Free and Protected: Trade Networks and City Formation*

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Abstract

This paper analyzes the role of international trade networks in city formation using a staggered removal of restrictions on trade with Europe within the Spanish Empire. Using detailed georeferenced data on infrastructure, physical geography, and maritime travel from historical logbooks, I show the reforms induced substantial reductions in trade costs. Using a difference-in-difference design, I show the trade cost shock promoted city formation, especially in the peripheral areas with lower population density. Moreover, it accelerated the formation of cities close to natural navigable waterways, such as coasts. To assess the long-run and aggregate effects, I use the calculated changes in trade costs to estimate the parameters of a dynamic spatial general equilibrium model. A series of counterfactuals demonstrate the role that the timing of the shock and the initial spatial distribution of population plays in determining the impact of trade on city formation. In particular, the model shows that the delayed opening of long-distance trade reduced the coastal population density, but that this effect smaller in areas less populated at the time of the reform. Finally, I find that the induced variation in coastal population density has persisted until the present, which has implications for welfare in regions with high internal transportation costs.

JEL Codes: N760, O190, O430, F620, F63

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1 Introduction

This paper analyzes the role of international trade networks in city formation. A growing theoretical literature shows the importance of trade induced urban growth for aggregate economic development, Fajgelbaum and Redding (2014), Nagy (2018), Coşar and Fajgelbaum (2016), Faber and Gaubert (2019).As a result, how city formation adapts to changes in trade networks has implications for economic growth, and raises questions about the inefficiency induced from failing to do so. The goal of this paper is to shed light on this question and assess the long-run implications this has for welfare.

I examine these issues in the context of the Spanish Empire, which at its height encompassed a substantial share of the American continent and founded most of its largest cities. Driven primarily by the timing of political developments in Europe, restrictions on Atlantic trade with Europe were gradually lifted throughout the empire in the 18th century. While only four ports were licensed for trade with Europe in 1765, by 1800 this had increased to 50 and no major ports were longer subject to restrictions. The staggered reductions in international trade costs induced by the reforms, makes it well suited for shedding light on these questions. First, I show that the staggered nature of the policy provided sizable and abrupt spatial and temporal variation in international trade costs, which in general change very slowly. Second, the policy affected *trade costs* with Europe, but as opposed to variation induced by innovations to transportation technology, it did not affect *travel costs* in general. Third, the large scale and geographic scope of the reforms allow for studying effect heterogeneity while keeping several institutional factors fixed. Finally, this feature also yields significant gains in terms of external validity.

The long-run impact of these policies on city formation is studied in three steps. First, I calculate decade specific bilateral trade cost matrices for grid-cells between 1760-1810 to quantify how the reforms affected shipping times in the Spanish Empire. The matrices are calculated allowing for shipping on land and sea using a wide variety of geographic features affecting trade costs. Shipping on land takes landcover, rivers, lakes, infrastructure such as roads and ports, as well as elevation into account. Costs of shipping across oceans are calculated using a large database on maritime logbooks in the 18th century as well as information on prevailing wind patterns. The trade cost matrices are calculated using cost-minimizing routes according to the Dijkstra algorithm with restrictions reflecting which ports allowed to trade directly with Europe the particular decade.

Next, I exploit local changes in trade costs to identify the reduced form effect of the reform on city formation. In order to do this, I match the grid-cells to a detailed territorial gazetteer of the Spanish Empire to extract founding dates for localities with a city (*ciudad*), town (*villa*), status in the Spanish administrative hierarchy. At the heart of the identification of the reduced form effect is a difference-in-difference approach. The approach compares changes in the prevalence of city formation in areas within the same administrative unit of the empire that experience different changes in trade costs. The key to a causal interpretation of these estimates is the assumption that changes in the rate of city formation across such localities would have been the same in the absence of the reforms. Pre-trend checks and several robustness exercises support a causal interpretation of the estimates. To account for spatial interdependencies, which could be substantial in this context, I follow Donaldson and Hornbeck (2016) and construct a measure of *market access*. The change in shipping time is then used as an instrument for the *market access* of a locality in order to capture the full effect of the reform in city formation.

Finally, to shed light on the long-run and aggregate effects of the reforms, I estimate the parameters of a dynamic quantitative spatial general equilibrium model. The model setup follows Allen and Arkolakis (2014) and Allen and Donaldson (2018) closely, but differs in its emphasis on how international trade costs affect geography. The model takes linkages between regions driven by migration and trade, as well as dynamic agglomeration forces into account by explicitly modeling these. The model parameters are estimated under the assumption that the *changes* in trade costs induced by the reforms are uncorrelated to *changes* in geographical fundamentals and amenities. While this is an untestable assumption, the abrupt manner in which the trade restrictions were removed and the reduced form evidence supports this assumption. The model is used for several purposes. First, since the model contains contemporaneous as well as dynamic agglomeration forces, it's ideally suited to studying the long-run dynamic adjustment of geography to changes in trade costs. Second, the model is used to run counterfactual exercises in order to shed light on how initial conditions affect the adjustment process. Finally, the model is used to assess the welfare implications of the policy and to what extent these depend on the initial geography. Qualitatively, this exercise is able to match all of the salient features of the reduced form exercise.

I find that the reform had large and heterogeneous effects on international trade costs between Europe and Spanish America. The median reduction in shipping times is around 16 days travel, ranging from the largest reduction of 60 days shorter travel to no change in shipping times. Next, I show the effect of the lower shipping time on city formation exploiting within locality variation. In the preferred specification a ten percent change in shipping times increases the probability of a locality containing a formal settlement by five percentage points. This translates into a seven percentage point effect of increasing market access, showing that city formation is highly responsive to changes centrality in the trading network. Next, I explore the mechanisms driving the effects. Consistent with theories of city formation emphasizing the role of trade in determining the location of cities, I find larger effects to changes in the trading network in places suitable for exports, and places that are less densely settled, in which and existing agglomeration economies are weaker. This further confirmed, by looking at commodity prices and trade volumes to American ports at responded to the reforms. What were the long-run impacts of the reforms? The structural estimates of the model show that both contemporary and lagged agglomeration spillovers play a role in the dynamic adjustment to the trade-cost shock. Moreover, the replicates key features of the reduced form results. It confirms that the reforms induced higher coastal population density and had smaller effects in areas with higher initial density. Next, the model is used to run a series of counterfactuals. First, by changing the initial population distribution, I show that lower population density tends to increase the effect of the reform and coastal population density. Second, I show that an earlier opening of long-distance trade would have increased the coastal population density after the reform. Finally, I show that the long-run spatial distribution of the population is affected by the timing of the trade-cost shock. Taken together, the results show that the impact of the trade-cost shock is highly contingent on initial conditions. The findings, therefore, support theories emphasizing the importance of sequencing between urban agglomeration and reduction in trade costs in determining the impact of trade costs on the location of economic activity.

This paper is related to a literature documenting the persistence in urban geography and the spatial pattern of economic activity as well as quantitative economic geography. The importance of path dependence is well documented. Davis and Weinstein (2002) argue that the combination of a strong persistence, increased concentration induced by industrialization, and quick recovery after the Allied bombing during World War II, provide support of increasing returns and locational fundamentals playing a crucial role in determining the size distribution of regions in Japan. Other papers provide more direct evidence of the existence of path dependence, Bosker et al. (2008), Redding, Sturm and Wolf (2010), Bleakley and Lin (2012), Michaels and Rauch (2018), Hanlon (2016). For example, Bleakley and Lin (2012) document a strong relationship between contemporary population density and portage sites in the United States. In the context of developing countries, Jedwab and Moradi (2015) and Jedwab, Kerby and Moradi (2017) find railway investment during the colonial era in Sub-Saharan Africa still is still associated with higher population density although they are no longer operational.

This paper contributes to this literature by studying the conditions under which a

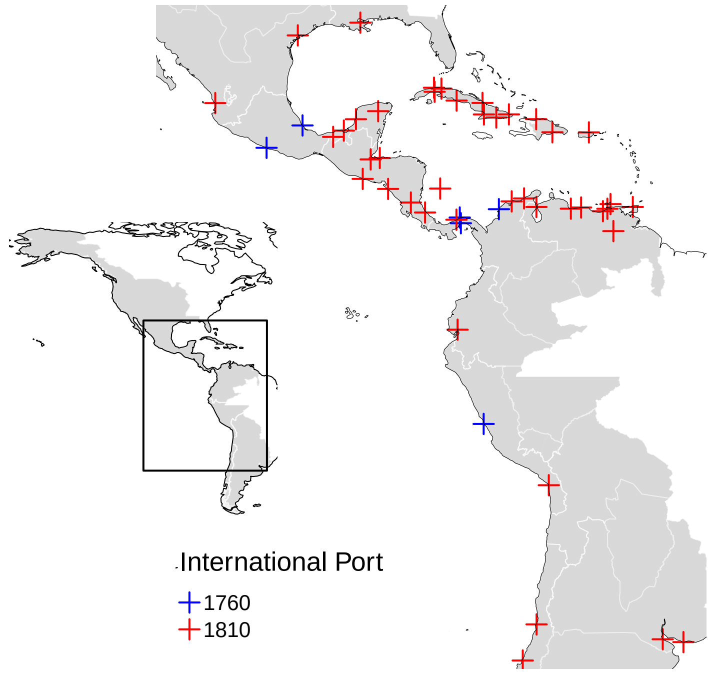

Figure 1: The map shows the extent of the territory claimed by the Spanish Empire in 1790 with its ports according to trading status. Ports denoted with a circle are the ports that opened to trade with Europe between 1766 and 1787, ports denoted with a square remained formally restricted to the end of the colonial period, while in the remaining ports trade was allowed since the founding.

society can adapt to the changing importance of natural advantages. While agglomeration economies are undoubtedly beneficial for economic growth, Duranton (2015), Henderson (2010); this paper shows that densely populated places are less able to take advantage of changing importance of natural advantages. The findings support the view that the sequence with which a region opens up to trade or achieves high population density affects the extent to which the economy is responsive to increased coastal advantage, Henderson et al. (2018), Alix-Garcia and Sellars (2019). Further, the paper contributes by providing evidence suggesting this kind of path inefficiency is detrimental for long-run development. Lastly, it contributes by providing estimates of lagged agglomeration spillovers relying on weaker assumptions than Allen and Donaldson (2018).

Second, the findings contribute to the literature on the impact of international trade on long-run development. Frankel and Romer (1999) document a positive relationship between the level of international trade and income using the distance to trading partners as an instrument for the opportunities to trade. Exploiting changes in travel costs induced by the advent of air travel, Feyrer (2019) shows that increases in trading opportunities are associated with an increased level of income. While there is strong evidence for positive average effects of trade on the level of income, the impact of increased reliance on trade is naturally highly contingent on initial conditions such as institutions, Acemoglu, Johnson and Robinson (2005). Trade reforms can have persistent economic effects by affecting the distribution of political and economic power of social groups, Jha (2013), Puga and Trefler (2014), Dippel, Greif and Trefler (2016). Pascali (2017) shows that the impact of the steamship in the second half of the 19th century on economic development only benefited countries with inclusive economic political institutions.

This paper provides evidence for the conditions and mechanisms through which trade can affects economic development in the long-run. Urban agglomeration can explain the discrepancy between the large elasticities estimated in reduced form and the smaller model based (see for example Arkolakis, Costinot and Rodríguez-Clare (2012)), as well as the large income gap between landlocked and coastal countries, Allen and Arkolakis (2014), Nagy (2018). Additional gains from opening for international trade arises when trade increases population density, especially in areas with high market access. The findings in this paper supports this view by providing evidence of large long-run impacts of increased trading opportunities on urbanization. Further, the findings extend upon this view by showing that this effect is contingent on the level of development and the population density when the country opens for trade.

Finally, the paper is related to the literature exploring the long-term impact of colonial institutions on economic development, Putterman, Bockstette and Chanda (2001), Acemoglu, Johnson and Robinson (2002).[1] In the context of Spanish America, several studies draw on different of colonial experiences to explain diverging long-run economic performance, Acemoglu, Johnson and Robinson (2002), Engerman et al. (2012). Incentives faced by early colonizers affects the type of political and economic institutions that are introduced, whereby it has a lasting effect on political and economic inequality, Acemoglu, Johnson and Robinson (2001). In a seminal paper, Dell (2010) studies the persistent effect of forced labor in the Spanish Empire, the *mita*. Comparing places on opposite sides of the catchment area boundary, it is shown to have a persistent effect on economic development. Bruhn and Gallego (2011) compare contemporary measures of income in places with different colonial activities finding that mining and plantation agriculture has had a lasting negative impact on economic development. While the impact different colonial experiences on economic development has been well documented, less is known about which particular institutions affect long-run development. This paper contributes to the literature by showing that maritime institutions have had a lasting effect on economic development through its persistent impact on economic geography.

The paper is structured as follows. Section 2 presents the historical background.

[1] See Spolaore and Wacziarg (2013) and Nunn (2014) for surveys of this literature.

Section 3 presentes the main features of the research design. Section 4 presents the main results while section 5 discusses the mechanisms. Section 6 presentes the long-run estimates. Section 7 concludes.

2 Historical Background

This section provides the historical background for the analysis. I discuss the background for the trade reforms and the historical relationship between trade reform and economic development within the Spanish Empire, and how this phenomenon could influence long-run regional development patterns.

The Spanish Commercial System. For centuries, trade between Europe and Spanish America was guided by mercantilist thought. A key aim of the commercial policy was to promote state wealth acquisition through trade surplus and accumulation, Walker (1979), Findlay and O'Rourke (2007). At the heart of the Spanish Atlantic commercial system from the 16th to the mid 18th century was a system of fleets and galleons. Two fleets left Spain every year, the New Spain *flota*, destined for Veracruz, and the *Tierra Firme galeones* destined for Cartagena and Portebello. The *galeones* and the *flota* would then meet in Havana, and sail the trade winds back to Europe. Shipping in the pacific was conducted by the *Armada del Sur*, carrying goods from the trade fairs in Portobello to Pacific ports in South America.[2] Ports that were too remote were supplied with register ships (*registros*) sailing under special permission from the crown. This was mainly the case for ports in Central-America, Buenos Aires, and Caracas, however, this was never done at a sufficiently large scale and these areas were to a large extent overlooked by Spanish merchants, Walker (1979). Official information was carried by *aviso* ships, which operated separately from the commercial system and were not permitted or equipped to carry freight.

The system purposefully restricted trade in several ways. All trans-Atlantic trade was funneled through the four main ports in the Americas (Cartagena, Callao, Portobello/Nombre de Dios, and Veracruz) and only Sevilla/Cádiz in Spain. Moreover, only Spanish merchants were allowed to take part in this trade.[3] The system, consolidated under Phillip II in the 1560s largely remained in place until the second half of the 18th

[2]Moreover, the Manilla galleon would sail between Acapulco and Manilla. In this paper, I ignore this port as the emphasis is on Atlantic trade.

[3]Trade in 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).

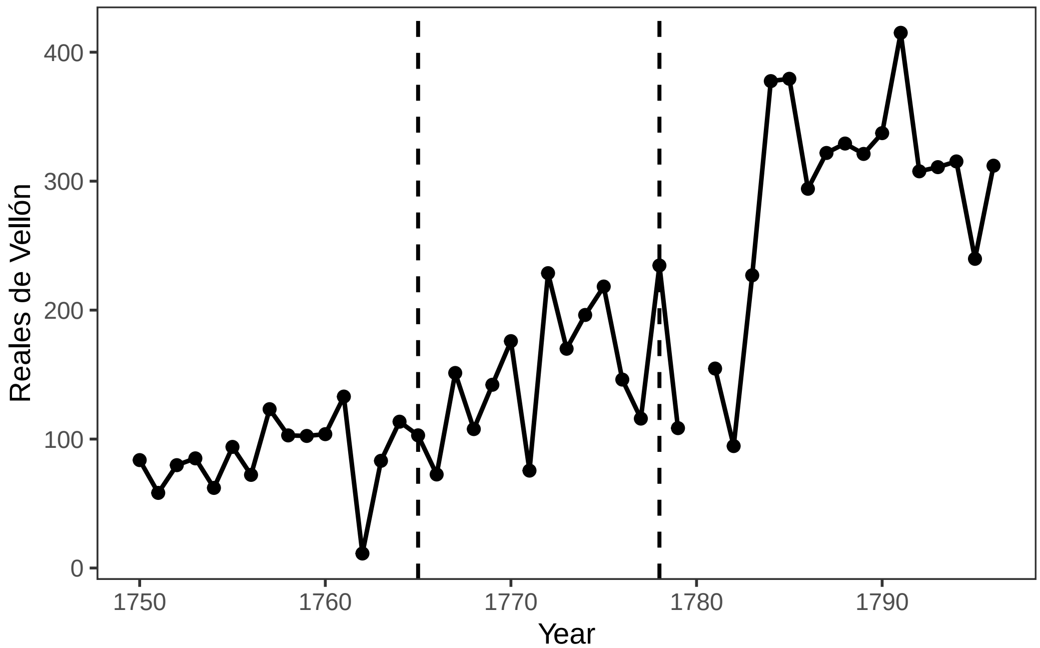

Figure 2: The figure the value of exports from Spain to American ports from 1750-1795. The vertical lines denote the beginning and end of the liberalization. Data for 1780 is missing in the original data source. Source: Cuenca-Esteban (2008).

century.[4] While the system ensured the steady flow of bullion across the Atlantic by limiting imports to the Americas, as well as facilitating the naval defense of convoys, it marginalized large areas that remained isolated from the official trade routes. According to Fisher, "The inevitable consequences ... were economic underdevelopment in the peripheral regions of America, at least until the liberalisation of trade in the second half of the eighteenth century", Fisher (1997) p. 73.

Reforming Trans-Atlantic Trade. Beginning in the 18th century, Spanish reformers were induced by geopolitical considerations, originating mainly in Europe, to overhaul the external trading system, Mahoney (2003). In the immediate aftermath of Spain's defeat in the Seven Years' War, a technical commission (the *junta de comercio*) was appointed under Charles III to assess and reform the system. The *junta de comercio* 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).[5] The largest

[4] Two notable exceptions were the change from using Nombre de Dios to using Portobelo on the Caribbean coast of Panama. In Spain, Cádiz rose to prominence over Seville in the 18th century, partly due to silting of the Guadalquivir.

[5] 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 policy 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

changes were to come in the Americas. Four ports in the Caribbean were opened already in 1766. Santo Domingo, Puerto Rico, Margarita, and Trinidad were opened for direct trade with Spain in 1765. The liberalization measures culminated in the decree of free trade in 1778 which opened the main remaining ports except in the Captaincy Generalacy of Venezuela (Caracas), where it was believed the Caracas companies tobacco monopoly was worth protecting, and New Spain (Campeche), which it was believed would have diverted too much trade away from other regions.[6][7] In the 1780s the remaining ports followed. Further liberalizations were on the horizon. Spain's alliance with revolutionary France in the late 18th century induced the British to implement a maritime blockade of Cádiz in 1797. As a result, trade with neutral nations during the Napoleonic war was allowed. The 18th century marked the definitive end of Spain's ability to enforce protected trade with the colonies. As a result, by the beginning of the 18th century, Spanish America enjoyed *de facto* although not *de jure* unrestricted trade with foreigners, Fisher (1998).

The relaxation of maritime trade during this period had affected economic growth in different regions. Formerly neglected regions such as Rio de La Plata, Venezuela, and Cuba became important exporters of hides, indigo, tobacco, sugar. Largely unrestricted sailing of individual ships allowed for specialization in a wider range of commodities, such as more perishable goods, to be exported. However, bullion remained an important export commodity, Fisher (1997) p. 38. The population and economies of the once stagnant peripheral colonies in Spanish America grew rapidly, Mahoney (2003), Bulmer-Thomas (2003). While it is generally agreed upon that the reforms had large effects on trade volumes, the magnitudes are disputed, Escosura and Casares (1983), Cuenca-Esteban (2008). Colonial imports to Spain increased tenfold and exports from Spain to the colonies fourfold, Fisher (1985), while more modest estimates are found in Cuenca-Esteban (2008) which are plotted in the Appendix. However, there is little doubt that trade increased substantially during the period. As a result of these developments, several formerly marginal areas in the Spanish empire became important economic regions. "...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. In Spain, Cádiz held on to its dominant position, accounting

Cádiz, Fisher (1997).

[6] *Reglamento y aranceles reales para el comercio libre de España a Indias de 12. de octubre de 1778*, and Fisher (1997)

[7] Even so, especially Veracruz was affected by the changes before the late 1780s since due to the abolition of the convoy system and the increased prevalence of *registros*.

for 85 percent of trade with the Americas between 1780 and 1800.

Historical accounts highlight the role of entrenched merchant guilds in resisting and in some instances blocking coastal development after the emergence of free trade, (see for example Mahoney (2010)). In some parts of the Spanish Empire, the government was confronted with local elite actors not interested in losing a monopoly position on trade. In the Audiencia of Guatemala "... a monopoly - an undesirable weed in an atmosphere of liberalized commerce - which already had taken deep root and was in full flower before the implementation in America of laws enacted to increase production and trade.", and "...Bourbon commercial reforms were too narrowly conceived and did not take into account the deep entrenchment of commercial interests established before reform efforts in America were attempted," Floyd (1961). The Audiencia of Mexico faced a similar situation. With the reforms, two competing groups of merchants emerged, in Veracruz and Mexico City. Merchants in Mexico City blocked the rise of Veracruz by purchasing and distributing directly in Mexico City, Mahoney (2010). Veracruz hence did not rise to become a new commercial center. In sum, in places with entrenched elites located oriented towards the interior, the reforms were met with resistance.

External Political Drivers. First, the drive to reform the Spanish commercial system should be understood as being embedded in a logic of interstate competition between the European powers 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 by the British during the Seven Years' war. This opened a window of opportunity for reform-minded policymakers which could rationalize reforming the external trading system regarding concerns about national security. As a result, the policy was implemented rapidly after the Seven Years' War, Fisher (1997). Therefore, the timing of the reforms is mainly driven by intensified interstate competition in Europe, rather than economic development in the Americas directly. Second, the reforms were 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 several actors in the Spanish Empire, Baskes (2013). Finally, the policies undoubtedly broadened access to international trade across the Spanish Empire which is apparent in trade statistics, Fisher (1985), Cuenca-Esteban (2008). These features of the implementation motivate a difference-difference design. That compares *changes* in city formation in localities within the same region that experienced different *changes* in shipping cost due to the lifting of the restrictions on maritime trade. The key assumption underlying a causal interpretation of the estimates is that changes in city formation would have evolved similarly in localities with different reductions in shipping times in the absence of the policy. The next section elaborates upon the research design.

3 Data

To empirically assess the importance of access to international trade networks, I construct a dataset containing geographic, demographic, and economic data for the Spanish Empire in the 18th century. The dataset consisting of 6,662 grid-cells of $0.5° \times 0.5°$ degrees. The geographic extent of the dataset partly or entirely covers the territories of the several contemporary nation-states.[8] The full extent of the study area can be seen in Figure ADD FIGURE. The main dataset is aggregated by 10-year intervals for the 100 years spanning 1720-1820 which gives a balanced panel of $6,662 \times 11 = 72,282$ observations. All data sources are aggregated to this level.[9] These data are used both in the reduced form and structural estimation. Below I describe each in turn.

3.1 Population and City Data

Populated Places The main outcome of interest is city formation. The main sample is constructed from a dataset of 15,000 places that existed in the Spanish Empire under the Bourbon dynasty, based on colonial censuses as well as various secondary sources, Stangl (2019*a*).[10] The dataset contains information on the founding of each locality, the legal status, its place in the ecclesiastical hierarchy, as well as longitude and latitude. The main dataset used in the analysis restricts the sample to places with the legal status of *city* or *town* according to Spanish territorial organization. The city (*ciudad*) which was the highest legal status afforded a population center in Spanish America and was typically granted directly by the crown. In some cases, cities 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. Below the city in the hierarchy was the town (*villa*). Taken

[8] These 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.

[9] I also, analyze different spatial resolutions and obtain qualitatively similar results. These results are reported in the Appendix.

[10] "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 very mostly not written for giving geographic information but may touch one specific detail or incidentally expose 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).

together, the final dataset on cities contains 710 cities spanning founded between 1500 and 1820.

To study long-run dynamics ensuing independence, I supplement this data with information from the *World Gazetteer*, which contains population data and geo-coordinates from official national statistical agencies. To determine the date of founding for several cities, I rely on the secondary historical literature and census data in some instances.[11] The longitude and latitude of each city is set to the historical functional center of the place. Finally, the dataset is combined with information colonial administrative borders compiled in Stangl (2019*b*). I assign each city to an audiencia, viceroyalty, as well as modern country borders. These have been subject to substantial change over the study period. For the main analysis, I fix audiencia and viceroyalty borders to 1790, i.e after large territorial reorganizations during the second half of the 18th century, and country borders pertaining to modern countries.

Population Data on population is compiled from various sources. First, demographic data on territories, mainly consisting of original census data, is from Stangl (2019*c*). This dataset contains the total population as well as the population by civil status for regions between 1700 and 1820. Unfortunately, this data is cross-sectional and therefore do not lend themselves to the panel dimension of the dataset. Therefore, I supplement this data with population estimates from HYDE 3.1, Klein Goldewijk et al. (2011). The dataset is a raster file of population density spanning the whole study region at 50-year intervals.[12] The dataset is constructed extrapolation of various historical population statistics. To assess the quality of this extrapolation for the region and time period in question, the dataset is cross-validated against colonial census data. In the Appendix, I show that population density data from Hyde 3.1 correlates strongly with historical population counts. Further, I use city-level population data from Buringh and Hub (2013) both to further validating the rasterized population data and for studying city growth at the city-level. Next, to quantify migration frictions in the structural model I use the bilateral population flows from the Mexican and Argentinian censuses of 1895 and 1865 respectively. Lastly, measure long-run outcomes I rely on various sources capturing geographic variation in contemporary economic geography. Following Henderson, Storeygard and Weil (2012).and subsequent work, regional development and population density are proxied using satellite imagery on light density averaged annually since 1992. Data on contemporary population density is from the Gridded Population of the World (GPW) version 4 dataset provided by

[11]Details and the list of references can be found in the Appendix.

[12]The dataset has been used extensively in economics, see for example .... The years used in this analysis are 1500, 1600, 1700, 1750. 1800, 1850, 1900, 1950, and 2000.

the Center for International Earth Science Information Network (CIESIN) at Columbia University. These two data sources are naturally highly correlated, and capture urban agglomeration and economic activity which is the main outcome of interest in this part of the analysis. To further assess what these data capture, I cross-validate the data with state-level as well as grid-cell level measures of GDP which shows the variables are highly correlated.[13]

3.2 Voyage and Trade Data

Voyage data The voyage durations are calculated using logbooks from the CLIWOC database (Climatological Database for the World's Oceans), García-Herrera et al. (2005). Originally compiled for studying historical oceanic climate conditions it 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.[14]The daily change in longitude and latitude is used to calculate the average travel speed. I follow Kelly and Ó Gráda (2019) and remove observations, where the speed is calculated to be implausible high, are dropped (above 10 knots), and travel in areas designated as being coastal in the dataset. To back out the relationship between average wind speed, direction and travel speed the data are combined with data on the average velocity and direction of the sea-surface winds provided by the US National Oceanic and Atmospheric Administration (NOAA).[15] Weekly data from 2011 to 2017 is downloaded and averaged by a $0.5° \times 0.5°$ for all cells covering the sea.[16] The strength of this data is the higher spatial resolution. However, using contemporary data to proxy historical wind conditions potentially introduced some measurement error and attenuation bias in the estimation procedure. To assess this, I cross-validate the relationship between historical and contemporary wind data as recorded in the logbooks, showing these are highly correlated.[17]

Trade data Data on trade flows come from two separate sources. First, data on trade between Spain and American ports from 1797-1820 comes from Fisher (1993). The data has been compiled from primary sources, mainly registers in the Americas and Spanish

[13]Data on GDP and the state-level is from Maloney and Caicedo (2016), Bruhn and Gallego (2011), and ...
[14]In the case of Spanish ships these are *paquebote*, *fregata*, and *navio*.
[15]The data is available here https://www.ncdc.noaa.gov/data-access/model-data/model-datasets/global-forcast-system-gfs.
[16]For cells covering land the wind speed is set to zero to prevent routes crossing land.
[17]These results are provided in the Appendix.

ports. The data documents how the share of total Spanish foreign exports are distributed on the 19 largest American ports between 1797-1820. These data are used to assess the relationship between the calculated changes in trade costs and trans-Atlantic trade in the reduced form. To estimate the gravity equation for trade needed for estimating the parameters of the structural model, I use data on bilateral trade flows at the country level from 1820 to 1870, Fouquin and Hugot (2016). The dataset contains 1.9 million bilateral trade observations. I restrict this dataset to be between 1820 and 1870 which roughly proxies the time before the introduction of steamships. Next, I restrict the sample to the countries in the analysis which results in 801 bilateral trade pair observations. Finally, the exact locations of ports are from Parry (1966), while the trading status of each port is from the decree itself *Reglamento y aranceles reales para el comercio libre de España a Indias de 12. de octubre de 1778*, as well as Fisher (1997).

3.3 Geography and Infrastructure

To control for time-variant correlates of geographic fundamentals and study potential mediating mechanisms, I use various sources to proxy for agricultural land quality. First, crop suitability from FAO's Global Agro-Ecological Zones is added. In the baseline model suitability for cotton, coffee, sugarcane, and cacao is aggregated to the grid-cell level. These variables measure the potential agroclimatic suitability of different crops. To reflects agricultural suitability with the traditional technology, the potential yield under rain-fed, low-input agriculture is used. Second, information the potential agricultural output (measured in calories) based on crops that were available for cultivation is constructed using FAO. These data are used as proxies for income in the structural estimation of the model. In addition, the location of mines that were active in the 18th century is added to the dataset. This data is from Fisher (1997).

Finally, I aggregate a range of geographical variables at the grid-cell level as controls. First, the terrain ruggedness index, average slope, and elevation by grid-cell is calculated. To proxy for the disease environment, I construct a dummy variable that takes the value one if the elevation is below 1500m. This is largely done to allow for time-variant impact of geographic features that could potentially be correlated with changes in remoteness through various mechanisms, (see for example Scott (2009), Nunn and Puga (2012)). Moreover, I include controls on potential vegetation to proxy for different geographic fundamentals, Ramankutty and Foley (1999). Navigable rivers played a less important role in trade than in Europe. To control for time-varying effects of distance to waterways and fresh-water access I use data on river flows from, Lehner, Verdin and Jarvis (2008).

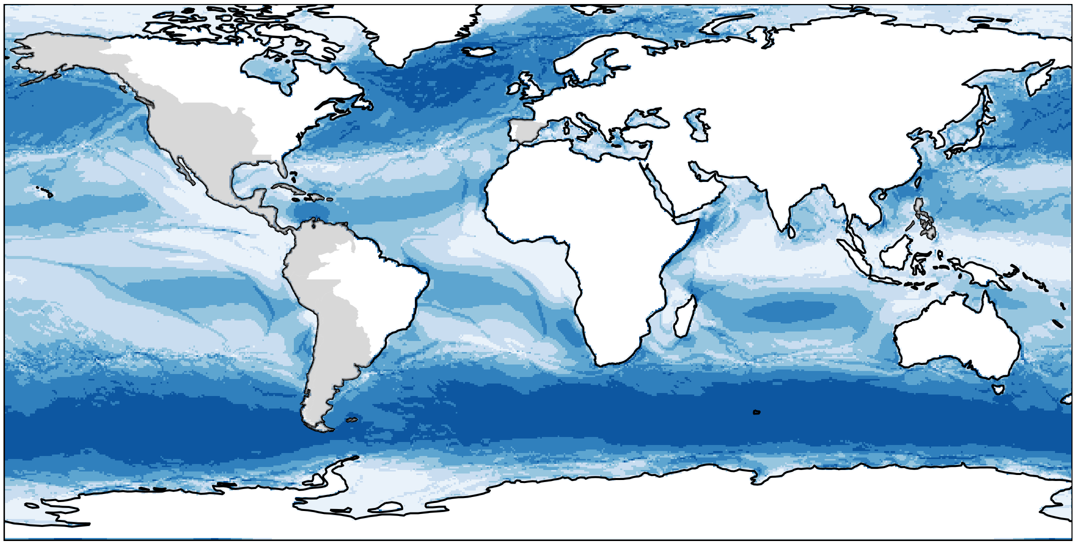

Figure 3: The figure shows the cost raster of maritime travel between 1750 and 1850. The conductance depends on the wind speed and direction and attenuates as the angle between the direction of travel and wind speed is reduced. Conductance is translated into travel times using 234,950 maritime logbook entries. For each move between two cells the conductance is calculated and the travel time is regressed on the conductance value to get an estimate of the relationship between conductance and time. The map plots the average conductance for each $1° \times 1°$ grid-cell where darker colors indicate that the cell can be crossed at higher speed. Grey areas denote territory claimed by the Spanish Empire in 1790. Source: NOAA and CLIWOC.

Finally, information on climatic variation is from Hijmans et al. (2005).

4 Calculating Trade Costs

To estimate the impact of the reform measures bilateral shipping times between localities by 18th century technology is calculated. This serves two purposes. First, changes in shipping times provides a time-varying instrument for actual trade costs. How this matrix is constructed is detailed below.

4.1 Maritime Transport

The world was divided into a matrix of $0.5° \times 0.5°$ squares.[18] For each square, weekly data from US National Oceanic and Atmospheric Administration (NOAA) was averaged over the period 2011 - 2017. The conductance faced by a vessel moving from each square to each of the eight adjacent square on the grid was calculated. In particular, Munoz (2004) proposes the following function for measuring conductance faced by a body relying

[18] Approximately 50km at the equator.

on wind propulsion,

$$T_{ij} = \begin{cases} \frac{\gamma}{S_i}, & \text{if } |\theta_{ij}| = 0 \\ \frac{\gamma \times |\theta_{ij}|}{S_i} & |\theta_{ij}| \neq 0, \end{cases} \tag{1}$$

where S_i measures the wind speed in a given point and θ_{ij} measures the deviation between the angle between node i and j and the wind direction. The underlying assumption is that higher wind-speeds and travel in the direction of the wind facilitates movement. The sailing time from each oceanic square to each of the eight adjacent squares on the grid was determined by the velocity and direction of the wind along the path in accordance with this function. The world matrix was then transformed into a weighted, directed graph in which every $0.5° \times 0.5°$ degree squares is a node and the conductance value to adjacent squares are the edges' weights.

$\hat{\gamma}$ is estimated from the using CLIWOC, García-Herrera et al. (2005). The dataset contains around 250,000 logbook entries of Spanish, British, Dutch, French and Swedish ships 1750-1850. Three restrictions are made on the sample to facilitate the calculations. First, observations when the ship is anchored in port are dropped. Second, logbook entries in coastal waters are removed because coastal navigation faced other constraints than wind conditions. Finally, to reduce measurement error, observations with implausibly high speeds are dropped, here defined as daily average speeds above ten knots. This results in 234,950 logbook entries in the final dataset. For each transition between two cells the conductance is calculated and the travel time is regressed on the conductance value to get an estimate of the relationship between conductance and time. Table A10 of the Appendix shows there is a strong correlation between the conductance value and the time spent sailing between two points. The resulting cost surface can be seen in Figure 3.

4.2 Overland Transport

Long-distance trade over land was largely reliant on pack animals. To calculate the costs faced by travel with pack animals, I rely on several pre-determined historical and geographic attributes that determined the travel speed. In the model, the pace of movement will depend on whether movement occurs on a road, the slope of the terrain, as well as the historical land cover. The slope of the topography can impede or facilitate movement following the Tobler-function, Tobler (1993). The number of days it takes to travel between i and j is given by the following expression,

$$T_{ij} = \kappa_i \times 5.36^{-1} \times e^{3.5|slope_{ij}+0.05|} \tag{2}$$

where $slope_{ij}$ measures the slope between cells i and j and κ_i is a coefficient determined by the landcover in cell i. It is assumed that travel on flat terrain on a road can be done at 4.5km per hour.

I rely on data on official travel routes in the Spanish Empire during the Bourbon period to measure the location of roads. I follow the literature and assume pace off the path to only be sixty percent of the pace on the path. Geographic attributes can further facilitate or impede movement. I rely on the literature for the terrain coefficients.[19] Six terrain types have a natural mapping between historical land cover data and the terrain coefficients. These are dense forests, grassland, deserts, open shrubland, and dense shrubland.[20] Finally, major rivers and lakes are included. In contrast to Western Europe and the United States, navigable rivers played a limited role in Spanish America. I interpret rivers and lakes mainly as obstacles to mobility. In the baseline case, it is assumed that lakes have to be circumnavigated, while rivers can be crossed at every point, however, only by reducing the pace by another 50 percent. The location of rivers and lakes is assumed to be time-invariant which is a reasonable assumption at the level of aggregation used in the analysis. Figure 5 shows the result of this exercise. Once the cost of passing through each cell is known, one can calculate bilateral costs by searching for the minimum-cost route of getting from a cell i to another cell j.

4.3 Least-Cost Path Problem

The estimates of shipping times between each adjacent cell are used to construct a matrix of bilateral travel times between all the cells used in the analysis. There will be many alternative paths to ship a good between districts i and j. Throughout, I assume goods are shipped following the least-cost path according to the Dijkstra algorithm, Dijkstra (1959). To represent the cost-minimizing trade routes, a time-varying $R \times R$ transition matrix, $\mathbf{T}_t$ is constructed. In the matrix, T_{ij} denotes the travel time between (not necessarily adjacent cells) i and j measured in days. Denote $\mathbb{1}^n_{ij}$, an indicator variable which is defined in the following manner,

$$\mathbb{1}^{nt}_{ij} = \begin{cases} 1, & \text{if cell } n \text{ is on the path between } i \text{ and } j \\ 0, & \text{cell } n \text{ is not on the path between } i \text{ and } j. \end{cases} \tag{3}$$

[19] For simplicity I assume a linear relationship between travel speed and the metabolic rate.

[20] The terrain factor makes the pace off-path 0.6 of the initial pace, 10/11 on grassland, 5/6 on dense and open shrubland, 2/3 in forests, and 10/21 in deserts.

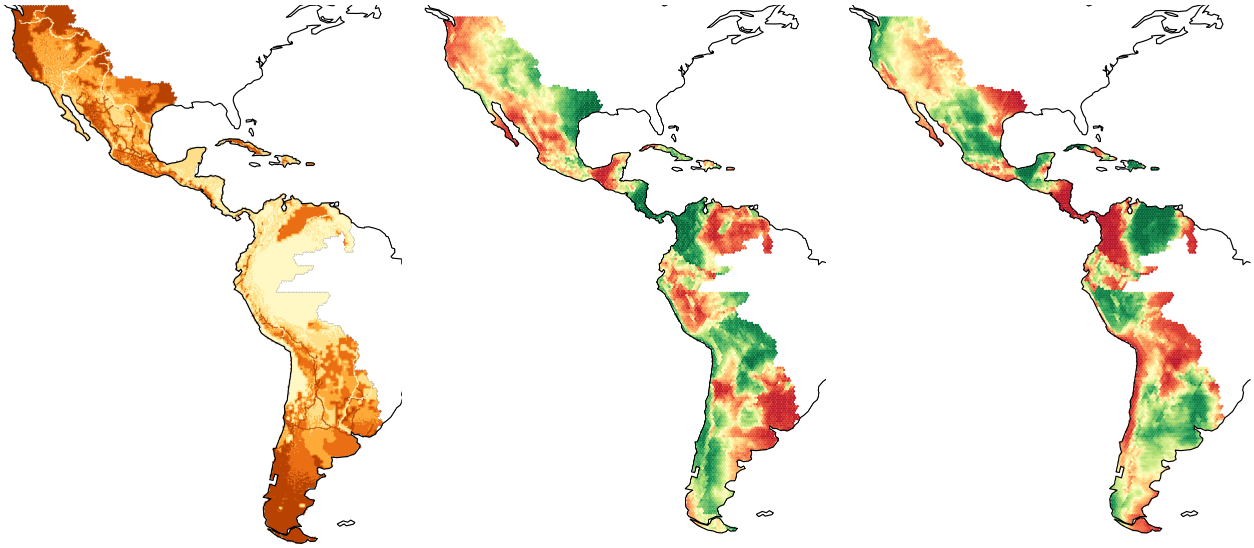

Figure 4: The left figure shows the average movement cost for each grid cell. Darker areas indicate less time consuming travel. The figure in the centre shows the residualized change in remoteness between 1750 and 1800 at the level of 4,777 1°×1° grid-cells. Brighter colors indicate larger reductions. The figure on the left shows the residualized change in market access 1750 and 1800 at the level of 4,777 1°×1° grid-cells. Brighter colors indicate larger increases

Each entry in the transition matrix is calculated as the sum of travel times between adjacent cells on the least-cost path. In particular, the entry at the i-th row and j-th column at time t, T_{ij}^t, denotes the travel time between cell i and j in year t and is given by the following expression,

$$T_{ij}^t = \sum_{k=1}^{R} \mathbb{1}_{ij}^{kt} T_{ik}^t. \tag{4}$$

$\mathbf{T}_t$ is calculated for each decade from 1760 to 1810 to capture the effect of the reform. This transition matrix of bilateral travel times forms the basis for both the reduced form and structural exercise. In the reduced form exercises, particular emphasis will be put on the column containing bilateral travel times between Europe and each cell in Spanish America.

The market access (MA_{it}) for a given locality is the sum of the population of all other localities, discounted by bilateral travel times, scaled by a trade elasticity θ. Having estimates for bilateral travel times within the Spanish Empire, the main explanatory variable is the actual market access of a given grid-cell which is given by the following expression,

$$MA_{it} = \sum_{j \in R} T_{ij}^{\theta} L_{jt}, \tag{5}$$

where T_{ij}^t measures the number of days shipping from i to j at time t, L_j^t the population size in j at t, and θ captures the distance elasticity. For the baseline estimates θ is set to -1. $M_{i(t)}$ will increase with one unit if an area one day away grows with one person.

4.4 Results and Assessment of the Transition Matrix

The results from these calculations can be seen in Figure 5 which plots the change in shipping times and market access for the 6,662 grid-cells for 1760 and 1790. The figure documents a substantial change in both shipping times and market access over this period. The average shipping time is reduced from around 11 percent over the course of the period, while the average market access increases by around 30 percent. However, these averages mask significant heterogeneity. The median reduction in shipping times is around 16 days travel, ranging from the largest reduction of 60 days shorter travel to no change in shipping times. The average shipping time prior to the reform is around 150 days. The localities with the largest reductions can be seen in Figure 4. Especially the River Plate region, Venezuela and parts of Central America experienced large changes in market access and shipping times throughout the reform period. As can be seen in the figure, changes in market access largely mirror the changes in shipping times.

How reliable are these estimates? Qualitatively the cost-minimizing routes replicate the routes chosen in practice (pacific/Atlantic over Panama, Mexico/Veracruz, Potosi/Lima). To assess whether calculated travel times reflect travel times faced in the 18th century, the results are cross-validated against several other data sources. First, I compare the results to measures sailing times according to . For each port, I calculate the sailing time from Cadiz to all the ports in the dataset for which the website records information. The average speed of 3.9 knots is used, which constitutes the average speed of Spanish freight ships in 1750, Kelly and Ó Gráda (2019). The two measures are shown to be highly correlated and robust to including controls. Next, I assess the correlation between predicted time travel and the duration of mail between major ports in the Spanish Atlantic in the late 18th century. Data on the speed of mail is from Baskes (2013). There is a strong correlation between predicted distance and the speed of mail in the dataset. This pattern is robust to controlling for geodesic distance, viceroyalty, as well as the longitude and latitude. Finally, I assess the validity of using NOAA data to study historical wind patterns. The CLIWOC data contains daily georeferenced data on wind speed and direction between 1750 and 1850 which is again used for cross-validation. In the Appendix, I show there is a strong correlation between the wind speed and direction predicted with modern data and the wind patterns described in the logbooks.

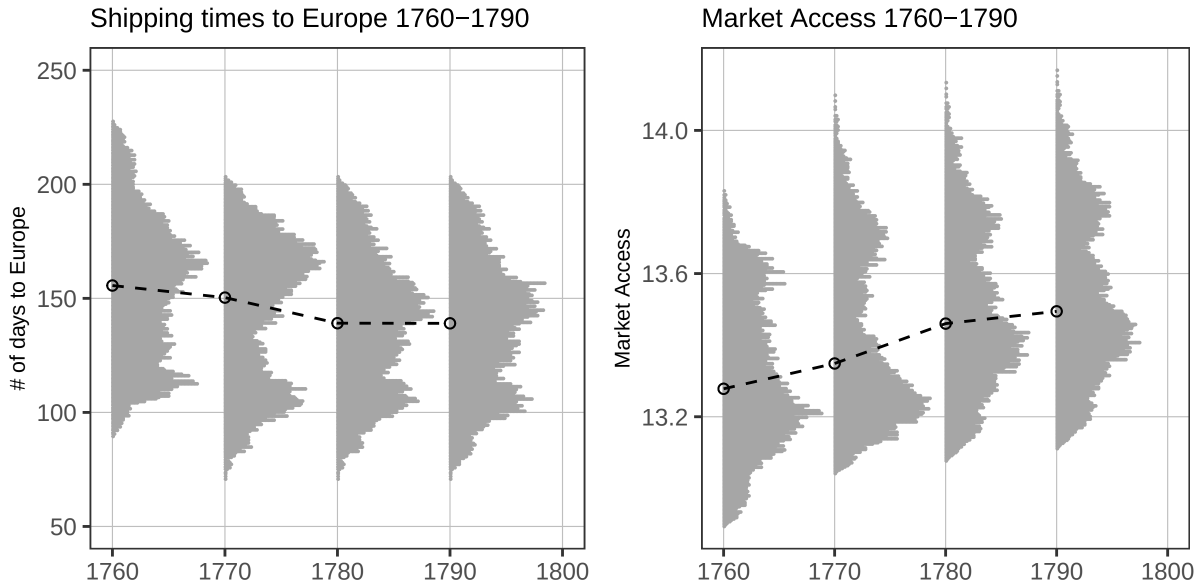

Figure 5: The left figure shows the average movement cost for each grid cell. Darker areas indicate less time consuming travel. The figure in the centre shows the residualized change in remoteness between 1750 and 1800 at the level of 4,777 1°×1° grid-cells. Brighter colors indicate larger reductions. The figure on the left shows the residualized change in market access 1750 and 1800 at the level of 4,777 1°×1° grid-cells. Brighter colors indicate larger increases

5 Reduced-Form Evidence

In this section, I present the main empirical specification and reduced-form result. The research design motivated by features of the implementation of the reforms.

5.1 Methodology

Difference-in-Difference. I begin by documenting the impact of the changes in shipping times on city formation. To quantify the effect, consider the following regression model,

$$y_{i(a,t)} = \alpha_i + \gamma_a \times \tau_t + \beta T_{i(t)} + \phi x_{i(t)} + \epsilon_{i(t)}, \tag{6}$$

where y_{iat} is an indicator equal to one is a city is present in cell i at time t and zero otherwise. I include the vector of pre-determined exogenous characteristics as discussed in Section 4.3 interacted with year indicator variables, which flexibly controls for fixed characteristics by allowing each to vary in importance over time. [21] For example, while elevation remains fixed or the location of bodies of water remained fixed over time, the

[21]The variables added to the baseline specification are average rainfall, temperature, distance to the coastline, terrain ruggedness, average slope, agroclimatic suitability for various cash crops, and the distance to the viceregal capitals in 1700.

benefits of these geographic characteristics might have changed with changes in the disease environment or irrigation techniques. I include audiencia-by-decade fixed effects, α_i, that account for shocks affecting all counties within a given audiencia in a particular decade. Here u_{it} is an error term potentially spatially correlated across nearby cells. In the baseline specification, the standard errors are therefore clustered at the level of the treatment assignment, in this case, the nearest port, Abadie et al. (2017). This results in 50 clusters.[22] The coefficient β captures the change in the probability of a cell containing a city for a one-unit change in shipping time to Europe. This variable is expressed in terms of days of travel from the grid-cell to Europe in year t.

Next, I consider the relationship between market access and city formation. To isolate the variation in market access that is induced by the reform, I use an instrumental variable approach. In particular, changes in market access is instrumented by the change in shipping time to Europe, using the following equation,

$$y_{i(a,t)} = \delta_i + \lambda_a \times \beta_t + \psi \widehat{MA}_{i(t)} + \omega x_{i(t)} + \mu_{i(t)}, \tag{7}$$

where $\widehat{MA}_{i(t)}$ is market access for cell i in decade t as predicted by shipping time to Europe. The parameter of interest, ψ thus measures the change in the probability of city formation in grid-cell i given a one percentage change in market access. The causal interpretation of the estimates relies on some further assumptions. I assume that the reform only affected market access through its effect on shipping times to Europe. This is a plausible assumption as the reforms changed trading regulations and not maritime communication more broadly. Moreover, it is assumed that the change in shipping time is correlated with the change in market access during the period. Under these assumptions, the coefficient ψ will be informative about counterfactual changes in market access.

Event Study. To assess the dynamics of adjustment to changing trade costs, I calculate the time-varying impact of the changes in shipping times on city formation. To quantify this effect, consider the following dynamic regression model,

$$y_{i(a,t)} = \alpha_i + \gamma_a \times \tau_t + \sum_{s=1700}^{1820} \mathbb{1}[t = s]\Delta T_i \times \tau_s + \phi x_{i(t)} + \epsilon_{i(a,t)}, \tag{8}$$

[22]The baseline specification contains 50 clusters. Standard tests can over reject the null with few clusters, Cameron, Gelbach and Miller (2008). Therefore, I estimate bootstrapped p-values using the wild cluster bootstrap to account for this as robustness. This correction matters little, as is shown in the Appendix. Further, 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 at 5,000km. This correction matters little for the size of the standard errors. These results are reported in the Appendix.

where y_{iat} is an indicator equal to one is a city is present in cell i at time t and zero otherwise; α_i is an audiencia fixed-effect; x_{it} is a vector of time-varying controls measured at the grid-cell level. τ_s, which are the coefficients of interest, non-parametrically trace out the probability of city formation around the time of the lifting of trading restrictions. Hence, it captures the average difference in the probability of a cell containing a city relative to the omitted year for a one unit change in shipping costs. $\epsilon_{i(a,t)}$ is again clustered at the level of the port. This specification is also useful in order to assess the validity of the research design. In the absence of pre-trends, the coefficient prior to the reform will be zero.

Cross-sectional Design. Finally, the long-run patterns of regional development are compared between localities more and less intensively treated by the reform. To look at the effect in the long-run, contemporary population density is treated as the main outcome. The following equation is estimated,

$$y_{i(a,c)} = \alpha_a + \gamma_c + \beta \Delta T_i + \lambda X'_i + \epsilon_i, \tag{9}$$

where y_i denotes population density in year 2000 and $\mathbf{x}'_{ia}$ a vector of control variables. In particular, $\mathbf{x}'_{ia}$ includes the distance to the closest port in 1750, the distance to the coastline for each grid-cell as well as the population size in 1750. Standard errors are again clustered at the port-level in the main specifications.[23] The assumption made for the interpretation of the estimates is that conditional on the controls, differences in changes in maritime remoteness between grid-cells do not reflect other factors that could induce differences in the outcomes in the long-run.[24] A causal interpretation of β naturally requires stronger assumptions than in the specifications relying on the timing for identification. Several exercises that provide support of the identifying assumptions are provided below.[25]

[23]Recent studies have shown the difficulty of conducting statistical inference with spatially correlated data. To address this concern, I report Conley standard errors in the tables and explicitly test and report Moran's I test statistics for all the specifications, Conley (1999).

[24]More formally, the identification assumption is $E[\epsilon_{ia}|x_{ia}, \alpha_a] = 0$.

[25]Table A10 presents several placebo-checks showing that the change in maritime remoteness is only related to the population after the opening of trade, and not before, also in the cross-section. Second, I calculate the bias-adjusted estimates in line with Altonji, Elder and Taber (2005) and Oster (2019) to show that very strong selection on unobservable characteristics is necessary to explain the estimated coefficients for most of the specifications. Finally, I rely on causal random forest estimation to estimate the impact of historical port locations on long-run development, Wager and Athey (2017).

5.2 Results

The results are presented in two parts. First, the main result is presented, the impact of maritime remoteness on city formation. Second, I present evidence regarding the mechanism. Finally, the robustness to several alternative interpretations is presented.

5.2.1 Shipping Times, Market Access, and City Formation

Table 4 displays the relationship between city formation, reductions in maritime shipping times, and market access induced by the lifting of trade restrictions. Column (1) shows the most parsimonious specification, only controlling for year fixed-effects. Seen in light of the large geographic area under consideration, different localities were likely to experience different shocks. Columns (2) addresses this by controlling for viceroyalty times time fixed-effect, absorbing all time-variant shocks common to the viceroyalty. Different development within viceroyalties can still give rise to differences in city formation unrelated to changes in shipping times. As a result, demographic and geographic controls times year effects are included in Columns (3) and (4) which absorb time-variant effects of demographics as well as geographic controls.

Table 4: Shipping Time, Market Access, and City Formation

City Formation	(1)	(2)	(3)	(4)
Panel A: OLS				
Market Access	0.019***	0.021***	0.016**	0.016**
	(0.005)	(0.006)	(0.008)	(0.007)
Panel B: IV				
Market Access	0.021***	0.027***	0.023***	0.024***
	(0.005)	(0.005)	(0.006)	(0.006)
Panel C: OLS				
Shipping Time	−0.015***	−0.020***	−0.018***	−0.020***
	(0.003)	(0.003)	(0.004)	(0.004)
Viceroyalty FE × Year		✓	✓	✓
Audiencia FE × Year			✓	✓
Controls × Year				✓
Observations	46,634	46,634	46,634	46,634

Note: The unit of analysis is at a 1°×1° grid-cell. The dependent variable is a dummy taking the value 1 if the grid-cell contains a city. The dataset is a balanced panel at a 20 year frequency for the period 1500-2000 for 4,777 grid cells. The dataset hence contains 6 × 4,777 = 28,662 observations. All specifications include grid-cell fixed-effects. Standard errors are clustered at the level of the closest port. ***p < .01, **p < .05, *

Panel A shows the results of the first-stage regression. The first-stage coefficients are stable across the various specifications. A one-standard-deviation increase in the shipping time reduces the market access by between 0.6 to 0.75 standard deviations. The F-statistics is above 18 for all specifications, showing that the first stage is strong. First, consider Panel B which shows the relationship between city formation and market access. Across the various specifications, a one standard deviation increase in market access is associated with a 0.25 – 0.3 percentage point increase in the probability of a city containing a city. This specification is stable to the inclusion of the different control variables. Comparing the point estimates with the OLS specification shows that the IV estimates are larger, showing that OLS tends to underestimate the effect of market access on city formation. One potential explanation for this is a classical measurement error. Taken together, the results show that there is removing trade restrictions had a sizeable effect on market access, which in turn promoted city formation.

5.2.2 Timing of the Effect

Next, I look closer at the *timing* of the effects in Table 4. The key assumption on which the causal interpretation of the estimates is based is that city formation would have happened at an equal rate in areas with different reductions in shipping costs in the absence of the reform. This assumption is more compelling if the change in city formation is the same in these localities prior to the reform. Moreover, to understand the long-run effect, the adjustment dynamics after the reform are considered. To this end, Equation (8) is estimated.

Figure 6 shows the estimated coefficients controlling for year times audiencia fixed effects. The plotted coefficients give the estimated difference between exposed and unexposed localities in year j relative to 1760, the year prior to the policy. The left panel shows the time-variant impact of an indicator variable for the above-median reduction in the shipping cost. Consistent with the identification assumption, there is no statistically significant difference in the change of city-formation in areas above or below the median exposure prior to the reform.[26] However, after the reform, the difference is increasing relative to 1760. By 1800, areas with an above-median change in exposure have a one percentage point higher probability of having a city than in 1760, after which the change again declines. The effect is precisely estimated and the equality of the two groups can be rejected at conventional levels by 1790. To facilitate comparison with the main specification, the right panel reports the effect with the log of the change in shipping cost as an explanatory variable. The figure shows that by 1790, places with a one percent

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

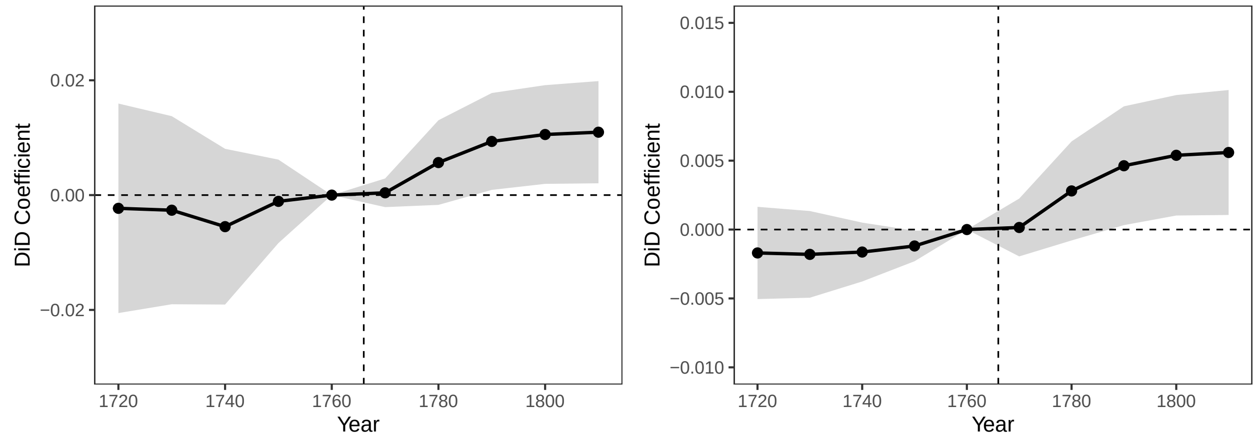

Figure 6: The figure shows the estimated coefficients of the difference in city formation in grid-cells according to the reduction in travel time to Spain. The dependent variable is a dummy-variable taking the value one if the grid-cell has a city. The data is binned in 20-year periods. The specification includes audiencia as well as audiencia times period fixed-effects. Standard errors are clustered at the port-level.

higher reduction in shipping costs will have a 0.5 percentage point higher probability of having a city relative to 1760.

Table ... provides several robustness checks to these results. The table shows the estimated coefficients for different specifications. Column (1) presents the estimate only including time fixed-effects. Column (2) adds grid-cell fixed-effects to controls for differences in level between areas with different treatment intensity. To control for different trends in areas differentially affected by the policy, Column (3) includes audiencia times time fixed-effects. This flexibly for all factors specific for a audiencia at a given time period. Column (4) interacts the post-dummy variable with geographical controls. This allows for various geographical controls to have a differential impact over time, unrelated to the policy. Column (5) adds various agro-climatic controls to the specification, for the same reasons. Taken together, the results show that the reforms promoted more rapid city formation in areas more heavily exposed to the reforms, but that this effect was temporary.

5.2.3 Heterogeneity: Settlement Type, Cores and Peripheries, and Network Centrality

Where did increased market access promote city formation? Redding and Sturm (2008) and Baum-Snow et al. (2018) find that the effect of market access on population density depends on the initial population distribution. To assess this, I study heterogeneity by the initial level of development. The sample is divided into a core and periphery. The core constitutes the most developed and densely populated areas under the Habsburgs and early Bourbon colonial regimes. The core region is denoted the audiencia of Lima as well as the audiencia of Mexico. The periphery is all other audiencias and frontier areas in the dataset that were significantly less settled and urban at this time.

The results are displayed in Figure 5. The baseline specification is estimated separately for the core, semi-periphery, and periphery. The first columns estimate the baseline specification with audiencia times year fixed effects, while the second column adds the main set of controls used in the analysis. The estimated effect in the core is somewhat mixed. There is a negative effect estimated for the core areas, however, part of the effect can be attributed to the areas reducing its maritime remoteness in the core being different on along dimensions captured by the controls. When adding these controls there is no statistically significant impact of the reform on city formation. The lowest effect is estimated for the semi-periphery. For these audiencias the effect is indistinguishable from zero. The largest effects are found in the peripheral areas. A one-unit reduction in maritime remoteness increases city formation by around eight percentage points. Taken together, these results show that the estimated effect in the main specification is mainly driven by peripheral regions at the time of the opening of Atlantic trade.

5.2.4 Long-Run Implications: Gradients in Distance to the Coast

Did the reforms promote city formation in coastal areas? This section presents evidence on the changing role of coastal proximity in determining the location of new cities throughout the reform period. In particular, the change of the effect of coastal proximity is compared between places in which the reforms substantially lowered shipping times to Europe to places where the changes were minor. Consider the following triple difference-in-difference specification,

$$\begin{aligned} y_{i(t,a)} \quad = \quad & \alpha_a + \beta_1 \text{Coast}_i + \beta_3 \text{Free}_i + \beta_2 \text{Post}_t + \\ & \phi_1(\text{Free}_i \times \text{Post}_t) + \phi_2(\text{Coast}_i \times \text{Post}_t) + \phi_3(\text{Free}_t \times \text{Coast}_i) + \\ & \theta(\text{Free}_i \times \text{Coast}_i \times \text{Post}_t) + \epsilon_{i(t,a)} \end{aligned} \tag{10}$$

where Distcoast_i denotes the (log) distance to the coastline, Free_i denotes a measure of reduction in shipping times (either the difference in shipping times between 1760 and 1810 or higher than median difference),[27] and Post_t is an indicator variable taking the value one after 1765. Standard errors are again clustered at the level of the closest port.

[27]This definition of the variable is used in the baseline specification to fascilitate interpretation of the coefficients. The results are robust to using the continuous measure of shipping times directly.

The Estimating $\theta > 0$ is consistent with the trade reforms accelerating city formation in coastal areas.

Table 2: Market Access and Coastal Cities

City Formation	(1)	(2)	(3)	(4)	(5)
Free × Post		0.066***	0.058**	−0.005	−0.013
		(0.028)	(0.029)	(0.046)	(0.048)
Coast × Post	−0.008***	−0.005***	−0.007***	−0.004	−0.006**
	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)
Periphery × Post				−0.008	0.008
				(0.020)	(0.024)
Free × Coast × Post		−0.009***	−0.008**	0.008	0.009
		(0.004)	(0.004)	(0.009)	(0.010)
Free × Periphery × Post				0.102**	0.096**
				(0.055)	(0.050)
Coast × Periphery × Post				−0.0005	−0.003
				(0.003)	(0.004)
Free × Coast × Periphery × Post				−0.021***	−0.021***
				(0.010)	(0.010)
Controls × Year FE			✓		✓
Observations	73,282	73,282	73,282	73,282	73,282
Adjusted R-squared	0.880	0.881	0.881	0.881	0.881

Note: Specifications contain grid-cell and viceroyalty × year fixed-effects. Dependent variable is a dummy taking the value one if the grid-cell contains a city. The dataset is a balanced panel at a 10 year frequency for the period 1720-1820 of 6,662 grid cells (11 × 6,662 = 73,282 observations). *Periphery* is indicator taking the value one if the grid-cell falls within the audiencias of Buenos Aires, Caracas, Santiago or outside areas pertaining to an audiencia, *Free* takes the value one if the grid-cell has above median reduction in shipping time, *Post* is one for observations after 1765. *Coastdist* is the log distance to the coastline. Controls include elevation, average slope, the terrain ruggedness index, longitude and latitude. Standard errors are clustered at the level of the closest port. ***$p < .01$, ***$p < .05$, **

Table 2 shows the results of this exercise. All specifications control for grid-cell as well as audiencia times year fixed-effects. Column (1) shows the average increase in the coastal gradient after the reform. After the reform, there is a larger reduction in the probability of a grid-cell containing a city as one moves away from the coastline. A ten percent reduction in coastal proximity has an 8 percentage point larger negative effect on the probability of a city. Column (2) and Column (3) considers the differential increase in the coastal gradient depending on whether the area experienced above-median reductions in shipping times. The interaction shows that areas that were affected by the trade reforms experienced an even larger increase in the importance of coastal proximity after the reforms. While the probability of a city declines by 0.7 percentage points after the reform on average, for places with higher exposure to the reforms it increases by almost twice that amount, 0.15 percentage points. Column (3) shows this result is robust to controlling the main control variables. This effect is both economically and statistically significant (the joint significance of the coefficients having a p-value of 0.059). Is this effect also more pronounced in the periphery? Column (4) and Column (5) addresses this question. The interaction between the differential change in the effect of coastal proximity is larger in the peripheral regions. This shows that the importance of coastal proximity increases more for treated areas in the periphery. Taken together, the effects in Table 2 show that the reform is associated with an accelerated formation of cities in coastal areas, an effect that is especially pronounced in the peripheral areas.

Have these effects persisted to the present? Consistent with the results from Figure 8, Table 10 shows that coastal population density is higher in areas that experienced a higher exposure to the reforms. The difference in population density, as well as nightlight luminosity, is higher between coastal and hinterland areas for places more exposed to the reform. Moreover, cells with higher exposure to the reform are also more likely to contain a coastal city in 2000 as proxied by nightlight luminosity.[28] As is apparent from Table 10, this pattern was not present in the data prior to 1750, but rather has emerged since. Taken together, the results from Table 9 and Table 10 support the interpretation that the reforms increased coastal population density in areas with high exposure to the reform.

5.3 Robustness

Both the long-run and medium-run effects are robust to samples used in estimation and to endogeneity concerns regarding selections on unobservables. I summarize robustness exercises below, while details are found in the Appendix.

Territorial Reorganization. The main assumptions underlying a causal interpretation of the estimated effects are similar trends in the absence of the policy and no other changes happening at the same time that affect the units in similar ways. One reasonable concern is other policies being implemented at the same time that affect urban development. An example of such a policy is the territorial reorganization that was implemented in Spanish America in the 18th century. The Viceroyalty of Rio de la Plata was carved out of the Viceroyalty of Peru in 1778. It is a possibility that this induced economic growth to be reoriented towards Buenos Aires in a way that is correlated with the reduction in travel times in this region. To investigate this possibility, I conduct two exercises. First, I drop all

[28]This is estimated using Equation (7) as a linear probability model (LPM). While it prevents a structural interpretation of the coefficients, it approximates the conditional expectation function and hence provides a simple approximation of the marginal effects of interest, Angrist and Pischke (2008).

grid-cells in the Viceroyalty of Rio de la Plata. The estimated coefficients are unchanged. Second, I exploit the fact that the Viceroyalty of Nueva Granada with the capital in Bogotá was carved out from the Viceroyalty of Peru already in 1717. I estimate the effect of this reform and do not find a similar effect. Taken together, these two pieces of evidence are not supportive of the notion that territorial reorganization drives the results. A second concern could be the impact the other institutional changes implemented in this period. These reforms were typically implemented in the viceregal capitals. To investigate the possibility of these reforms driving the result, I control for the interaction between the distance to the viceregal capitals in 1790 with time dummy variables. Also, this exercise leaves the estimated coefficient unchanged. THE INTENDANT SYSTEM, controls

Changes in Maritime Technology. It is unlikely that the changing maritime remoteness calculated to be correlated with changes in maritime technology for at least four reasons. First, the Consensus among economic historians has been that maritime technology remained stagnant between the 16th and 18th centuries and the introduction of the steamship, North (1968), Harley (1988). These studies have largely been based on voyage durations and or the cost of shipping freight. A notable exception is Kelly and Ó Gráda (2019). As pointed out in this paper, the absence of growth in maritime technology in this period is surprising given historical the scholarship maritime inventions such as the iron reinforced hulls, copper sheathing, and the marine chronometer. Also using data from García-Herrera et al. (2005), they find evidence that sailing speeds for British East India Company and Navy ships increased from around 1770. Second, they find no increases in sailing speeds for Spanish ships, which stood for the largest share of legal trade with Spanish America during this period. Third, the increase is gradual and hence does not coincide with the timing of the changes in trade volume, or prices shown in Figure ... and Figure ... Finally, it is unlikely that general increases in maritime productivity should differentially impact ports by their change in trading status during this period. As a result, it seems unlikely that the effects capture changes in maritime technology rather than changes in institutions governing trade.

Assessing Spatial Autocorrelation. Kelly (2019) shows that in the studies of long-run persistence, explanatory and outcome variables often exhibit a high degree of spatial autocorrelation. When this is the case, the p-values of statistical tests can be biased downward. Moreover, the issue is not remedied by traditional methods such as Conley standard errors or clustering methods. To explore whether the results in Section 6.5 suffer from this, two exercises are conducted. First, I first explicitly test for spatial correlation of the residuals in the baseline specification.[29] Second, as suggested by Kelly (2019) placebo regressions using randomly-generated spatially-autocorrelated noise instead of our explanatory variable are calculated. This is done under different assumptions on the strength of autocorrelation. Taken together, these exercises provide some evidence that the residuals in the regressions presented in Section 6.5 exhibit spatial autocorrelation. To remedy this, I use the covariance matrix estimator suggested in Kelly (2020). This approach corrects for spatial correlation by making parametric assumptions about the distribution and spatial dependence of the residuals. As shown in that paper, how well this function form assumption captures the structure of the residual is testable by looking at the correlation between the residuals implied by the model and the residuals backed out from the regression. Making this adjustment gives qualitatively similar results to Table 9 and Table 10.

Varying the Cell Size. So far, all specifications have used administrative borders of audiencias viceroyalties in 1790 and modern country borders to absorb unobserved geographic heterogeneity. However, there might be unobserved variables that are geographically clustered in a manner that is not captured by these borders. I relax this assumption in two ways. First, I use viceroyalty and audiencia borders between 1710 and 1750 as additional controls. Second, I use virtual country fixed-effects to take into account various regional unobservables that could potentially be related to the city in the early 19th century. The results from these exercises are presented in the Appendix. Taken together, the estimated effects are robust to these exercises, suggesting that the geographic controls capture time-varying geographic heterogeneity well. The choice of grid-cell size has been shown to have sizeable effects on point estimates under certain conditions, Briant, Combes and Lafourcade (2010). Therefore, I assess the robustness of the results to choosing different grid-cell sizes.[30] I construct two additional datasets with different resolutions and reestimate the main effects in Table 4. This table is reported in the Appendix. While reducing the resolution lowers the precision as should be expected, the point estimated remains economically and statistically significant.

Establishment of New Merchant Guilds. Having shown that there was a large effect of the policies on subsequent economic development, a natural next question is who gained. Here I ask if local institutions mediated the long-run impact of the trade reform? I continue by assessing whether the location of merchant guilds (*consulados*) explain the

[29]This is done both using the distribution under the null derived from the analytical approach as well the distribution under the null using Monte-Carlo simulation.

[30]This is known in the literature as the modifiable areal unit problem.

heterogeneity of the effects documented above. To empirically operationalize this concept in this context I look at heterogeneity by a geographical alignment between commercial and political elites in two ways. First, I ask whether an audiencia has a merchant guild located in the hinterland or at the coast. The audiencias for which this is the case in Mexico, Confines, Santiago, and Santa Fe.[31] Second, I look at the whether the political capital of the audiencia is located at the largest commercial port or not. This is the case for the audiencia of Confines, Mexico, Santa Fe, Quito, and Charcas.[32] Both these variables to some extent capture the extent to which a port city encounters resistance from the interior regions.

Figure 5 shows the time-varying effect for whether or not there is a merchant guild in the interior in the baseline specification similar to Figure 4. As can be seen from the figure, there is a strong tendency of the estimated effect to be attenuated in places with interior audiencia capitals while the effect is higher in places where the audiencia capital is located at the port. The same pattern arises when comparing places with and without interior merchant guilds. As can be seen in Figure A3, the effect is concentrated in the places with merchant guilds located in the most important port city.

Effects in Brazil. tba

Sample Selection. tba

Causal Random Forest. tba

5.4 Mechanisms

So far, evidence on a robust relationship between maritime remoteness and city formation has been established. What explains this effect? This section explores the mechanisms: first, the increased importance of commodity exports, second, increased population density and urbanization, and finally the emergence of elite incentives in facilitating growth induced by increased opportunities to trade.

5.4.1 Commodity Export Growth

The reorganization of trade routes increased market access for several cities. While this reduced average transportation costs and stimulated trade, it could potentially change the composition of traded commodities. Shorter travel times opened new export markets by making the shipping of perishable goods profitable. As a result, new cities could

[31] The Audiencia of Mexico roughly corresponds to current day central Mexico, Confines to Guatemala, El Salvador, and Honduras, Santiago to Chile, and Santa Fe to Colombia.

[32] The audiencia of Quito roughly corresponds to modern-day Ecuador, Charcas to modern-day Bolivia.

have formed to take advantage of commercial opportunities in well-connected coasts and hinterlands.

Spanish Trade. To assess this mechanism, I first look at the relationship between changes in travel times and trade with Spain using data on trade between Spain and American ports from 1797-1820 from Fisher (1993). Table 3 shows that reductions in maritime remoteness increased the trade volume with Spain. The explanatory variable is the change in maritime remoteness between 1750 and 1800 as defined in equation 4 while the dependent variable is the share of Spanish exports to 19 American ports. Column (1) shows the baseline results without any additional controls. Column (2) includes the geodesic distance to Cádiz as control while Column (3) adds viceroyalty fixed-effects. Column (4) combines the two controls while Column (5) adds the longitude and latitude as additional controls. Taken together, there is a robust relationship between reductions in maritime remoteness increases in the export share from Spain 1800-1820. A one-unit reduction in ΔT increases the trade share with around 10 percentage points, i.e if the distance to Spain in terms of sailing time is reduced to half, this increases the trade share with around 8 percentage points. The estimates are stable when gradually adding control variables, although precision is lost when adding the full set of controls in Column (5). In sum, the table shows that while the reforms increased trans-Atlantic trade in general, ports with larger reductions in remoteness increases their trade shares more.

Commodity Prices. To further assess the impact of the reform on trade volumes, the prices of commodities produced in the Spanish empire are considered. Posthumus (1946) contains price data on 49 commodities traded in Amsterdam between 1750 and 1800. Out of these 49, four commodities were important export commodities in the Americas. These were indigo, sugar, tobacco, and cocoa. Consider the following specification,

$$Price_{c(t)} = \alpha_c + \beta \text{Treat}_c \times \text{Post}_t + \epsilon_{c(t)}, \tag{11}$$

where $Price_{c(t)}$ measures the price of commodity c in year t and (normalized to 100 in 1750), treat is a dummy for American export commodities, Post_t is a dummy variable taking the value one after 1778, and ϵ_i is an error term. The standard errors are clustered at the commodity-level to account for the variance changing over time, as documented in Jacks, O'Rourke and Williamson (2011). Table ... shows the results. For all the specifications there is a strong differential impact of the post-dummy, suggesting the reform induced lower prices of these traded commodities. Crucially, to account for disruptions of Atlantic trade induced by naval conflicts (in particular the American revolutionary war), Treat_c is interacted with a dummy variable taking the value one for years in which there was a war where important Atlantic maritime powers were belligerents (Seven Years' War and the American Revolutionary War). As can be seen in Column (4) the effect is robust to controlling for this variable. Taken together, both these pieces of evidence are consistent with the reform spurring increased trans-Atlantic trade within the Spanish Empire.

Export Crop Suitability. Can increased production of export commodities account for the increased rate of city formation? To assess this explanation measures of crop suitability under traditional technologies are used. The crops considered are export crops of which production was intensified during the late 18th century. For each grid-cell, the average suitability of cane sugar, cacao, coffee, cotton, and tobacco is calculated. If new cities formed largely as a result of new commercial opportunities, one would expect the effect to be stronger in areas more suitable for export agriculture. Table 7 presents the results. For each crop, the baseline specification with the full set of controls is calculated. For cotton, tobacco, and wheat the interaction between reductions in travel time and crop suitability is positive and significant. This shows that areas that are suitable for the cultivation of these crops tend to experience a stronger effect of reductions in maritime remoteness on city formation than areas less suitable. For the case of sugar cane, the effect is also positive, however, the estimate lacks the precision of the other estimated effects. Finally, the mediating effect of distance to active mineral deposits is considered. The interaction between distance to mineral deposits and reductions in maritime remoteness is not significant and is positively related to increases in city formation. This is natural, as areas close to mineral deposits were already developed and changed their market access relatively little as a result of the intensifying commercial ties with Spain. In sum, the evidence point in the direction of city formation being driven in part by the increased opportunities to ship perishable goods.

5.4.2 Urbanization and Frontier Expansion

Some text. . . .

Urbanization So far, the evidence has focused on the extensive margin of city growth, ignoring the intensive margin. Do population growth and urbanization explain the increases in city formation in better-connected areas? To explore this, I use two main data sources. First, I use spatially disaggregated data on the population from Klein Goldewijk et al. (2011). The data provides information on the total population, population density, as well as the fraction of the population residing in an urban area. The data is again averaged at the grid-cell level and included as the dependent variable in the baseline specification. Second, I use information on the city population from Buringh and Hub (2013) which contains the population size for the largest cities in the Spanish Empire in the 18th and 19th centuries. To validate both these data sources I compare with colonial census data from the second half of the 18th century.

The main results of this exercise are presented in Table 8. The first column for each outcome contains the baseline specification without controls, while the second column includes the main controls used in the analysis. There is not a statistically significant relationship between the average level of the population and the change in travel time, however, there is a strong effect on the share of the urban population. This points towards increases in urbanization playing an important role in driving city formation, rather than population growth per se. This is confirmed by looking at the data on cities. While the approach restricting the analysis to cities cannot distinguish between urbanization and natural population growth, the estimates using the city population confirm the interpretation of urbanization explaining the effect on city formation.

City Formation in Frontiers. Did increases in market access promote city formation by expanding the frontier of settlement? To investigate this, I contrast the effect of reductions in shipping costs in areas with low vs. high state capacity. Several approaches are taken to proxy for state capacity. First, similar to Acemoglu, García-Jimeno and Robinson (2015) distance state infrastructure is used. To do this I use a dataset on around 900 post offices in Spanish America in the 18th century. Second, the level of state capacity is assumed to be lower in areas further away from the audiencia capital. Finally, I use several maps of frontier areas in the 18th century constructed by historians. As can be seen in Figure... all these approached give roughly the same areas. The estimated interactions are presented in Table ... Taken together they show that city formation was more responsive to changes in shipping times and market access in areas with some state presence.

5.4.3 The Trans-Atlantic and Intra-American Slave Trades

So far, the evidence shows that increased trading opportunities induced increases in the cultivation of cash crops in previously less densely settled areas. The frontier expansion has long been linked to labor coercion... In this section, I use data from ... to investigate this. The data contains ... which constitutes around 80 percent of voyages disembarking captives in the Americas. At 21 of the 39 directly took part in the slave trade.[33] Figure ... shows the time-variation in the number of ships disembarking captives in at Spanish ports from 1740 to 1820. The variation closely tracks the reform and provides suggestive evidence of increased demand for slave labor induced by the increases in trade and settlement. To assess this more in detail, the number of ships arriving at each port is aggregated by year and the differential across ports affected by *comercio libre* and not is estimated. Consider the following specification.

$$\text{Ships}_{p(t)} = \alpha_p + \beta_1 \text{Free}_p \times \text{Post}_t + \beta_2 \text{Spanish}_p \times \text{Post}_t + \beta_3 \text{Free}_p \times \text{Post}_t \times \text{Spanish}_p + \epsilon_{p(t)}, \tag{12}$$

where $\text{Ships}_{p(t)}$ measures how many ships carrying slaves to port p at time t, Free_p denotes if the port was subject to changing trading status during the Bourbon reforms. The standard error is again clustered at the port-level, constituting the level of the treatment. Table ... shows the results of this exercise. Taken together there is no differential increase in the number of ships disembarking at ports that gain trading privileges.

5.4.4 Trans-Atlantic Migration

tba

5.4.5 Rerouting vs. Transshipment

The opening of ports to direct trade with Europe could affect trade costs for a locality in two ways. First, the fastest route potentially changes because shipment would no longer have to through another port. This would reduce the travel time directly and be particularly be the case for places on the Caribbean and Atlantic seaboard. Second, transshipment could be costly in and of itself, due to various costs associated with transshipment. This could induce gains of port openings that work beyond reductions in shipping times. This would particularly be the case for localities located on the Pacific seaboard. To investigate which of these two effects dominates the sample is split into localities for which the shortest path to Europe goes through ports located on the Pacific on the one hand, and localities for which the shortest path to Europe goes through ports located in the Caribbean or the Atlantic coasts. The results can be seen in Table ....

[33] These were Havana, Santiago de Cuba, Campeche, Veracruz, Portobelo, Santo Tomas de Castilla, Cartagena, Caracas/La Guaira, Rio de la Hacha, Nombre de Dios/Portobello, Puerto Cabello, Maracaibo, Nueva Barcelona, Trujillo, Montevideo, Maldonado, Buenos Aires, Lima, Valparaiso, and Ecuador (port unspecified).

displays the results. The table shows that the largest effect is found for localities that experience changes in routes, rather than avoiding transshipment. Taken together the findings in this section points towards increases in market access and lower shipping times to Europe promoting city growth in places suitable for export agriculture.

Three patterns emerge. . . .. Largely unrestricted and faster sailing of individual ships allowed for increased specialization in a wider range of commodities, such as more perishable goods to be shipped long distances.

6 Dynamic Model

The reduced form evidence shows a strong relationship between reductions in maritime remoteness and city formation. This is largely driven by urbanization in areas suitable for export crop production in previously less densely settled areas. In light of this evidence, I now layout a dynamic spatial general equilibrium framework that incorporates these channels and can be estimated using the data at hand and the time-varying nature of transportation costs in this context. I proceed by building a structural model, for two purposes. . . .

6.1 Theoretical Framework

The model follows the setup in and Allen and Donaldson (2018) closely. The model differs in the emphasis on international trade and changes in trade costs. Moreover, it incorporates city formation as will be elaborated upon below. The economy consists of several locations indexed by i, n where $n \in \Omega$ over discrete time periods $t = 0, 1, 2, ...$ Every agent lives for two periods, and supplies labor inelastically in the second period while making decisions on where to locate in the first period. The size of the population in period 0 exogenous and given by $\{L_{r,0}\}_{r\in\Omega}$.

Geography. A locality i can be either in Europe Eu or in America Am.

Consumption. The demand side of the model consists of two parts. First, the utility of a representative agent in region $j \in \Omega$ depends on agglomeration spillovers. The strength of the contemporanous spillover effect, determined by β_1, could for example capture costs related to congestion, while the lagged spillover, determined by β_2 could capture the housing stock or other persistent urban amenities. Second, utility depends on consumption of a goods produced in all other regions. Each region is assumed to produce a unique good that enters the utility function with constant elasticity of substitution, Armington (1969). In particular, the utility of a representative agent in region $r \in \Omega$ is given by the following function,

$$L_{jt}^{\beta_1} L_{j,t-1}^{\beta_2} \times \left(\sum_{i \in \Omega} q_{ij}^{\frac{\sigma-1}{\sigma}} + e^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}}, \tag{13}$$

where q_{ij} denotes the quantity of good shipped region i to region j, σ is the elasticity of substitution between any two varieties, and L_t denotes the labor force in region j at time t, hence β_1 and β_2 denote the strength of contemporaneous and past agglomeration spillovers respectively. As a result, this gives the price index P_{it}.

Production. Production is characterised by a static optimisation problem that can be solved for equilibrium wages and prices given the supply of labour available in each locality period of time t. In each location a continuum of firms indexed by h produce a unique variety under perfect competition and constant returns to scale with the following production function,

$$q_{it}(h) = \bar{A}_{it} L_{it}^{\alpha_1} L_{i,t-1}^{\alpha_2} \times l_{it}(h) \tag{14}$$

where l_{it} denotes the amount of labor used by h, $\bar{A}_{it}$ is an exogenous level of productivity, and L_{it} denotes the total population in region i at time t. α_1 and α_2 denote the strength of contemporaneous and historical agglomeration spillovers respectively. The firms take $L_{i,t-1}$ and L_{it} as exogenously given. Each period the whole labor force produces the variety of region i, hence $\int l_{it}(h)dh = L_{it}$. Moreover, since there is perfect competition, $w_i = \frac{p_{it}}{A_{it}}$.

Trade. The framework described above is amenable to incorporating both international and intranational trade. Trade between from region i to region j at time t is costly and takes the iceberg form. For one unit $q_{ij,t}$ to arrive in j $\tau_{ij,t}$ units of the good need to be shipped. Using he expenditure function, the demand function for $q_{ij,t}$, and the competitive price this gives the following gravity relationship for the trade-flow between i and j at time t,

$$X_{it} = \tau_{ij,t}^{1-\sigma} \left(\frac{w_{it}}{A_{it}} \right)^{1-\sigma} P_{jt}^{\sigma-1} w_{jt} L_{jt} \tag{15}$$

Proofs of existence and uniqueness of the equilibrium depends on symmetric bilateral transportation costs (but not migration costs). There it is assumed that $\tau_{ij,t} = \tau_{ji,t} = \frac{\tau_{ij,t}+\tau_{ji,t}}{2}$ throughout.

Migration. The young at time $t-1$ choose location in t in order to maximize utility. The utility of a particular location depends on the deterministic utility $V_{j,t}$ which depends on the productivity of location j and its access to other markets. In addition, there is an idiosyncratic component to preferences which enters multiplicatively and is assumed to be independent draws from a Frechet-distribution with shape parameter θ. Migration between two locations i and j is costly and given by μ_{ij}. Migration across between continents is assumed infinite, such that $\mu_{ie} = \mu_{ei} = \infty$ for all i in the Americas. Taken together, the utility gained from by moving from location i to j at time t is given by the following expression,

$$V_{ij,t} = \frac{V_{j,t}}{\mu_{ij,t}} \times \epsilon_{ij,t} \tag{16}$$

Each agent chooses the location that maximizes utility when young, hence $V_i = \max_{k \in \Omega}\{V_{ik}\}$. Using the properties of the Frechet distribution and the fact that the ϵ are independent, the expected utility of a young person before he knows the realization of the shock is given by,

$$\mathbb{E}\left[V_{i,t}\right] = \left(\sum_{i \in R} \left(\frac{V_{j,t}}{\mu_{ij,t}}\right)^{\theta}\right)^{\frac{1}{\theta}}, \tag{17}$$

Again using the properties of the Frechet distribution gives the following gravity relationship of migration flows between i and j,

$$L_{ij,t} = \mu_{ij,t}^{-\mu} \Pi_{i,t}^{-\theta} L_{i,t-1} V_{j,t}^{\theta}, \tag{18}$$

where $\Pi_{i,t}$ is the expected expected utility if for people born in region i. This equation gives the law of motion of population flows in the model.

Equilibrium and Steady-State. A geography is a sequence of variables that are assumed exogenous in the model, $G_t = \{\bar{A}_{i,t}, \bar{u}_{i,t}, \tau_i, \mu_i, L_{i,0}\}_{i \in \Omega}$ where τ_i and μ_i are vectors of dimension $|\Omega| \times 1$. Given a geography an equilibrium is defined as a sequence of the endogenous variables such that all markets clear at each time t. In particular, an equilibrium is a sequence $E_t = \{L_{i,t}, w_{i,t}, V_{i,t}, \Pi_{i,t}\}_{i \in \Omega}$ such that in each region total sales equals the payment to labor, trade is balanced, the total population equals the population arriving at a location, and the total population equals the number of people exiting a location. As shown in the Appendix, this corresponds to the below equation system.

Definition 1 *(Equilibrium) An equilibrium given a geography G_t, is a sequence $E_t = \{L_{it}, w_{it}, V_{it}, \Pi_{it}\}_{i \in \Omega}$ such that,*

1. $w_{it}^{\sigma} L_{it}^{1-\alpha(\sigma-1)} = \sum_{i \in \Omega} K_{ijt} L_{jt}^{\alpha_1(\sigma-1)} V^{1-\sigma} w_{jt}^{1-\sigma}$,

2. $w_{it}^{1-\sigma} L_{it}^{\beta_1(1-\sigma)} V^{\sigma-1} = \sum_{i\in\Omega} K_{jit} L_{jt}^{\alpha_1(\sigma-1)} w_{jt}^{1-\sigma}$,

3. $L_{it} V_{it}^{-\theta} = \sum_{i\in\Omega} \mu_{jit} Pi_{jt}^{-\theta} L_{jt-1}$,

4. $L_{it-1} = \sum_{i\in\Omega} \mu_{ijt}^{-\theta} \Pi^{-\theta} L_{it-1} V_{jt}^{\theta}$,

where $K_{ijt} = \left(\frac{\tau_{ij}}{\bar{A}_{it} L_{it-1}^{\alpha_2} \bar{u}_{jt} L_{jt-1}^{\beta_2}} \right)^{1-\sigma}$.

In this economy, one can define the steady-state given a geography as the allocation that the economy converges to in the long-run. Moreover, the economy exhibits path dependence, if the long-run steady state of the economy depends on initial conditions. In terms of the notation used in the model, this can be defined in the following manner.

Definition 2 *(Steady-state and Path Dependence) A steady state given a geography* $\{G_t\}_{t\in K}$*, is a sequence* $\{E_t\}_{t\in K}$ *such that* $\{E_t\} = E^*$ *for all t. The economy exhibits path dependence if there exists geographies* $\{G_0\}$ *and* $\{G_0'\}$ *such that* $E^*(G_0) \neq E^*(G_0')$.

Allen and Donaldson (2018) and Allen, Arkolakis and Li (2015) show the parameter space under existence and uniqueness of the equilibrium holds.[34] If this holds in the current context is an empirical question. The next section structurally estimates the model, and shows that the conditions of uniqueness of equilibrium holds in the current context. The model can not be solved in closed form. In order to solve it the equilibrium conditions are combined to reduce the dimensionality of the problem and the solved numerically.[35]

[34] In particular, Allen and Donaldson (2018) show that in this class of models, existence and uniqness is guaranteed by the spectral norm of **B** being less than one. In with the paramters in the baseline model the spectral norm equals 0.97, where **B** is given by the following expression,

$$\mathbf{B} = \begin{bmatrix} \frac{\theta(1+\alpha_1\sigma+\beta_1(\sigma-1))-(\sigma-1)}{\sigma+\theta(1+(1-\sigma)\alpha_1-\beta_1\sigma)} & \frac{(\sigma-1)(\alpha_1+1)}{\sigma+\theta(1+(1-\sigma)\alpha_1-\beta_1\sigma)} \\ \frac{\theta}{(\sigma+\theta(1+(1-\sigma)\alpha_1-\beta_1\sigma))\tilde{\sigma}} & \frac{\theta(1-(\sigma-1)\alpha_1-\beta_1\sigma)}{\sigma+\theta(1+(1-\sigma)\alpha_1-\beta_1\sigma)} \end{bmatrix}. \tag{19}$$

[35] In particular, the $4 \times R$ equations are combined into R equations that are only functions of the indirect utilities in each location. This is done by exploting results in Allen and Arkolakis (2014) that shows that the destination and origin fixed effects are proportional. As a result, the wage can be eliminated from the equation system. The resulting equilibrium condition is homogenous in labor, and therefore does not pin down the population size, however, this is backed out from the data. The following equation is solved numerically

$$V_i^{\tilde{\sigma}\sigma} L_i^{\gamma_1} = \sum_{s\in\Omega} \tau_{ij}^{1-\sigma} \bar{A}^{(\sigma-1)\tilde{\sigma}} \bar{u}_i^{\tilde{\sigma}} \bar{u}_j^{(\sigma-1)\tilde{\sigma}} \bar{A}_j^{\sigma\tilde{\sigma}} L_{i,t-1}^{\gamma_2} L_{j,t-1}^{\gamma_3} V_j^{(1-\sigma)\tilde{\sigma}} L_j^{\gamma_4} \tag{20}$$

where $\gamma_1 = \tilde{\sigma}(1-\alpha_1(\sigma-1)-\beta_1\sigma)$, $\gamma_2 = \tilde{\sigma}(\alpha_2(\sigma-1)+\beta_2\sigma)$, $\gamma_3 = \tilde{\sigma}(\alpha_2\sigma+\beta_2(\sigma-1))$, $\gamma_4 = \tilde{\sigma}(1+\alpha_1\sigma+\beta_1(\sigma-1))$, and finally $L_i = V_i^{-\theta} \sum_{s\in\Omega} \left(\sum_{k\in\Omega} \mu_{sk}^{-\theta} V_k^{\theta} \right)^{-1} L_{s,t-1}$.

6.2 Parameter Estimation and Identification

In order to quantify the effect of opening trans-Atlantic trade the parameters of the model are estimated using the changes in trade costs induced by the reform. To fasciliate estimating and solving the model, it is calculated on a smaller grid of 1075 cells. There are six parameters, $\{\sigma, \theta, \alpha_1, \alpha_2, \beta_1, \beta_2\}$, as well as $|\Omega|$ geographic fundamentals and local amenities, $\{\bar{A}_{it}, \bar{u}_{it}\}_{i\in\Omega}$. The estimation proceeds in three steps. First, the trade costs and migration costs are calculated by estimating the gravity equation for trade and migration respectively. Second, given the trade and migration costs, the equilibrium conditions are inverted in order to back out the endogenous variables for which there is no data, $\{p_{it}^{\sigma-1}, P_{it}^{\sigma-1}, V_{it}^{\theta}, Pi_{it}^{\theta}\}_{i\in\Omega}$. Third, taking the logarithm of the definition of the endogenous productivity and amenity shocks, $A_{it} = \bar{A}_{it} L_{it}^{\alpha_1} L_{it}^{\alpha_2}$ and $u_{it} = \bar{u}_{it} L_{it}^{\beta_1} L_{it}^{\beta_2}$, and taking first differences, the parameters are estimated. Finally, the local amenities and fundamentals are calculated as the estimated residuals of the estimated model. The steps of this procedure and the underlying assumptions for identifying the parameters are elaborated upon below.

Step 1: Gravity Equations. To estimate the trade costs, it is assumed that the costs of shipping or migrating between two locations i and j is a function of the travel time, T_{ijt}. The cost of shipping is assumed to be given by $\tau_{ijt} = T_{ijt}^{\kappa}$ while the cost of migrating is $\mu_{ijt} = T_{ijt}^{\lambda}$. I ignore a time subscript here because I find very similar estimates of κ when I allow κ to be time-variant. Taking the natural logarithm of the gravity equation for trade and the migration (equations 10 and 12) and inserting τ_{ij} and μ_{ij} gives the following relationships,

$$ln(X_{it}) = \kappa(1-\sigma) ln(T_{ijt}) + ln\left(\frac{w_{it}}{A_{it}}\right)^{1-\sigma} + ln\left(P_{jt}^{\sigma-1} w_{jt} L_{jt}\right), \tag{21}$$

$$ln(L_{it}) = -\theta\lambda ln(T_{ij,t}) + ln\left(\Pi_{it}^{-\theta} L_{it-1}\right) + ln\left(V_{jt}^{\theta}\right), \tag{22}$$

where the last two terms in each regression are interpreted as origin and destination fixed effects respectively. The equations are estimated using OLS with standard errors clustered at the origin and destination pair. The results are given in Table 9. The table shows there is a strong relationship between travel time and trade volumes as well as migration. A one percent increase in the travel time reduces trade flows with 0.6 percent and migration with 2.5 percent. Using these estimates, a matrix of trade as well as migration costs can be calculated. These matrices will be used in the quantitative exercises as well as in backing out the remaining structural parameters of the model.

Step 2: Model Inversion. The equilibrium conditions are used to invert the model to solve for the endogenous variables given the data. Imputing data on the population size and wages as proxied by agricultural productivity, all the parameters as well as the exogenous amenity and productivity values are identified. The model is inverted in the following manner,

$$p_{it}^{\sigma-1} - \sum_{j\in\Omega} Y_{it} T_{ijt} \left(\frac{Y_{jt}}{Y_{it}}\right) P_{jt}^{\sigma-1} = 0 \tag{23}$$

$$P_{it}^{\sigma-1} - \sum_{j\in\Omega} T_{jit} \left(p_{jt}^{\sigma-1}\right)^{-1} = 0 \tag{24}$$

$$V_{it}^{-\theta} - \sum_{j\in\Omega} M_{jit} \left(\frac{L_{jt-1}}{L_{it}}\right) \Pi^{-\theta} = 0 \tag{25}$$

$$\Pi^{-\theta} - \sum_{j\in\Omega} M_{ijt} V_{jt}^{\theta} = 0 \tag{26}$$

Given $\{L_{it}, w_{it}\}_{i\in\Omega}$, this system uniquely solves for the endogenous variables $\{p_{it}^{\sigma-1}, P_{it}^{\sigma-1}, V_{it}^{\theta}, Pi_{it}^{\theta}\}_{i\in\Omega}$. The system is solved using population data, trade and migration costs for years before and after the reform, 1760 and 1800.

Step 3: Parameter Estimation. The functions more the amenity and productivity are used in order to identify the parameters of the model. First, taking the logarithm of these variables of the productivity term A_{it} gives the following expression,

$$ln(p_{it}^{\sigma-1}) = (\sigma-1)ln(\tilde{w}_i) + \alpha_1(1-\sigma)ln(L_{it}) + \alpha_2(1-\sigma)ln(L_{it-1}) + \epsilon_{it} \tag{27}$$

where $\tilde{w}_i$ is a proxy for the real wage of locality i such that $\tilde{w}_i = w_i + \psi_i$ and $\epsilon_{it} = (1-\sigma)ln(\bar{A}_{it})$. Since $\bar{A}_{it}$ is unobserved and is correlated with the population level through migration, the OLS estimator of Equation (27) does not identify the the structural parameters directly. I address this issue by using the change in shipping costs as an instrument for the population level (while conditioning on the lagged level). The core assumption here is that $\bar{A}_{it}$ is uncorrelated with ΔT_i in the population, $\mathbb{E}\left[\Delta T_i A_{it} | \tilde{w}_i, L_{it-1}\right] = 0$. While this assumption is untestable, the absence of pre-trends and the evidence provided in the reduced form provides support this assumption.

Next, taking the logarithm of the local amenity value u_{it} and taking first differences gives the following expression,

$$\Delta ln(V_{it}^{\theta}) = \theta \Delta ln(\tilde{w}_{it}) + \frac{\theta}{\sigma-1}\Delta ln(P_{it}^{(1-\sigma)}) + \beta_1\theta\Delta ln(L_{it}) + \beta_2\theta\Delta ln(L_{it-1}) + \theta\Delta\bar{u}_{it}. \tag{28}$$

Again, the explanatory variables are correlated with the unobservable error term $\bar{u}_{it}$ due to migration. Since this expression contains two endogenous variables, I take first-differences under the assumption that the utility derived from various geographical characteristics, $\bar{u}_{it}$, changes only very slowly, such that $\mathbb{E}\left[\Delta\bar{u}_{it}\right] = 0$. To address potential measurement error in the L_{it}, I instrument this variable with the change in shipping times also in this case. The identifying assumption, in this case, is that the change in shipping time is uncorrelated with measurement error in L_{it}.

Results. The estimated parameters are found in Table 10. The σ parameter is estimated to 2.45 while the migration elasticity θ is 11.9. These are both somewhat smaller than found in Allen and Donaldson (2018), but still within the set of common values found in the literature. The contemporaneous agglomeration spillover, α_1 is positive, meaning that there are positive externalities in co-location. The lagged agglomeration externality however is negative, meaning that there are productivity gains in locating in less densely settled areas. As one would expect, the lagged and contemporaneous amenity externalities, β_1 and β_1 are negative, meaning there are negative congestion costs of high population density. All point-estimates are statistically significant at conventional levels of statistical significance. Given these parameter values there is a unique equilibrium.[36] Table displays the parameter estimates used in the baseline models of the counterfactual exercises.

6.3 Model Fit

Table 3: Model Parameters

Productivity		Amenity	
σ (Elasticity of Subs.)	4.4	θ (Migration Elasticity)	3.5
α_1 (Contemp. Prod. Spillover)	0.2	β_1 (Contemp. Amenity Spillover)	-0.38
α_2 (Lagged Prod. Spillover)	0.02	β_2 (Lagged Amenity Spillover)	0.14

Note: The unit of analysis is at a 1°×1° grid-cell. The dependent variable is a dummy taking the value 1 if the grid-cell contains a city. The dataset is a balanced panel at a 20 year frequency for the period 1500-2000 for 4,777 grid cells. The dataset hence contains 6 × 4,777 = 28,662 observations. All specifications include grid-cell fixed-effects. Standard errors are clustered at the level of the closest port. $^{***}p < .01$, $^{**}p < .05$, *

To assess the performance of the theoretical framework, this section studies the evolution of the spatial distribution of economic activity predicted by the model and compares it to the population growth in the data. Since the future evolution of population density is not used to estimate the parameters of the model, this can be seen as a test of

[36] Uniquness is guaranteed by $\rho(\mathbf{B}) = 0.997$.

the model performance. In order to do this, the estimated parameter values are imposed on the model. Then the model is solved for the initial population distribution in 1760 and solved forward. The population distribution in 1810 implied by the model is then compared to the population in the data. As the population is highly persistent over time, both levels and changes are compared.

Table 7 displays the results of this exercise. The figures plot the population distribution on the predicted population distribution for each 50-year period from 1750 to 2000. For each year there is a strong correlation between the model output and the actual population distribution. As expected, the correlation is stronger for years closer to 1750 for which the model was solved. For later years the relationship becomes less precise but remains positive. For 1800 R^2 0.84 while it declines to around 0.4 for the 20th century. In sum, the model shows a high correlation with the data. For population growth the association is naturally weaker, however, it remains strong even after controlling for fixed effects and the controls used in the analysis. Unfortunately, the lack of high-resolution 18th-century spatial data prevents me from testing the model on most variables other than population. In the next section, the model is validated further by comparing it to the reduced form effects in the first part of the paper.

6.4 Counterfactuals

This section uses the model to conduct counterfactual exercises. Since there exists a unique general equilibrium in the model, the counterfactuals yield determinate predictions for the impact of the changes in the policy. The key object of interest is the population allocation under the scenario of changing trade costs, relative to the counterfactual of trade costs remaining constant. Throughout the section, L_t^G denotes the population allocation at time t with initial condition G assuming trade costs changed in accordance with the reform, while $\bar{L}_t^G$ denotes the case where shipping times remain fixed. The object of interest is therefore $\tilde{L}_t^G = \frac{L_t^G}{\bar{L}_t^G}$, the relative difference across the two scenarios. One period in the model, taken to represent one generation, is assumed to be 40 years.

Several counterfactuals are presented below. First, I show that the model replicated the four broad patterns of the reforms documented in the reduced form analysis. Second, I consider different opening dates. In particular, what would be the long-run impact of the Spanish Empire being incorporated in international trading networks earlier? The welfare effects of these different policy scenarios are then quantified.

The Impact of the Reform. The reduced form estimation of the impact of the reform does not take general equilibrium, or spillovers between different localities, into account. The

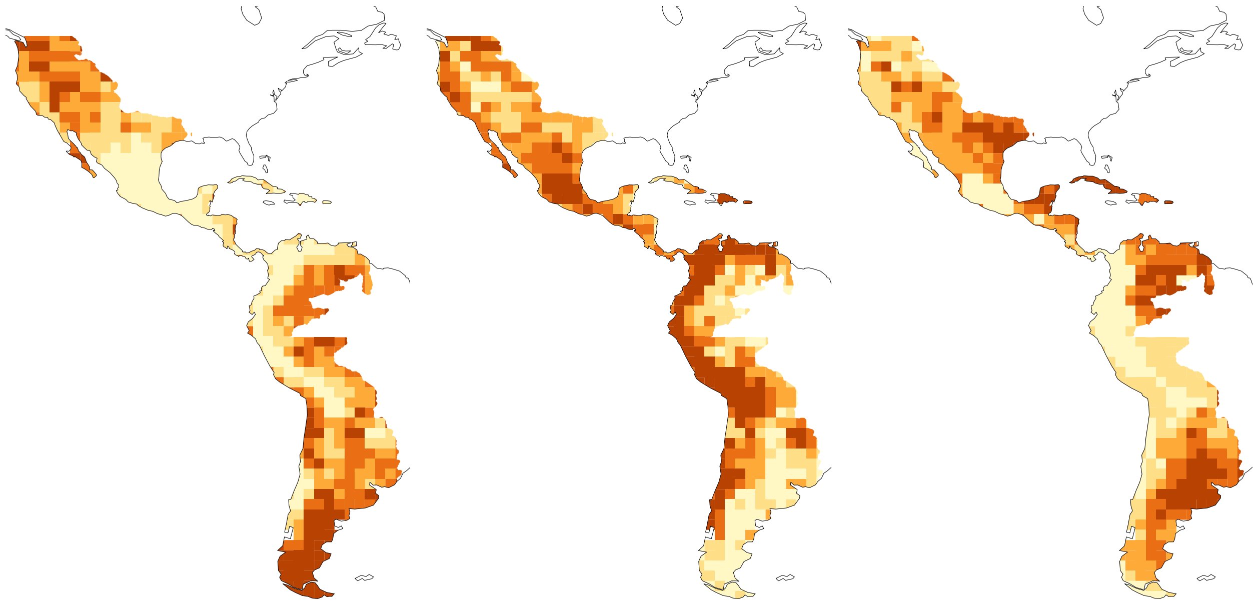

Figure 7: The figures show the results from the structural estimation. The left map shows the geographic fundamental productivity by grid-cell. This is the residual from Equation (19). The center map shows the amenity value for each grid-cell. This is the residual from Equation (20). The left map shows the change in population induced by the change in trade costs according to the model with the estimated parameters. In all the maps, warmer colors indicate higher values.

theoretical framework presented above explicitly models linkages between different cells working through endogenous trade and migration decisions. Starting out, the long-run impact of the policy is therefore simulated and compared to the reduced form. Two scenarios are considered. The model is solved for the population level in 1750 as the baseline, L_0, and then solved forward under two assumptions. First, the trade cost matrix remains constant this gives rise to the counterfactual population $\{L_i^c\}_{i\in\Omega}$ in the case where the population had not changed. Second, the baseline distribution is calculated under the baseline scenario, $\{L_i^b\}_{i\in\Omega}$, where the trade costs changed as they did in the data between 1750 and 1800. The object of interest is the ratio between the two, labeled $\tilde{L}$.

Qualitatively, the results from this exercise can be seen in the right-side map in Figure 7 which displays the distribution of $\tilde{L}$. In the map, warmer colors indicate a higher population density relative to what would have been achieved with constant trade-costs. Hence, it shows the regions that grow more as a result of opening trade. The figure shows that qualitatively the results are consistent with the reduced form evidence. Two types of places gained from the reduction in remoteness. First, places that gained in terms of market access grew more as a result of the policy. This is the case in Argentina, Venezuela, Chile, parts of Central America and southern Mexico. Increased market access makes these places become more attractive through cheaper imports. Quantitatively the result can be seen in Panel A of Table 4. A one standard deviation reduction in trade costs increases the relative population size of a grid-cell by 0.108 standard deviations. The effect is concentrated in coastal areas as can be seen by the relative difference between the population size under the two scenarios that is declining in distance from the coastline.

Table 4: Main Counterfactual Exercises

	ΔT	Coast	Core	Pop.
Panel A: Initial Pop.				
1760:	0.108	-0.085	1.162	-0.047
1700:	0.128	-0.087	1.077	-0.063
1600:	0.104	-0.094	1.147	-0.065
Panel B: Opening year				
1700:	0.022	-0.067	-0.181	-0.066
1600:	0.026	-0.036	-0.118	-0.05
Panel C: Long-run				
1700:	0.091	0.105	-0.239	-0.128
1600:	0.047	-0.071	-0.007	-0.061

Note: The unit of analysis is at a 1°×1° grid-cell. The dependent variable is a dummy taking the value 1 if the grid-cell contains a city. The dataset is a balanced panel at a 20 year frequency for the period 1500-2000 for 4,777 grid cells. The dataset hence contains 6 *imes* 4,777 = 28,662 observations. All specifications include grid-cell fixed-effects. Standard errors are clustered at the level of the closest port. note***p $<$ .01, note**p $<$ .05, note*

The Role of Initial Conditions. Next, I assess the impact of initial conditions on the impact of the reform. In the model, while lower transportation costs tend to make coastal localities more attractive, higher population density and agglomeration economies in the hinterland will generally attenuate this effect. To assess the quantitative significance of this effect, the long-run impact of the change in trade costs are assessed with different initial conditions. First, the initial population distribution is set to 1700. Next, the distribution is set to 1600. For each simulation, the model is solved forward in order to give the implied population after the reform.

The results from this exercise are displayed in Panel A of Table 4. The first column shows that the impact of the reform is positive for all initial conditions. A one standard deviation reduction in the trade cost increases the relative population size by around 0.1 standard deviations. The effect is again attenuated by higher initial population density. Further, the model confirms that a more interior initial condition tends to reduce the responsiveness of the population distribution to changing trade costs. This can be seen from the tendency of the coastal population density to be more strongly affected by the trade cost shock, the lower the initial level of population. Does this conditional relationship of trade liberalization matter quantitatively in the current context? To assess this the welfare between the different scenarios is compared. The results from this exercise shows that a geography that is more responsive to increases in trading opportunities is beneficial in terms of welfare, although the effects are quantitatively small.

Earlier Opening to Trans-Atlantic Trade. What would be the effect of opening trade with Europe earlier? To assess this in light of the model, alternative opening years are considered. The model is solved for opening at different points in time, and population levels of different grid-cells are again compared in the two scenarios. The baseline is therefore again the scenario where the trade costs are changed in 1760. The resulting distribution of the population is then compared with opening in 1700 and 1600.

The results of this exercise can be seen in Panel B of Table 4. The ratio between the actual and counterfactual population density is standardized, hence the interpretation of the coefficient is therefore interpreted as how many standard deviations higher the population is in coastal areas in comparison to the hinterland. If trans-Atlantic trade had been opened already in 1700 there would have been a higher population density in coastal areas by the year 1800. Coastal areas only have 0.06 standard deviations higher population density on average as compared with the hinterland. As one shifts the opening date earlier in time, the effect is similar in magnitude. This effect is robust to changing the definition of what constitutes a coastal area. Taken together, this supports the view that low coastal population density partly is driven by the late opening of trans-Atlantic trade during the colonial era that has persisted until the present. However, an earlier opening of trade with Europe would again only have modest effects on welfare.

Long-run Effects. Finally, I solve the model 150 years forward in time and assess the role of initial conditions in determining the long-run steady state. For the baseline parameters, the long-run steady state is not unique. Therefore, changing initial conditions potentially have effects on the long-run steady-state.[37]. Again, I compare the effect of opening for trade in 1700 or 1600 relative to the baseline case which was opened in 1760.

The results can be seen in Panel C of Table 4. In both cases, it can be seen that the direct impact of the trade costs is larger the earlier trade opened. This is consistent with the long-run impact of the trade cost shock being mediated through agglomeration economics. However, the impact on coastal population density appears more ambiguous. Opening for trade with the 1600 population distribution leads to a higher coastal population

[37] This follows from the fact that $\rho(\alpha_1 + \alpha_2, \beta_1 + \beta_2) > 1$.

density, while the opposite is true for the 1700 population distribution. The effect is again smaller for grid-cells with higher initial population density and smaller in the core areas. Taken together, the results show that the long-run impact of trade cost shocks is highly contingent on initial conditions.

6.5 Robustness Checks

Alternative Spillover Parameters. tba

Changes in coastal amenity values. While the baseline estimates account for fixed differences in amenity values across localities, it remains a possibility that there were changes in coastal amenity values during this period that can rationalize the above findings.

Secular change in productivities. The assumption in the baseline simulations that all variables other than trade costs are constant after the reform is unlikely to be realistic. . . .

Secular change in trade costs. Another quantity which we might expect to undergo secular change over the simulation period is trade-costs. If international trade continues to grow in line with the recent historical trajectory, this might be expected to favour coastal regions with easy access to international ports. I therefore simulate the model assuming that international. . .

Secular change migration costs. Finally, ...

7 Conclusion

This paper uses the abrupt opening of Trans-Atlantic trade within the Spanish Empire to study the impact of maritime trade on economic geography in the long-run. I calculate the changes in travel times to Europe induced by a reorganization of the maritime communication in the wake of the Bourbon reforms in the 18th century. Using a difference-in-difference research design that relies on comparing areas within the same region that differentially reduced its maritime remoteness due to the policy, I estimate the impact of lower remoteness on the location of cities and economic development in the long-run. I find a statistically and economically significant positive effect on urbanization associated with reduced travel time to Europe. Moreover, the opening of Atlantic communication is associated with a changing role of coastal access. While not being predictive of the founding of new cities before the opening of trade, they are highly predictive in the following centuries. To assess the aggregate impact and conduct counterfactual simulations, the calculated changes in remoteness are used to estimate the parameters of a dynamic spatial general equilibrium model. Consistent with the reduced form evidence, the model shows that the late opening of the Trans-Atlantic trade reduced the coastal population concentration, but less so in sparsely populated the colonial periphery. Moreover, I find that the effect is contingent on initial conditions. Lower levels of population density facilitated the geographic reorientation towards coastal areas. Finally, I show that this matters for welfare in the long-run, in the context of the model. Taken together, the findings of this paper show that in the very long-run, international trade has a larger effect on the spatial distribution of the population if the economy is less developed as it opens for international trade.

Poor access to coastal areas is often promoted as an obstacle to economic development, Coatsworth (1978). This paper argues that differences in coastal development, and as a result access to maritime trade, can in part be attributed to institutional differences as maritime trade was opened in the late 18th century. As a result, only in places were coastal reorientation happened does the economic geography reflect reliance on maritime trade. The findings of this paper support the view that places that achieves high population density before they open to seaborne trade are less concentrated in coastal areas. As coastal population density is important for economic prosperity this is a case of path inefficiency and a disadvantage of early economic development. The findings have several policy implications. The emphasis on developing hinterland cities and regions in many developing countries could be misguided, as these areas could be on different development paths given the different sequencing in achieving high population density versus opening to trade.

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