and exports. The duties typically depended on the origin of the goods, with lower rates on goods originating from Spain. These measures effectively monopolized trade in the merchant guilds in Seville (later Cadiz), Mexico City, and Lima, and only the merchant guilds of these cities were allowed to buy and sell goods at the trade fairs at Veracruz and Portobelo. These locations then in turn managed trade with other locations in their respective viceroyalties, typically transported by third parties using mule trains (*recuas*) or wagons (*carros*) depending on road conditions. The system limited trade with Europe across large parts of the Spanish empire in America, however, there was still some maritime communication and trade occurring in locations too remote relative to the large trade routes. In addition to dispatch ships (*avisos*), ships sailing under special permission of the crown (*registros*) occasionally supplied ports that were too remote relative to the large trade routes. However, this was never done at a sufficiently large scale (Walker, 1979) and increased the reliance on contraband trade which was sizeable (Christelow, 1942). While as a rule, there were no restrictions on inter-regional trade (Elliott, 2006, p. 111), there were cases where inter-regional was discouraged. For example, there were policies in place to limit trade between the Viceroyalties of Peru and New Spain to reduce the demand for the goods of the Manilla Galleon in Peru. Another example is the erection of a customs barrier in Córdoba (Argentina) in 1618 (Scobie, 1971, p. 53).

Mercantilist restrictions and high trade costs ensured that trade was limited to non-competing goods with a high value-to-weight ratio. Important exports during the period beyond precious metals were hides, tallow, sugar, indigo, and cochineal (Rahn Phillips, 1990). The slave trade was subject to different rules. Trade of slaves was allowed for British ships from early to the mid 18th century as a result of the treaty of Utrecht, the *asiento* (Walker, 1979). These measures facilitated naval defense of convoys and limited imports to the Americas, thus limiting the flow of bullion to other places than the Iberian Peninsula while keeping prices for Spanish exports artificially high. It also facilitated the managing of risk in a context where long shipping times and costly communication made it difficult to predict demand (Baskes, 2013). As a result, in addition to remittances directly controlled by the crown, private remittances to Spain were substantial (Cuenca-Esteban, 2008). However, a likely consequence of Spanish mercantilist policies before the liberalization in the late 18th century was the underdevelopment of peripheral areas in America (Fisher, 1997, p. 73). There were few changes to this system until the second half of the 18th century but there were some notable changes. In return for the support of France during the War of the Spanish Succession, French ships were allowed to trade along the Pacific coast for some time. Moreover, as part of the treaty of Utrecht, the English were granted the right to send a ship of 500 tons to the trade fairs. Finally, the trade fair at Veracruz was moved inland to Jalapa.

Reforming transatlantic trade. Beginning in the 18th century, Spanish policymakers were induced by geopolitical considerations, originating mainly in Europe, to overhaul the external trading system (Elliott, 2006). In the immediate aftermath of Spain's defeat in the Seven Years' War, a special *junta* was appointed under Charles III to "review ways to address the backwardness of Spain's commerce with its colonies and foreign nations" Stein and Stein (2003). Drawing on ideas for reforming the system of government in America that had been circulating for a long time, the *junta* proposed the abolition of the Cádiz monopoly as well as the fleet system. Further, it proposed opening 14 ports on the Iberian Peninsula as well as 35 ports in the Americas (Fisher, 1997). The ports that were opened on the Iberian peninsula in this period was Malaga, Almería, Cartagena, Alicante, Tortosa, Barcelona, Santander, Gijón, La Coruña, Palma de Mallorca, Santa Cruz de Tenerife. While the reform is believed to have a role in promoting the rise of the Barcelona textile industry, in the early 19th century, around 80 percent of Spanish trade with the Americas still went through the port of Cádiz (Fisher, 1997). Several ports in the Caribbean were opened already in 1765. Santo Domingo, Puerto Rico, Margarita, and Trinidad were opened for direct trade with Spain in 1765. Further, reform was slowed by the Esquilache riots in 1766, and the liberalization measures culminated in the decree of free trade in 1778, which opened several of the remaining ports. This was with the exception of Venezuela (Caracas), where it was believed the Caracas companies tobacco monopoly was worth protecting, and New Spain. Even so, especially Veracruz was affected by the changes before the late 1780s due to the abolition of the convoy system and the increased prevalence of register ships. In the 1780s, the remaining ports followed. Spanish communication with the Americas was disrupted during the Napoleonic wars (O'Rourke, 2006). Out of necessity, trade with neutral nations was therefore allowed. This marked the end of Spain's ability to enforce protected trade with the colonies. By the beginning of the 19th century, Spanish America enjoyed *de facto* although not *de jure* unrestricted trade with foreigners (Fisher, 1998). As a result, direct trade with Britain, not mediated through Spain, grew in importance (Prados de la Escosura and Casares, 1983). Independence was mostly followed by high tariffs, mainly driven by the revenue needs of post-independence governments (Coatsworth and Williamson, 2004).

The historical literature emphasizes the role of European interstate competition and the resulting increased need for a modernized imperial defense as motivating the reform. Thus, the drive to reform the Spanish commercial system can be understood as being motivated by the intense interstate competition between the European states of the 18th century (Kuethe and Andrien, 2014). Highlighted in the historical literature as an important impetus for the reform was the "humiliating" capture of Havana and Manila by the British during the Seven Years' war. This opened a window of opportunity for reform-minded policymakers in Spain who now could justify reforming the commercial system with concerns about the territorial integrity of the empire in what has been described in the historical literature as a "defensive modernization" (Stein and Stein, 2003). Furthermore, commercial expansion of Havana during the British occupation showcased the economic potential of the Spanish colonies.

The reform was therefore implemented rapidly after the Seven Years' War (Fisher, 1997). As a result, the timing of the reform is mainly driven by intensified interstate competition in Europe, rather than economic development in the Americas directly. Moreover, the reform was implemented from above, and no significant ports in which the policies were applied were excluded. This is also apparent from the fact that the policies were resisted by powerful interests in the Spanish Empire (Baskes, 2013). Finally, the selection of ports is unlikely to be driven by the perceived commercial potential of its hinterland. This is apparent when considering the case of New Spain. As the most important colony of the Spanish empire in America, it was believed New Spain would have diverted too much trade away from other regions (Fisher, 1997). Moreover, avoiding confrontation with merchants in New Spain whose resources was a key source of revenue for the crown. As a result, New Spain was not subject to the reform until the late 1780s.

It is generally agreed upon that the reform increased trade. This was recognized by contemporaries as well as in the historical literature. Floridablanca (minister under Charles III and not a neutral observer) wrote about a fortunate revolution (*feliz revolución*) when referring to Spanish export growth after 1778. When referring to Veracruz, went from "gloomy and ugly" to "elegant and growing" (Stein and Stein, 2003). The magnitudes in the economic history literature are contested (Cuenca-Esteban, 2008). Colonial imports to Spain increased tenfold and exports from Spain to the colonies fourfold according to Fisher (1985), while more modest estimates are found in Cuenca-Esteban (2008), also suggesting large effects. However, while the reform stimulated trade, the terms of trade in many ports presumably remained depressed (Francis, 2017). Fisher (1993) provides data on the composition of Spanish imports from Spanish America between 1782 and 1796 for the ports of Cadiz and Barcelona (which accounted for around 88 percent of imports from Spanish America). Precious metals still accounted for 56.4 percent of imports through this period. The other commodities were typically high-value agricultural commodities (tobacco 13.6, cacao 7.8, sugar 5.5, indigo 5.2, cochineal 4.2, hides 3.4 and cotton 0.4 percent) (Fisher, 1993). Cadiz remained the dominant port for trade with Spanish America between 1778 and 1796 (76.4 percent of total exports and 84.2 percent of imports). The remaining important ports were Barcelona (9.6 and 3.8 percent), Malaga (4.8 and 1.3 percent), Santander (3.3 and 2.6 percent), and La Coruña (3 and 6.8 percent) (Fisher (1993) p.20 and p.25).

Some accounts highlight that the lower trade costs induced by the reform promoted agricultural development. "... for the first time, the metropolis succeeded in unleashing the agricultural potential of its American possessions whilst also promoting the continued expansion of mining production. The relationship between this economic growth and the liberalization of trade is abundantly clear", (Fisher, 1997, p. 197). Moreover, lower trade costs induced by unrestricted sailing potentially allowed for specialization in a wider range of commodities, such as more perishable goods. However, bullion remained an important export commodity (Fisher (1997), p. 38). Moreover, it has been argued that the population and economies of previously stagnant peripheral colonies in Spanish America grew rapidly (Mahoney, 2010). In summary, the historical literature suggests the restrictions imposed on trade in goods with the Americas stunted economic development, and efforts induced by European interstate competition to relax these marked the beginning of a process that would have large effects on trade and affect economic development in the second half of the 18th century.

D Figures

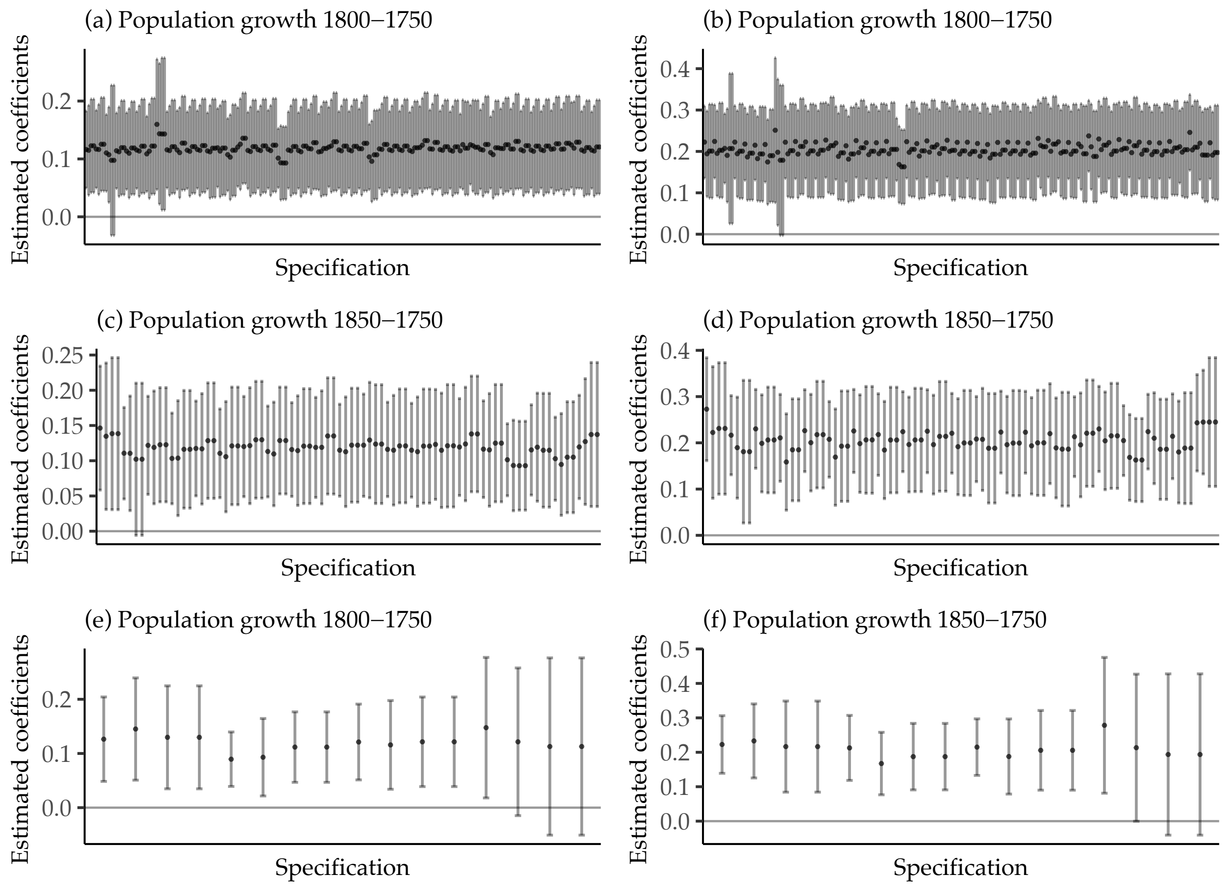

Figure A1: The figure shows the estimates in Table 5 for different subsamples. Panel (a) and (b) shows the model re-estimated after removing each port catchement areas. Panel (c) and (d) shows the model re-estimated after removing each country. Panel (e) and (f) shows the model re-estimated after removing each viceroyalty.

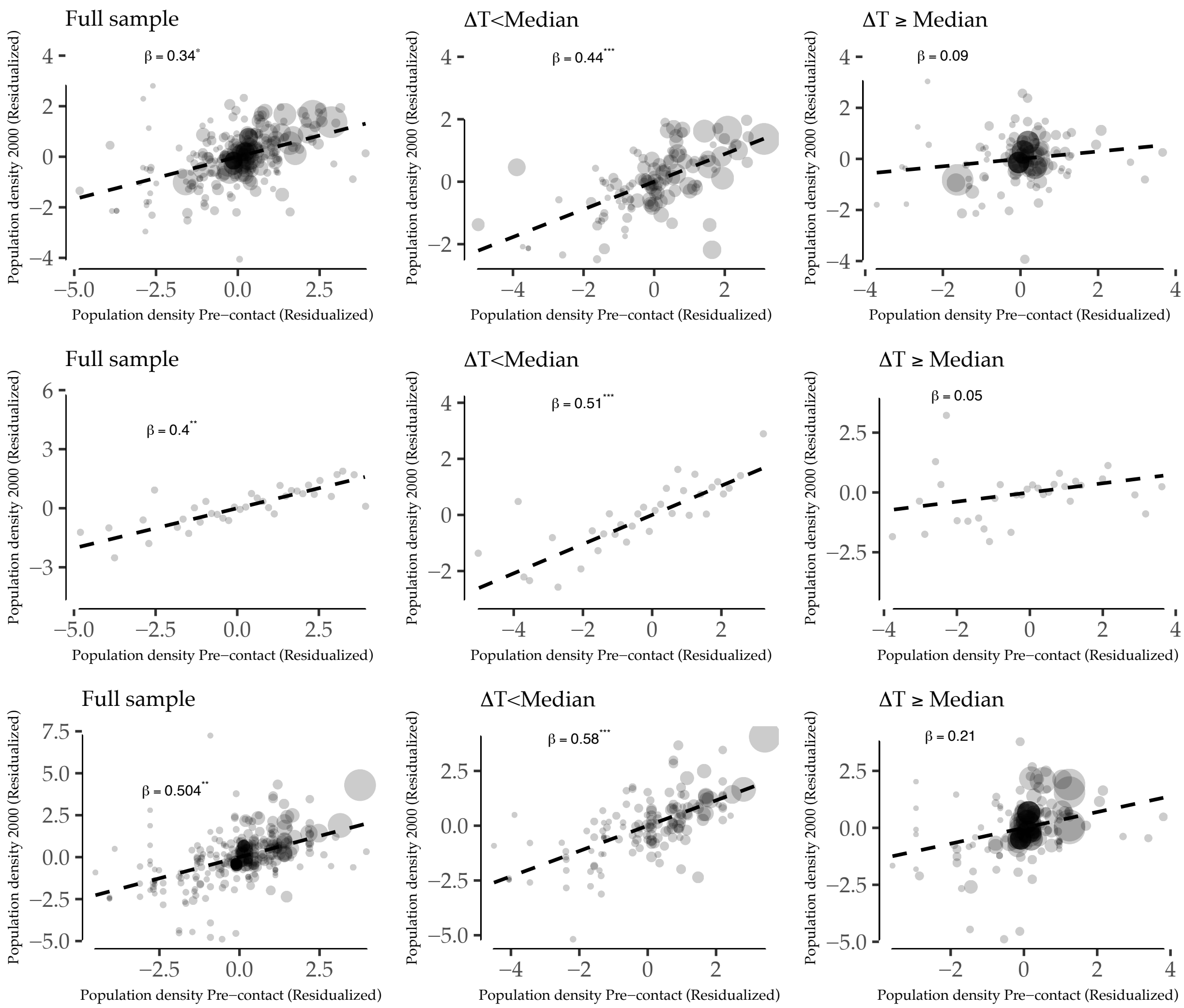

Figure A2: The figure shows the relationship between pre-contact population density and the population density in year 2000 at the level of the province. The left figure shows the relationship for the full sample. The middle figure shows the relationship for provinces with below median change in the distance to Europe between 1760 and 1810. The right figure shows the relationship for the sample above median reduction in shipping time to Europe between 1760 and 1810. Pre-colonial population density is the number of people per square kilometre pre-contact. The dependent variable is the log of people per square km in 2000. The full sample contains 337 observations. **Geographical controls:** Altitude, ruggedness, rainfall, and inverse distance to the coast (see Maloney and Valencia (2016) for details). **Standard errors** are clustered at the country-level.

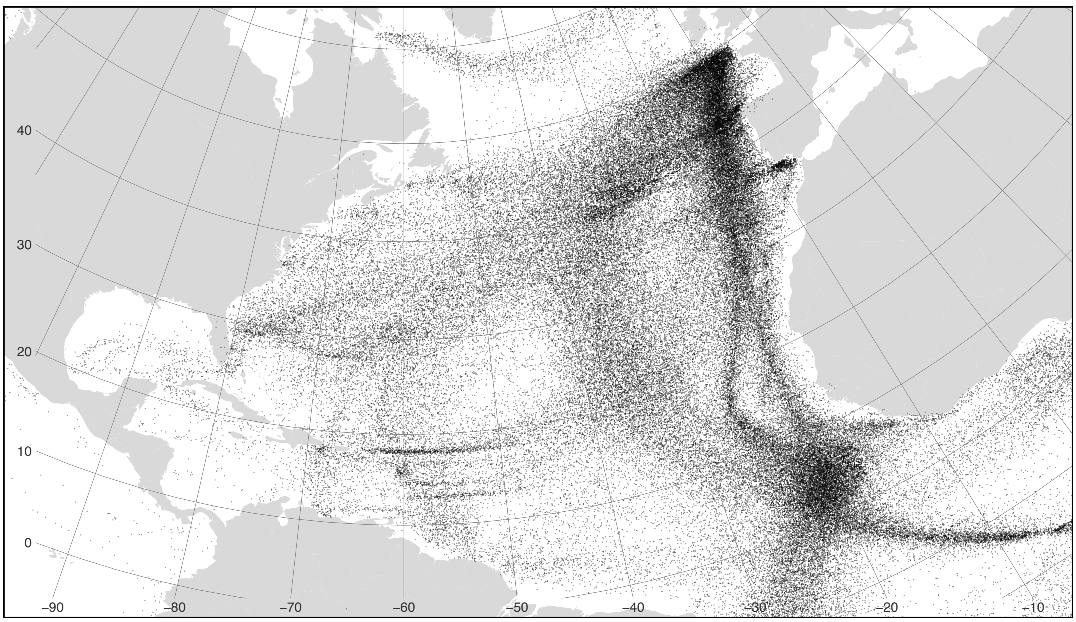

Figure A3: The figure shows the logbook entries used to estimate the travel times in the main analysis. Each dot representes a logbook entry between 1750 and 1850. Source: CLIWOC.

E Tables

Table A1: Shipping time and population growth (Argentina excluded)

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it'}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.146***	0.135**	0.138**	0.088*
	(0.045)	(0.053)	(0.055)	(0.048)
N	280	280	280	280
R^2	0.053	0.068	0.077	0.254
Panel (b): Population growth 1850-1750				
Change in shipping time	0.273***	0.222***	0.231***	0.148**
	(0.057)	(0.073)	(0.073)	(0.059)
N	280	280	280	280
R^2	0.078	0.101	0.128	0.326
Panel (c): Population growth 1750-1700				
Change in shipping time	0.066	0.041	0.034	0.034
	(0.049)	(0.058)	(0.061)	(0.060)
N	230	230	230	230
R^2	0.012	0.036	0.059	0.059
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Population (1750)				✓

Note: Shipping time is standardized. The unit is a city. **Dependent variable:** Population growth. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. ***$p < .01$, **$p < .05$, * $p < .1$

Table A2: Shipping time and population growth (Argentina excluded)

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it-1}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.084	0.088*	0.081	0.102
	(0.051)	(0.052)	(0.050)	(0.146)
Population (1750)	−0.262***	−0.267***	−0.279***	−0.259***
	(0.071)	(0.073)	(0.071)	(0.077)
Change in shipping time × Population (1750)	−0.189*	−0.207*	−0.224**	−0.196*
	(0.098)	(0.105)	(0.104)	(0.111)
N	280	280	280	280
R^2	0.206	0.220	0.239	0.291
Panel (b): Population growth 1850-1750				
Change in shipping time	0.197***	0.166**	0.157**	0.051
	(0.063)	(0.080)	(0.072)	(0.203)
Population (1750)	−0.334***	−0.337***	−0.369***	−0.337***
	(0.070)	(0.076)	(0.079)	(0.083)
Change in shipping time × Population (1750)	−0.210**	−0.243**	−0.285**	−0.267**
	(0.104)	(0.117)	(0.121)	(0.128)
N	280	280	280	280
R^2	0.186	0.204	0.247	0.296
Panel (c): Population growth 1750-1700				
Change in shipping time	0.062	0.040	0.033	−0.055
	(0.048)	(0.057)	(0.059)	(0.181)
Population (1750)	−0.032	−0.035	−0.049	−0.017
	(0.041)	(0.040)	(0.040)	(0.032)
Change in shipping time × Population (1750)	0.009	−0.006	−0.027	0.003
	(0.062)	(0.063)	(0.059)	(0.052)
N	230	230	230	230
R^2	0.020	0.043	0.067	0.194
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Audiencia FE				✓

Note: Shipping time is standardized. The unit is a city. **Dependent variable:** Population growth. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. ***p < .01, **p < .05, * p < .1

Table A3: Shipping time and population growth (capitals excluded)

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it'}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.106^{***}	0.101^{**}	0.105^{**}	0.060
	(0.036)	(0.044)	(0.044)	(0.040)
N	293	293	293	293
R^2	0.040	0.059	0.065	0.244
Panel (b): Population growth 1850-1750				
Change in shipping time	0.214^{***}	0.182^{***}	0.183^{***}	0.109^{**}
	(0.046)	(0.056)	(0.060)	(0.048)
N	293	293	293	293
R^2	0.068	0.089	0.115	0.325
Panel (c): Population growth 1750-1700				
Change in shipping time	0.039	0.016	0.005	0.006
	(0.035)	(0.041)	(0.038)	(0.037)
N	241	241	241	241
R^2	0.007	0.036	0.056	0.057
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Population (1750)				✓

Note: Shipping time is standardized. The unit is a city. **Dependent variable:** Population growth. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table A4: Shipping time and population growth (capitals excluded)

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it-1}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.053	0.062	0.058	0.051
	(0.047)	(0.053)	(0.047)	(0.077)
Population (1750)	-0.296^{***}	-0.298^{***}	-0.312^{***}	-0.300^{***}
	(0.065)	(0.070)	(0.068)	(0.071)
Change in shipping time × Population (1750)	-0.129	-0.148	-0.164^{*}	-0.161^{*}
	(0.085)	(0.095)	(0.093)	(0.097)
N	293	293	293	293
R^2	0.202	0.218	0.235	0.268
Panel (b): Population growth 1850-1750				
Change in shipping time	0.153^{***}	0.138^{**}	0.125^{**}	0.078
	(0.057)	(0.070)	(0.063)	(0.067)
Population (1750)	-0.387^{***}	-0.393^{***}	-0.426^{***}	-0.404^{***}
	(0.058)	(0.064)	(0.067)	(0.067)
Change in shipping time × Population (1750)	-0.128	-0.162	-0.198^{*}	-0.207^{*}
	(0.094)	(0.109)	(0.110)	(0.107)
N	293	293	293	293
R^2	0.189	0.208	0.251	0.296
Panel (c): Population growth 1750-1700				
Change in shipping time	0.037	0.012	-0.001	-0.001
	(0.036)	(0.042)	(0.039)	(0.066)
Population (1750)	-0.023	-0.025	-0.041	-0.016
	(0.039)	(0.038)	(0.039)	(0.034)
Change in shipping time × Population (1750)	-0.008	-0.032	-0.049	-0.034
	(0.059)	(0.063)	(0.060)	(0.065)
N	241	241	241	241
R^2	0.008	0.038	0.061	0.160
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Audiencia FE				✓

Note: Shipping time is standardized. The unit is a city. **Dependent variable:** Population growth. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table A5: Shipping time and population growth (far from port)

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it'}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.079^{***}	0.051	0.060^{*}	0.004
	(0.022)	(0.032)	(0.032)	(0.032)
N	226	226	226	226
R^2	0.022	0.044	0.065	0.289
Panel (b): Population growth 1850-1750				
Change in shipping time	0.204^{***}	0.163^{***}	0.174^{***}	0.100^{**}
	(0.041)	(0.044)	(0.049)	(0.039)
N	226	226	226	226
R^2	0.064	0.101	0.145	0.318
Panel (c): Population growth 1750-1700				
Change in shipping time	0.018	−0.021	−0.013	−0.016
	(0.027)	(0.035)	(0.039)	(0.036)
N	192	192	192	192
R^2	0.001	0.045	0.073	0.076
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Population (1750)				✓

Note: Shipping time is standardized. The unit is a city. **Dependent variable:** Population growth. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table A6: *Shipping time and population growth (far from port)*

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it-1}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	-0.013	-0.026	-0.028	-0.084
	(0.044)	(0.056)	(0.050)	(0.055)
Population (1750)	-0.303^{***}	-0.306^{***}	-0.326^{***}	-0.343^{***}
	(0.070)	(0.076)	(0.076)	(0.065)
Change in shipping time × Population (1750)	-0.247^{**}	-0.260^{**}	-0.290^{**}	-0.329^{***}
	(0.105)	(0.115)	(0.118)	(0.101)
N	226	226	226	226
R^2	0.210	0.230	0.270	0.381
Panel (b): Population growth 1850-1750				
Change in shipping time	0.116^{**}	0.085	0.076	-0.012
	(0.055)	(0.068)	(0.064)	(0.069)
Population (1750)	-0.324^{***}	-0.336^{***}	-0.370^{***}	-0.358^{***}
	(0.069)	(0.079)	(0.084)	(0.066)
Change in shipping time × Population (1750)	-0.210^{**}	-0.257^{**}	-0.320^{**}	-0.332^{***}
	(0.104)	(0.124)	(0.128)	(0.103)
N	226	226	226	226
R^2	0.171	0.205	0.263	0.332
Panel (c): Population growth 1750-1700				
Change in shipping time	0.011	-0.027	-0.024	-0.052
	(0.034)	(0.039)	(0.036)	(0.058)
Population (1750)	-0.046	-0.055	-0.073^{*}	-0.017
	(0.052)	(0.044)	(0.044)	(0.030)
Change in shipping time × Population (1750)	-0.004	-0.029	-0.064	0.001
	(0.078)	(0.070)	(0.062)	(0.056)
N	192	192	192	192
R^2	0.015	0.057	0.089	0.220
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Audiencia FE				✓

Note: Shipping time is standardized. The unit is a city. **Dependent variable:** Population growth. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table A7: Shipping time and urban population growth (removing outliers)

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it'}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.055^{**}	0.032	0.023	-0.013
	(0.023)	(0.026)	(0.023)	(0.019)
N	267	267	267	267
R^2	0.016	0.047	0.062	0.270
Panel (b): Population growth 1850-1750				
Change in shipping time	0.176^{***}	0.147^{***}	0.127^{***}	0.079^{**}
	(0.035)	(0.038)	(0.041)	(0.036)
N	276	276	276	276
R^2	0.072	0.095	0.110	0.324
Panel (c): Population growth 1750-1700				
Change in shipping time	0.014	0.003	-0.014	-0.016
	(0.020)	(0.025)	(0.030)	(0.028)
N	232	232	232	232
R^2	0.001	0.034	0.063	0.068
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Population (1750)				✓

Note: Shipping time is standardized. The cities with the ten percent largest city growth are removed. The unit is a city. **Dependent variable:** Population growth. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table A8: Shipping time and population growth

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it-1}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.004	−0.008	−0.022	−0.050
	(0.036)	(0.039)	(0.032)	(0.037)
Population (1750)	−0.226***	−0.228***	−0.237***	−0.238***
	(0.075)	(0.079)	(0.079)	(0.081)
Change in shipping time × Population (1750)	−0.145	−0.164	−0.179*	−0.181*
	(0.100)	(0.106)	(0.107)	(0.108)
N	267	267	267	267
R^2	0.219	0.242	0.266	0.301
Panel (b): Population growth 1850-1750				
Change in shipping time	0.124***	0.111**	0.085*	0.049
	(0.037)	(0.046)	(0.048)	(0.064)
Population (1750)	−0.271***	−0.275***	−0.292***	−0.282***
	(0.070)	(0.077)	(0.082)	(0.085)
Change in shipping time × Population (1750)	−0.152	−0.175	−0.199	−0.197
	(0.109)	(0.120)	(0.126)	(0.129)
N	276	276	276	276
R^2	0.193	0.212	0.236	0.272
Panel (c): Population growth 1750-1700				
Change in shipping time	0.006	0.001	−0.018	−0.072**
	(0.022)	(0.025)	(0.027)	(0.031)
Population (1750)	−0.066*	−0.066	−0.078*	−0.066
	(0.040)	(0.043)	(0.044)	(0.041)
Change in shipping time × Population (1750)	−0.037	−0.047	−0.063	−0.063
	(0.056)	(0.060)	(0.059)	(0.058)
N	232	232	232	232
R^2	0.021	0.052	0.086	0.162
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Audiencia FE				✓

Note: Shipping time is standardized. The unit is a city. **Dependent variable:** Population growth. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. ***p < .01, **p < .05, * p < .1

Table A9: Shipping time and urban population growth (close to post office)

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it'}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.091**	0.104**	0.100**	0.059
	(0.040)	(0.044)	(0.047)	(0.040)
N	248	248	248	248
R^2	0.030	0.056	0.065	0.241
Panel (b): Population growth 1850-1750				
Change in shipping time	0.207***	0.199***	0.179***	0.113**
	(0.050)	(0.058)	(0.064)	(0.048)
N	248	248	248	248
R^2	0.071	0.098	0.115	0.325
Panel (c): Population growth 1750-1700				
Change in shipping time	0.025	0.007	0.009	0.009
	(0.036)	(0.042)	(0.037)	(0.036)
N	217	217	217	217
R^2	0.003	0.035	0.055	0.055
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Population (1750)				✓

Note: The table reports OLS estimates. Shipping time is standardized. The unit of observation is a city in a certain year. **Dependent variable:** The change in the natural logarithm of city population. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. The sample is restricted to locations with 55km of a post office in 1750. **Standard errors:** Clustered at the level of the closest port. ***$p < .01$, **$p < .05$, * $p < .1$

Table A10: Shipping time and population growth

Dependent variable:	City population growth: $\ln L_{it} - \ln L_{it-1}$			
	(1)	(2)	(3)	(4)
Panel (a): Population growth 1800-1750				
Change in shipping time	0.049	0.077*	0.070*	0.077
	(0.039)	(0.041)	(0.042)	(0.059)
Population (1750)	−0.227***	−0.235***	−0.248***	−0.231***
	(0.081)	(0.083)	(0.081)	(0.086)
Change in shipping time × Population (1750)	−0.120	−0.143	−0.157	−0.141
	(0.110)	(0.113)	(0.112)	(0.115)
N	248	248	248	248
R^2	0.175	0.202	0.222	0.262
Panel (b): Population growth 1850-1750				
Change in shipping time	0.157***	0.167***	0.141**	0.078
	(0.049)	(0.059)	(0.060)	(0.069)
Population (1750)	−0.286***	−0.293***	−0.319***	−0.305***
	(0.082)	(0.089)	(0.093)	(0.095)
Change in shipping time × Population (1750)	−0.124	−0.157	−0.191	−0.204
	(0.113)	(0.125)	(0.131)	(0.135)
N	248	248	248	248
R^2	0.180	0.204	0.233	0.283
Panel (c): Population growth 1750-1700				
Change in shipping time	0.021	0.006	0.006	−0.003
	(0.036)	(0.041)	(0.036)	(0.060)
Population (1750)	−0.038	−0.041	−0.056	−0.041
	(0.039)	(0.037)	(0.037)	(0.030)
Change in shipping time × Population (1750)	−0.003	−0.017	−0.037	−0.037
	(0.055)	(0.056)	(0.052)	(0.048)
N	217	217	217	217
R^2	0.012	0.042	0.068	0.151
Controls		✓	✓	✓
Viceroyalty FE			✓	✓
Audiencia FE				✓

Note: The table reports OLS estimates. Shipping time is standardized. The unit of observation is a city in a certain year. **Dependent variable:** The change in the natural logarithm of city population. **Controls:** Elevation, crop suitability, the location of active mines, distance to the coastline. **Standard errors:** Clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table A11: Spatial persistence in high and low exposure areas (without Argentina)

Dependent variable:	Population density 2000 (log)			
	(1)	(2)	(3)	(4)
Panel (a): Full sample				
Population density 1500 (log)	0.382***	0.286**	0.541***	0.359**
	(0.126)	(0.120)	(0.166)	(0.160)
Panel (b): ΔT <Median				
Population density 1500 (log)	0.617***	0.542***	0.615***	0.512***
	(0.074)	(0.084)	(0.090)	(0.099)
Panel (c): ΔT ≥Median				
Population density 1500 (log)	0.279***	0.155**	0.206	0.008
	(0.105)	(0.063)	(0.278)	(0.118)
Country FE			✓	✓
Controls		✓		✓
Observations	96	95	96	95
Adjusted R-squared	0.197	0.398	0.315	0.451

Note: Market access is standardized. The unit of analysis is at the province-level. Pre-colonial population density is the number of indigenous people per square kilometre before the arrival of Columbus from Maloney and Valencia (2016). The dependent variable is the log of people per square km in 2000. The full sample contains 258 observations. **Geographical controls:** Altitude, ruggedness, rainfall, and inverse distance to the coast (see Maloney and Valencia (2016) for details). **Standard errors** are clustered at the country-level. ***p < .01, **p < .05, * p < .1

Table A12: Coastal consentration in high and low exposure areas (without Argentina)

Dependent variable:	Population density 2000 (log)			
	(1)	(2)	(3)	(4)
Panel (a): Full sample				
Distance to coast	-4.742^{***}	-3.780^{**}	-7.572^{***}	-6.684^{***}
	(1.444)	(1.489)	(2.362)	(2.148)
Panel (b): ΔT <Median				
Distance to coast	9.490^{***}	10.002^{***}	9.424^{**}	7.891^{**}
	(2.507)	(1.935)	(3.722)	(3.071)
Panel (c): ΔT ≥Median				
Distance to coast	-3.552^{**}	-2.140	-5.713	-5.593
	(1.734)	(1.302)	(3.471)	(3.144)
Country FE			✓	✓
Controls		✓		✓
Observations	100	95	100	95
Adjusted R-squared	0.162	0.365	0.377	0.436

Note: Market access is standardized. The unit of analysis is at the province-level. Pre-colonial population density is the number of indigenous people per square kilometre before the arrival of Columbus from Maloney and Valencia (2016). The dependent variable is the log of people per square km in 2000. The full sample contains 258 observations. **Geographical controls:** Altitude, ruggedness, rainfall, and inverse distance to the coast (see Maloney and Valencia (2016) for details). **Standard errors** are clustered at the country-level. $^{***}p < .01$, $^{**}p < .05$, $^{*}p < .1$

Table A13: Event-study specification (settlements)

Dependent variable:	Indicator for cell containing a settlement			
	(1)	(2)	(3)	(4)
Δ T $\times$ $\mathbb{1}$ (*year* = 1710)	−0.011	−0.019**	−0.025**	−0.031***
	(0.011)	(0.008)	(0.010)	(0.008)
Δ T $\times$ $\mathbb{1}$ (*year* = 1720)	−0.004	−0.011	−0.016	−0.021**
	(0.010)	(0.008)	(0.010)	(0.008)
Δ T $\times$ $\mathbb{1}$ (*year* = 1730)	−0.002	−0.007	−0.012	−0.016**
	(0.009)	(0.008)	(0.010)	(0.007)
Δ T $\times$ $\mathbb{1}$ (*year* = 1740)	−0.001	−0.005	−0.009	−0.012*
	(0.008)	(0.006)	(0.008)	(0.006)
Δ T $\times$ $\mathbb{1}$ (*year* = 1750)	−0.005	−0.007**	−0.009**	−0.011***
	(0.004)	(0.003)	(0.004)	(0.003)
Δ T $\times$ $\mathbb{1}$ (*year* = 1770)	0.002	0.005**	0.007**	0.009***
	(0.003)	(0.002)	(0.003)	(0.002)
Δ T $\times$ $\mathbb{1}$ (*year* = 1780)	0.002	0.013	0.016	0.020**
	(0.008)	(0.009)	(0.010)	(0.009)
Δ T $\times$ $\mathbb{1}$ (*year* = 1790)	0.014	0.033***	0.037**	0.042***
	(0.012)	(0.011)	(0.015)	(0.013)
Δ T $\times$ $\mathbb{1}$ (*year* = 1800)	0.014	0.037***	0.041**	0.048***
	(0.013)	(0.012)	(0.016)	(0.014)
Δ T $\times$ $\mathbb{1}$ (*year* = 1810)	0.017	0.042***	0.047***	0.057***
	(0.015)	(0.013)	(0.018)	(0.015)
City FE	✓	✓	✓	✓
Controls × time FE		✓	✓	✓
Viceroyalty × time FE			✓	✓
Population 1750 × time FE				✓
Observations	55,154	55,154	55,154	55,154

Notes: The unit of analysis is at a 0.5°×0.5° grid-cell. **Observations:** The dataset is a balanced panel at a 10 year frequency for the period 1710-1810 for 6,662 grid cells. The full dataset contains 11 × 6,662 = 73,282 observations. The omitted year is the year prior to the treatment, therefore **N = 73,282 - 6,662 = 66,620**. **Controls:** Distance to the coast (log), elevation, presence of an active mine, terrain ruggedness, and crop suitability. **Standard errors:** Clustered at the level of the closest port. ***p < .01, **p < .05, * p < .1

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