

# Trade Costs and the First Wave of Globalization

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## Abstract

We study the international integration of goods markets at the bilateral level between 1870 and 1913. We illustrate how a general equilibrium model of trade with trade costs due to Novy (2005) can be used to derive a composite measure of barriers to trade at the bilateral country level. The change in this measure over time and its cross-sectional variation is then examined. We break a large set of determinants of trade costs into four main categories: geographic, political, transportation/communications and institutional/cultural. We then use these factors to explain trade costs at the bilateral level. We find that all of these factors play a role in explaining the dispersion of trade costs. Transportation costs and other factors related to proximity seem to explain the largest fraction of the variance in trade costs. Membership in the British Empire and a shared language are also of great importance. Tariffs, and increased exchange rate regime coordination also play as large of a role as these latter factors.

## 1 Introduction

Trade costs are a key obstacle to international economic integration. In this paper, we study the evolution and the determinants of a new measure of international integration during the first wave of globalization from 1870 to 1913. We present a micro-founded multiple-country general equilibrium model of trade in differentiated products based on Novy (2005) that incorporates iceberg trade costs. These costs are broad and encompass not only shipping costs and tariffs but also many other informational, institutional and non-pecuniary barriers to trade. The model yields a gravity equation of international trade which we then use with trade and output data to compute implied bilateral “trade costs” *relative* to those in other markets. The outcome is a

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theoretically consistent measure which can then be aggregated at the country level to provide a measure of overall integration with the global economy.

The magnitudes of estimated trade costs exhibit considerable variation over time and space. Our findings suggest that the average level of trade costs fell by no more than 10 percent in the forty years before World War I in our baseline calculations. Country pairs like France and the UK and the US and UK have flat or slightly rising measures of trade costs. These countries did not become relatively more integrated after 1870.

We also argue that trade costs were very important in determining the overall level of international trade. Trade costs declined at a rate of about 0.2 percent per year for the average country pair. These changes do not seem dramatic when compared to the fact that export growth outpaced output growth by about two percentage points per year between 1870 and 1913. Nevertheless, after accounting for economic expansion, declines in trade costs explain the remaining one third of the observed trade boom. Such a large impact of small changes in trade costs is quite possible under plausible assumptions about the structure of the global economy, namely, the way consumers substitute between home and foreign goods as recently emphasized by Obstfeld and Rogoff (2001). The novel interpretation of late nineteenth century global economic integration is that changes in overall trade costs were small. The roughly two percent annual decline in freight indexes between 1870 and 1913 investigated by Shah Mohammed and Williamson (2003), and Harley (1988) before them, gives a misleading indication as to the evolution of total trade costs. Many other factors determined the level of integration.<sup>1</sup> Nevertheless, the corollary is that a large rise in trade could still have occurred due to small changes in overall trade costs.

In terms of levels, trade costs are relatively high in 1870. At the median they are equivalent to a tariff on the FOB price of 90 percent. At the same time, their values (again in tariff equivalents) range between 28 percent to nearly 228 percent. In 1913, the median tariff equivalent had decreased slightly to 76 percent, and the bottom and top end fell somewhat to 25 percent and 199 percent. The aggregate movements mask interesting changes to trade costs at the bilateral level and amongst various countries. We present some evidence on these measures,

and point out that our model has the capability to track integration at the bilateral level and at the national level in a theoretically more appealing way than simply looking at simple trade shares.

After examining these levels and trends, we turn to the determinants of bilateral integration. Again, conventional wisdom is that transportation improvements were a key driver of the increase in international integration prior to 1913. But recent work by Jacks (2005) on nineteenth century commodity markets has shown that falling trade costs were driven by factors such as monetary regimes and trade policy rather than technological factors affecting shipping costs. Estevadeordal, Frantz and Taylor (2003), Flandreau and Maurel (2001), and López-Córdova and Meissner (2003) looked at bilateral trade flows between 1870 and 1913 and found that monetary regime coordination as well as cultural and political factors played a very important role in explaining trade patterns. We seek to expand on these studies by looking at ways these and many other factors mattered for the evolution of the bilateral integration measure derived from a micro-founded model of trade.

Many factors including shipping costs, geographic constraints, institutions and cultural links, and policies explain the dispersion of trade costs in the cross section in the late nineteenth century. Our evidence also suggests proximity was the most important in explaining the variation in the data amongst all of our various determinants of integration. Secular reductions in maritime shipping costs and the generalized diffusion of the railroad decreased the wedge of distance so that other factors increased their relative importance in driving integration in the years just prior to 1913. Also, shared and inherited institutions that were bestowed upon Latin American colonies do not lead to lower trade costs amongst them while shared language and membership in the British Empire increased integration. These two latter factors seem to be as important as tariffs and exchange rate policy in affecting the size of trade costs.

## **2 Current Perspectives on Trade Costs**

Trade costs could simply be defined as the costs of transaction and transport associated with the exchange of goods. But for all the simplicity of this definition, economists still have a limited

understanding of their nature. Specifically, what determines the levels of trade costs as well as their evolution through time is subject to much debate. However, the topic is experiencing a new round of inquiry as trade economists grapple with the inability of much of the standard theory in predicting the direction and size of trade (cf. Treffer, 1995; Davis and Weinstein, 2003).

In one of the earliest contributions to this literature, Hummels (2001) attempts to measure trade costs indirectly by first presenting information on international freight and tariff rates and, then, estimating the technological relationship between freight rates and distance. From this basis, he is able to back out the level of trade costs implied by trade barrier proxies found in the empirical literature. Hummels concludes that the tariff-equivalent trade cost estimates derived from this method—coming up in the range of 100 to 200 percent—are "implausibly large" (p. 13).

However, Anderson and van Wincoop (2004) present a comprehensive survey on trade costs and argue that the representative tariff equivalent of trade costs might be as much as 170 percent for a typical developed country, corresponding to iceberg trade costs of roughly 74 percent. Additionally, they note that the trade costs faced by developing countries are significantly larger, suggesting that trade costs could have important implications for economic growth.

More generally, why we care about trade costs is a relatively straightforward matter: they directly bear on a host of issues in international trade, finance, and macro. Baier and Bergstrand (2001), for one, demonstrate the importance of trade costs in explaining post-World War II international integration while Brainard (1997) and Markusen and Venables (2000) provide a key role for trade costs in foreign direct investment decisions. Furthermore, Obstfeld and Rogoff (2000) clearly place trade costs at the heart of the "major puzzles" of international macroeconomics. Clearly, as Anderson and van Wincoop (2004) succinctly express it, "trade costs matter" (p. 691).

### 3 Historical Perspectives on Trade Costs

Economic historians generally concede that the fifty years before World War I was an earlier period of globalization akin to our own. The body of work by Kevin O'Rourke, Jeffrey Williamson, and others has directed the attention of economists and historians alike back to this time of unprecedented—and in many respects, unsurpassed—integration of global commodity, capital, and labor markets (O'Rourke and Williamson, 1999). Historical accounts, as well as popular conceptions of trade in the years from 1870 to 1913, have generally stressed the singular role played by developments in transportation and communication technologies in conquering time and space. In this account, it is the extension of the railroad and telegraph networks which take pride of place in promoting economic integration domestically and in helping move goods to ports for sale on international markets. The increased use of steam ships—along with the telegraph—in the maritime industry plays a similar role with respect to international markets (see James, 2001, pp. 10-13). Accordingly, O'Rourke and Williamson write that the "impressive increase in commodity market integration in the Atlantic economy [of] the late nineteenth century" was a consequence of "sharply declining transport costs" (1999, p. 33). Shah Mohammed and Williamson (2003) note a fall in a real sea freight rate index between 1870 and 1913 from 122 to 75. They also remark that European and periphery tariffs rose substantially after 1870. They go on to reason that if integration in 1913 was historically unprecedented that this must have been due to declining transportation costs on land and at sea.

At the same time, some recent research suggests an equally strong role for developments outside the communication and transportation sectors. Jacks (2005) offers evidence that, at least for the nineteenth century, freight costs can only explain a relatively modest fraction of observed commodity price differentials and, thus, trade costs. Jacks concludes that trade costs were also powerfully influenced by exchange rate stability or the choice of monetary regime and, of course, commercial policy as well as the diplomatic environment in which trade took place. Likewise, in examining bilateral trade flows, Estevadeordal, Frantz and Taylor (2003), Flandreau and Maurel (2001), and López-Córdova and Meissner (2003) found that monetary regime coordination as well as cultural and political factors played a very important role in

explaining global trade patterns.

A contemporary study of the penetration into the British Empire of non-Empire goods was conducted and published in 1897. This report, a survey of colonial governors, illustrates that the factors driving trade patterns might be boiled down into technological, informational and institutional factors (Trade of the British Empire and Foreign Competition 1897). A fourth category includes the variety and quality of goods. Within these broad categories it is obvious that to determine total trade costs it is infinitely more complex than adding together an ad valorem tariff value and shipping costs. Shipping costs alone varied by good, season and with local economic conditions. The Governor of the colony of Victoria in Australia hesitated to even give an average of the freight costs from Europe due to such fluctuations. The diffusion of the steamship was no simple affair either as such a mode of transportation favored certain classes of goods while sail ships, still in heavy use as late as 1894, favored others. Add to this government subsidies and on several key liners traveling between East Asia and Europe and any single cost index based on only several commodities and routes is bound to be problematic for any particular market. Moving on from shipping, various governors from Canada and back to the Straits Settlements noted how differential marketing techniques, proximity, information about local tastes and needs, quality, appearance of goods exchange rate stability and even the precise weights and measures used in the marketing process helped determine trade flows.

In as much as trade costs determine trade flows, all of these factors must have some bearing on the spatial and temporal variation of trade costs. Thus, apart from estimating trade costs for the period from 1870 to 1913, this paper will make a first cut at explicitly decomposing trade costs along the lines of geography, proximity, transport, monetary standards and trade policy, and political and cultural linkages.

## **4 International Trade in General Equilibrium with Trade Costs**

Even given the complexity of tracking down direct measures of trade costs, one additional problem exists. One can only judge how costly trade is with reference to the costs of alternatives. Anderson and van Wincoop (2003) have forcefully made the point that the true impact of

bilateral trade barriers can only be identified when compared to trade barriers with all other partners. Trade patterns are homogeneous of degree zero with a uniform change in trade costs. Moreover, trade costs relative to those with other trading partners matter. Suppose that shipping costs fell by ten percent on the dollar between two partners. This might not necessarily lead to more integration if a trade treaty with another set of trade partners decreased tariffs by 20 percent per dollar of imports. In this example, trade integration might actually decrease in the first pair while it should increase in the second pair. Studying particular components of trade costs can tell us little about patterns of integration and could be highly misleading. We therefore proceed to show how to develop an indicator of bilateral integration that takes these relative forces into account. Once it is developed, we will be able to use it to infer which types of factors drove bilateral integration and which ones, if any, washed out at the bilateral level but affected all international trade.

The aim of the model (based on Novy 2005) developed in the following pages is to give rise to a gravity equation that explicitly incorporates trade costs. The model developed below is a general equilibrium model with monopolistic competition in goods differentiated by the country of origin. Many papers have developed gravity models of trade and some of the them have even focussed on trade in general equilibrium. Explicit examples are Baier and Bergstrand (2001) who study how increasing returns, transport costs, tariffs and imperfect substitutability across destination markets give rise to a gravity model of trade with trade costs, economic size and price indexes as arguments. Anderson and van Wincoop (2003) also derive a gravity model of trade based on conditional general equilibrium and featuring iceberg costs of trade. Like Baier and Bergstrand their model generates a rather complicated gravity model that is a function of inherently unobservable price indexes. The benefit of the Anderson and van Wincoop model is that it demonstrates how the impact of a bilateral barrier to trade varies depending on its relation average or “multilateral” protection. In a similar vein, Eaton and Kortum (2002) develop a Ricardian model with stochastic technological differences. Their model gives rise to a gravity model of trade extremely similar to that of Anderson and van Wincoop’s conditional general equilibrium model of goods differentiated by place of origin. We show how to derive

an intuitive gravity model that eliminates the price index terms in Anderson and van Wincoop but allows for bilateral and multilateral resistance terms.

The model is a general equilibrium set-up with optimizing households and firms. There are  $J \geq 2$  countries with  $j = 1, 2, \dots, J$ . The range of all goods produced and of all households in the world is the continuum  $[0, 1]$ . Country  $j$  produces the goods range and comprises the household range  $[n_{j-1}, n_j]$ , where  $n_0 = 0$  and  $n_J = 1$ . The fraction  $s_j$  of goods is tradable so that  $[n_{j-1}, n_{j-1} + s_j(n_j - n_{j-1})]$  is the range of all tradable goods produced by country  $j$ . These can be purchased by all households in the world. The remaining range  $[n_{j-1} + s_j(n_j - n_{j-1}), n_j]$  represents country  $j$ 's nontradable goods. The latter are only available for purchase to country  $j$  households. As the central ingredient of this model there exist exogenous bilateral trade costs  $\tau_{j,k}$  that are incurred when goods are shipped from country  $j$  to country  $k$  and that are "iceberg" in form, i.e. shipping a good between two locations entails a proportional trade cost, where

$$\tau_{j,k} \begin{cases} \geq 0 & \text{for } j \neq k \\ = 0 & \text{for } j = k \end{cases}$$

Note that in general these bilateral trade costs can be asymmetric so that  $\tau_{j,k} \neq \tau_{k,j}$ .

#### 4.1 Households

All households within one country are identical. They like consumption and dislike work such that their utility can be described as

$$(1) \quad U_j = \ln C_j + \eta \ln(1 - h_j)$$

where  $C_j$  and  $h_j$  denote per-capita (i.e. per-household) consumption and labour input in country  $j$ . The parameter  $\eta$  is identical across countries.  $C_j$  is a CES composite consumption index defined as

$$(2) \quad C_j \equiv \left( \sum_{k=1}^J \int_{n_{k-1}}^{n_{k-1} + s_k(n_k - n_{k-1})} (c_{ji})^{\frac{\rho-1}{\rho}} di + \int_{n_{j-1} + s_j(n_j - n_{j-1})}^{n_j} (c_{ji})^{\frac{\rho-1}{\rho}} di \right)^{\frac{\rho}{\rho-1}}$$

where  $c_{ji}$  denotes the per-capita consumption of good  $i$  in country  $j$ . So the country  $j$  consumption index (2) is defined over all tradable goods produced in the world, which are given by the first term within the parentheses of (2), plus all nontradable goods produced by country



$j$ , which are given by the second term within the parentheses. The parameter  $\rho > 1$  is the elasticity of substitution and is identical across countries and varieties.

The consumption-based price index is defined as the minimum expenditure for one unit of  $C_j$  and can be derived as

$$(3) \quad P_j = \left( \sum_{k=1}^J \int_{n_{k-1}}^{n_{k-1} + s_k(n_k - n_{k-1})} (\xi_{ji})^{1-\rho} di + \int_{n_{j-1} + s_j(n_j - n_{j-1})}^{n_j} (\xi_{ji})^{1-\rho} di \right)^{\frac{1}{1-\rho}}$$

Here  $\xi_{ji}$  denotes the prices of the individual goods as follows

$$(4) \quad \xi_{ji} = \begin{cases} \left( \frac{1}{1-\tau_{k,j}} \right) p_k^T & \text{for } n_{k-1} \leq i \leq n_{k-1} + s_k(n_k - n_{k-1}) \quad \forall j, k \\ p_j^{NT} & \text{for } n_{j-1} + s_j(n_j - n_{j-1}) \leq i \leq n_j \end{cases}$$

All  $p$ 's are denominated in one world currency.  $p_j^{NT}$  is the price of all nontradable goods produced by country  $j$ . It is evident from (3) and (4) that higher trade costs  $\tau_{k,j}$  push up the price index.  $p_k^T$  denotes the f.o.b. price of all tradable goods produced by country  $k$  and  $\left( \frac{1}{1-\tau_{k,j}} \right) p_k^T$  is the c.i.f. price of the same goods when traded with country  $j$ . The c.i.f. price is  $\left( \frac{1}{1-\tau_{k,j}} \right)$  times the f.o.b. price since when one unit of a tradable good produced by country  $k$  is shipped to country  $j$ , only the fraction  $(1 - \tau_{k,j})$  arrives at the destination. Thus, the tariff equivalent of iceberg trade costs can be expressed as

$$(5) \quad \text{tariff equivalent from } k \text{ to } j = \left( \frac{1}{1 - \tau_{k,j}} \right) - 1$$

One can show that maximizing consumption (2) subject to the minimum expenditure (3) yields the individual demand function

$$(6) \quad c_{ji} = \left( \frac{\xi_{ji}}{P_j} \right)^{-\rho} C_j$$

Finally, the per-capita budget constraint in country  $j$  is given by

$$(7) \quad P_j C_j = W_j h_j + \pi_j$$

where  $\pi_j$  denotes the per-capita profits made by country  $j$  firms, which are fully redistributed to country  $j$  households.

## 4.2 Firms

There is monopolistic competition such that each firm is the single producer of one particular good and sets the profit-maximizing price. Not all firms within one country are symmetric since, say, in country  $j$ , the fraction  $s_j$  of firms produces tradable goods, whereas the fraction  $(1 - s_j)$  produces nontradable goods. Let  $y_j^T$  denote the tradable output produced by one country  $j$  firm and  $y_j^{NT}$  the nontradable output produced by one country  $j$  firm. In addition, let  $y_{j,k}^T$  be the tradable output produced for country  $k$  so that

$$(8) \quad y_j^T \equiv \sum_{k=1}^J y_{j,k}^T$$

All firms face a linear production function that has constant returns to scale and that operates with labour as the only input, i.e.

$$\begin{aligned} y_{j,k}^T &= A_j h_{j,k}^T \\ y_j^{NT} &= A_j h_j^{NT} \end{aligned}$$

where  $A_j$  is an exogenous and country-specific technology level that is the same across the tradable and nontradable sectors.  $h_{j,k}^T$  and  $h_j^{NT}$  denote the amount of labour used to produce  $y_{j,k}^T$  and  $y_j^{NT}$ , respectively, with  $h_j^T \equiv \sum_{k=1}^J h_{j,k}^T$ . Note that since all households within one country are identical, they each spread their labour over all firms according to how much labour input each firm needs. This means that in one country each household works for every domestic firm, but not for foreign firms since labour is assumed to be internationally immobile.

Clearing markets, it follows from the demand function (6) that

$$(9) \quad (1 - \tau_{j,k}) y_{j,k}^T = \left( \frac{\left( \frac{1}{1 - \tau_{j,k}} \right) p_j^T}{P_k} \right)^{-\rho} (n_k - n_{k-1}) C_k$$

The right-hand side of (9) represents how much of one good produced in country  $j$  the  $(n_k - n_{k-1})$  households in country  $k$  demand while the left-hand side is the amount that arrives in country  $k$  after being shipped there from country  $j$ . Accordingly, it follows for a nontradable good that

$$(10) \quad y_j^{NT} = \left( \frac{p_j^{NT}}{P_j} \right)^{-\rho} (n_j - n_{j-1}) C_j$$

Thus, all tradable firms within one country are symmetric and all nontradable firms within one country are symmetric.

The profit function for a tradable firm in country  $j$  is

$$(11) \quad \pi_j^T = \sum_{k=1}^J (p_j^T y_{j,k}^T - W_j h_{j,k}^T)$$

where  $W_j$  is the nominal wage that is assumed to be same in the tradable and nontradable sectors. Plugging (9) into (11) and maximizing with respect to  $p_j^T$  yields a price markup of

$$(12) \quad p_j^T = \frac{\rho}{\rho - 1} \frac{W_j}{A_j}$$

For nontradable firms the same procedure leads to a price markup of

$$(13) \quad p_j^{NT} = \frac{\rho}{\rho - 1} \frac{W_j}{A_j}$$

so that

$$(14) \quad p_j^T = p_j^{NT} \equiv p_j$$

Thus, all country  $j$  firms set the same price  $p_j$ , irrespective of whether they produce tradable or nontradable goods.

### 4.3 Solving the model

Each country  $j$  household maximizes utility (1) subject to the budget constraint (7), leading to the optimal labour supply condition

$$(15) \quad \frac{\eta}{1 - h_j} = \frac{W_j}{P_j C_j}$$

In order to further solve the model it is useful to define per-capita output, labour supply and profits as

$$\begin{aligned} y_j &\equiv s_j y_j^T + (1 - s_j) y_j^{NT} \\ h_j &\equiv s_j h_j^T + (1 - s_j) h_j^{NT} \\ \pi_j &\equiv s_j \pi_j^T + (1 - s_j) \pi_j^{NT} \end{aligned}$$

It follows

$$\pi_j = p_j y_j - W_j h_j$$

Combined with (15) this yields the optimal per-capita labour supply

$$(16) \quad h_j = \frac{\rho - 1}{\rho - 1 + \rho\eta}$$

It can be shown that the real wage, consumption and real profits are given by

$$(17) \quad \frac{W_j}{P_j} = \frac{\rho - 1}{\rho} \theta_j^{\frac{1}{\rho-1}}$$

$$(18) \quad C_j = h_j \theta_j^{\frac{1}{\rho-1}}$$

$$(19) \quad \frac{\pi_j}{P_j} = \frac{h_j}{\rho} \theta_j^{\frac{1}{\rho-1}}$$

where  $\theta_j$  is a highly nonlinear expression consisting of exogenous variables and parameters

$$(20) \quad \theta_j \equiv \left( \sum_{k=1}^J s_k (n_k - n_{k-1}) (1 - \tau_{k,j})^{\rho-1} A_k^{\rho-1} \left( \frac{\theta_j s_j}{\theta_k s_k} \left( \frac{A_j (1 - \tau_{j,k})}{A_k (1 - \tau_{k,j})} \right)^{\rho-1} \right)^{\frac{\rho-1}{2\rho-1}} \right) + (1 - s_j) \left( (n_j - n_{j-1}) A_j^{\rho-1} \right)$$

The explicit solution to  $\theta$  is the solution to a system of polynomial equations. Numerically it can be shown that a unique solution exists for any given combination of admissible exogenous parameters.

#### 4.4 A gravity equation with trade costs

This subsection presents the gravity equations that arise from the theoretical model. This simplified gravity equation is then used in Section 5 to generate bilateral trade costs for the period from 1870 to 1913.

All goods that are exported from country  $j$  to country  $k$  are

$$EXP_{j,k} = s_j (n_j - n_{j-1}) y_{j,k}^T$$

since  $s_j (n_j - n_{j-1})$  is the number of country  $j$  firms producing tradable goods. Novy (2005) shows that using the market-clearing condition (9), the price markup (12), the real wage (17)

and the expression for consumption in (18), one can derive a gravity equation that explicitly incorporates trade costs

$$(21) \quad EXP_{j,k} = (s_j)^{\frac{\rho-1}{2\rho-1}} (s_k)^{\frac{\rho}{2\rho-1}} (1 - \tau_{j,k})^{\frac{(\rho-1)^2}{2\rho-1}} (1 - \tau_{k,j})^{\frac{\rho(\rho-1)}{2\rho-1}} \\ (GDP_j - EXP_j)^{\frac{\rho}{2\rho-1}} (GDP_k - EXP_k)^{\frac{\rho-1}{2\rho-1}} \left( \frac{POP_k}{POP_j} \right)^{\frac{1}{2\rho-1}}$$

where

$$\begin{aligned} EXP_{j,k} &= \text{real exports from } j \text{ to } k \\ EXP_j &\equiv \sum_{k \neq j} EXP_{j,k} \\ GDP_j &= \text{real GDP of country } j \\ POP_j &= \text{population of country } j \end{aligned}$$

The intuition about the gravity equation (21) is in line with intuition from the standard gravity equation literature. The expression  $(GDP_k - EXP_k)$  can be interpreted as domestic absorption in country  $k$ . The more individuals consume domestically, the more they also want to consume of foreign goods so that exports  $EXP_{j,k}$  from  $j$  to  $k$  go up. Note that the technology levels  $A_j$  or  $A_k$  do not show up in (21). They are implicit in the export and GDP variables.

Moreover, trade increases in the tradables shares  $s_j$  and  $s_k$ , whereas it is diminished by higher trade costs  $\tau_{j,k}$  and  $\tau_{k,j}$ . As a special feature of this model, relative population is a determinant of trade.<sup>2</sup> If the population in country  $k$  rises relative to country  $j$  while GDP in each country remains the same, this means that productivity in country  $k$  has declined relative to country  $j$  simply because more people produce the same amount of goods. Via the price markup (12) this translates into a higher relative price for country  $k$  goods and therefore into more demand for exports from  $j$  to  $k$ .

Gravity equation (21) also captures what Anderson and van Wincoop (2003) call multilateral resistance. The intuition is that the level of exports from  $j$  to market  $k$  can be affected by trade barriers between  $k$  and third markets besides  $j$ . Imagine that all else being equal the trade barrier  $\tau_{kl}$ ,  $l \neq j$ , goes up. Exports from  $k$  to  $l$ ,  $EXP_{kl}$ , drop but exports  $EXP_{jk}$  increase. Since the total export terms in (21) capture other trade barriers, they can be referred to as multilateral resistance variables. Intuitively, if trade with a third country is hampered because

of higher trade costs, then some of that trade will be shifted to other partners and the relative cost of trading there will decline.

By symmetry, one can derive a gravity equation for  $EXP_{k,j}$ . With two such equations it becomes possible to solve for trade costs as

$$(22) \quad \tau_{j,k} = 1 - \frac{(EXP_{k,j})^{\frac{\rho}{\rho-1}} \left(\frac{POP_k}{POP_j}\right)^{\frac{1}{\rho-1}}}{(EXP_{j,k})(GDP_k - EXP_k)^{\frac{1}{\rho-1}} (s_j)^{\frac{1}{\rho-1}}}$$

$$(23) \quad \tau_{k,j} = 1 - \frac{(EXP_{j,k})^{\frac{\rho}{\rho-1}} \left(\frac{POP_j}{POP_k}\right)^{\frac{1}{\rho-1}}}{(EXP_{k,j})(GDP_j - EXP_j)^{\frac{1}{\rho-1}} (s_k)^{\frac{1}{\rho-1}}}$$

Equations (22) and (23) show that bilateral trade costs between two countries can differ depending on the direction of trade. For example, suppose that initially all variables in countries  $j$  and  $k$  are symmetric ( $EXP_{jk} = EXP_{k,j}$ ,  $POP_j = POP_k$  etc.). It follows that  $\tau_{jk} = \tau_{k,j}$ . Then assume that country  $k$  absorption ( $GDP_k - EXP_k$ ) increases, all else being equal, resulting in a higher  $\tau_{jk}$  such that  $\tau_{j,k} > \tau_{k,j}$ . Intuitively, if country  $k$  can afford more absorption without simultaneously consuming more goods from  $j$ , this means that trade costs  $\tau_{jk}$  from  $j$  to  $k$  must have gone up. But  $\tau_{k,j}$  remains unaffected since country  $j$ 's ability to absorb has not changed.

Unfortunately, computing asymmetric trade costs on the basis of (22) and (23) yields fairly volatile time series of trade costs, mainly because of high frequency variation in the balance of trade. Therefore, in Section 5 bilateral trade costs are computed with two additional simplifying assumptions. The first is that trade costs are symmetric for a given country pair so that  $\tau_{j,k} = \tau_{k,j}$ . The second assumption is that the fraction of tradable goods produced is the same across all countries so that  $s_j = s_k = s$ . (22) and (23) can then be simplified to the gravity equation

$$(24) \quad \tau_{j,k} = \tau_{k,j} = 1 - \left( \frac{EXP_{j,k} EXP_{k,j}}{(GDP_j - EXP_j)(GDP_k - EXP_k) s^2} \right)^{\frac{1}{2\rho-2}}.$$

To see this, take the product,  $(1 - \tau_{k,j})(1 - \tau_{jk})$ , and use the imposed symmetry to arrive at (24). We use equation (24) as a basis to compute trade costs for as many dyads as possible between 1870 and 1913.

## 4.5 Allowing for trade imbalances

Most countries run trade deficits or surpluses. These trade imbalances often persist for some time until rebalancing is required. For example Australia and Canada ran persistent current account deficits during our period of study (see Bayoumi, 1989 for analysis). In order to find out how trade imbalances affect our conclusions so far we incorporate them into the model. Our conclusion is that trade imbalances wash out when the focus is on total trade and symmetric trade costs.

The per-capita budget constraint (7) is generalized to

$$(25) \quad P_j C_j + \sum_{l=1}^J T_{j,l} = W_j h_j + \pi_j$$

where  $T_{j,l}$  are nominal per-capita transfers from country  $j$  to country  $l$ . As an accounting identity it follows

$$(n_j - n_{j-1})T_{j,l} = -(n_k - n_{k-1})T_{l,j}$$

For analytical convenience it is now assumed that per-capita transfers are a fraction of per-capita consumption spending

$$T_{j,l} = \beta_{j,l} P_j C_j$$

with  $\beta_{j,j} = 0$  for all  $j$  such that the budget constraint (25) can be rewritten as

$$(26) \quad (1 + \sum_{l=1}^J \beta_{j,l}) P_j C_j = W_j h_j + \pi_j$$

If  $\sum_{k=1}^J \beta_{j,l} > 0$ , then  $j$  runs a trade surplus and, thus, is a creditor country.

Appendix B outlines the derivation of the following expressions. The optimal labour supply condition (15) becomes

$$(27) \quad \frac{\eta}{1 - h_j} = \frac{W_j}{(1 + \sum_{l=1}^J \beta_{j,l}) P_j C_j}$$

and consumption follows as

$$(28) \quad C_j = h_j \theta_j^{\frac{1}{\rho-1}} (1 + \sum_{l=1}^J \beta_{j,l})^{-1}$$

The markups (12)-(14), per-capita output (16), real wages (17) and real profits (19) are not affected. If  $j$  runs a surplus, this reduces its per-capita consumption  $C_j^3$ . Intuitively, due to log utility in (1), output  $h_j$  is constant. If  $j$  transfers some of its produced wealth to other countries, then its consumption must fall.

Now use the notation

$$\sum_{l=1}^J \beta_{j,l} = \frac{CA_j}{CONS_j}$$

where

$$CA_j = \text{nominal current account of } j$$

$$CONS_j = \text{nominal consumption of } j$$

The gravity equations corresponding to (22) and (23) become

$$(29) \quad \tau_{j,k} = 1 - \frac{(EXP_{k,j})^{\frac{\rho}{\rho-1}} \left(\frac{POP_k}{POP_j}\right)^{\frac{1}{\rho-1}} \left(1 + \frac{CA_j}{CONS_j}\right)}{(EXP_{j,k})(GDP_k - EXP_k)^{\frac{1}{\rho-1}} (s_j)^{\frac{1}{\rho-1}} \left(1 + \frac{CA_k}{CONS_k}\right)}$$

$$(30) \quad \tau_{k,j} = 1 - \frac{(EXP_{j,k})^{\frac{\rho}{\rho-1}} \left(\frac{POP_j}{POP_k}\right)^{\frac{1}{\rho-1}} \left(1 + \frac{CA_k}{CONS_k}\right)}{(EXP_{k,j})(GDP_j - EXP_j)^{\frac{1}{\rho-1}} (s_k)^{\frac{1}{\rho-1}} \left(1 + \frac{CA_j}{CONS_j}\right)}$$

For example, suppose that initially both  $j$  and  $k$  have a balanced current account ( $CA_j = CA_k = 0$ ). If  $j$  now becomes a surplus country ( $CA_j > 0$ ) all else being equal, then  $\tau_{j,k}$  drops whereas  $\tau_{k,j}$  increases. Intuitively, country  $j$  would not run a surplus unless trade costs shifted into directions favorable for exports from  $j$  to  $k$  and disadvantageous for imports from  $k$  to  $j$ . Observe that equation (24), which is the one used for the computations in Section 5, is *not* affected by introducing trade imbalances. Assuming symmetry cancels out bilateral imbalances and shifts the focus to total trade flows relative to total bilateral absorption which are more likely to be driven by long-run fundamentals than transitory imbalances.

In order to understand the model's implications for *bilateral* trade imbalances it is useful to look at the ratio  $V_{j,k}$  of nominal exports between  $j$  and  $k$

$$V_{j,k} \equiv \frac{p_j EXP_{j,k}}{p_k EXP_{k,j}} = \frac{1 + \frac{CA_j}{CONS_j}}{1 + \frac{CA_k}{CONS_k}}$$



What matters for the ratio  $V_{j,k}$  is whether the two countries each run a deficit or a surplus *in total*. In other words, even if  $j$  transfers money to  $k$  ( $T_{j,k} > 0$ , which might seem like a surplus for  $j$ ), it can still be the case that  $k$  is a net exporter to  $j$  ( $V_{j,k} < 1$ ). As this example shows, a country runs either a surplus or a deficit against *all* its trading partners, regardless of the monetary flows from individual trading partners. Financial flows, thus, do not necessarily match trade flows.

## 5 Patterns in the Trade Cost Estimates

### 5.1 Data and Methods

In this section, we provide an overview of trends in trade costs from 1870 to 1913. Before proceeding directly to these patterns, however, a few words should be reserved for how the trade cost estimates are derived. We make use of the trade cost expression given in (24) and combine this with data on the level of exports and GDP for a large number of countries—see Table 1 below for the countries included in the sample. Roughly speaking, the sample countries accounted for over 70 percent of world GDP and trade in 1913. The GDP data was taken from Maddison (1995) while the trade data was taken from Barbieri (1996) and López-Córdova and Meissner (2003). For the trade data, we generally used the value of exports from each country in the pair. However, Barbieri’s data set is not complete and leaves out colonial dependencies and a number of other observations. When data was missing we relied on the data set from López-Córdova and Meissner (2003) which reports the sum of exports and imports by country pair. To approximate the product of exports, we divided the sum by two and then squared the quotient. We realize that this may impart some biases in estimated trade costs, but robustness checks which allow for heterogeneity and such data problems give us an indication that the problems are not of first-order importance. We also note that the entire sample is unbalanced and somewhat at the mercy of the availability of Maddison’s GDP data which is more plentiful in certain benchmark years. We use as much data as possible but end up with an unbalanced panel that bulges in particular years. By including time dummies and country indicators and conditioning on a host of variables we believe that sample selection and measurement error

issues are kept to a minimum.

For the reported results, the fraction of tradable goods produced ( $s$ ) was set to 0.8 while the elasticity of substitution ( $\rho$ ) was set to eleven. When the elasticity of substitution is set equal to eleven this corresponds to a ten percent markup over marginal cost.<sup>4</sup> Typical estimates in the contemporary literature range between five and twelve as noted in Anderson and van Wincoop (2004). In an appendix below, we present the results of a robustness check on derived trade costs for different values of  $s$  and  $\rho$ . The percentage change in trade costs is quite stable for believable parameters. More importantly, assuming (as is standard) homogeneity of cross-country preferences, the values of the parameters have no bearing on the relative magnitudes of trade costs between observations, so that patterns in cross-sectional and temporal variation in trade costs should be preserved no matter what values are used. Since we are mainly interested in explaining the cross-sectional and time-series variation in trade costs and trade, our results would seem fairly robust to alternative assumptions about  $\rho$ .

As for the trade costs themselves, Figure 3 presents the global index of trade costs for the period. Although subject to some variation most likely associated with the business cycle, the general trajectory is clear: trade costs on average fell by nearly ten percent from 1870 to 1913. Section 6 is dedicated to explaining this drop. In what follows, we will also make a distinction between trade costs across and within regions. Figures 4 through 6 trace the development of trade costs across the regions of the European core and periphery, North and South America, Asia, and Oceania. These figures plot the unweighted average of trade costs by region when one country in the pair is in the given region and the other is not.

Most regions clearly enjoyed lower trade costs at the end of the period. It also appears that the entirety of Europe and the entirety of the Americas shared common trade conditions as the patterns for the European core and periphery and for North and South America exhibit a good deal of synchronization. This is clearly not the case for Asia and Oceania. Indeed, Oceania (which includes observations for Australia and New Zealand) seems to have been on a trajectory far removed from that of the rest of the world since its trade costs seem to rise in the middle of the period. This could be due to federation in Australia in 1901 which ultimately

eliminated internal tariffs and was associated with higher external tariffs. These diversionary effects can be quite strong as Irwin (2006) has shown.

Considering the development of trade costs within the same regions as in Figures 7 through 9, a few observations are in order. First, the common cycles detected in Figures 2a and 2b are no longer apparent. Indeed it is hard to even talk of a common trend in these series as the European core tended to exhibit an *upward* trend in trade costs while trade costs increased significantly within Oceania. However, the big winner here seems to have been Asia which posted a 25 percent decrease in its internal trade costs in the period.

We next consider a finer breakdown of trade costs in Tables 2 through 4. Table 2 shows the simple average and trade weighted averages of trade costs by country for four periods. The weights are the ratio of the product of exports from  $j$  to  $k$  and  $k$  to  $j$  to the total value of these products across observed trading partners. We also include the number of partner-year observations over which each average was taken so as to highlight that core countries are over-represented in our data set. From the table one readily observes trade costs in the range of 20 to 60 percent. These iceberg values would give rise to tariff equivalents of 25 to 150 percent. These levels are based on the assumption that  $\rho = 11$ , but observe that lower values would give rise to even higher estimated trade costs. Nevertheless, we are struck by the extreme similarity between this range and that reported in Anderson and van Wincoop's (2004) survey of recent literature where they report: "international trade barriers are in the range of 40–80 percent for a representative elasticity estimate (i.e.,  $\rho = 8$ )". It is worth remarking that the range seems to have declined somewhat over time however and this could be a further topic of long-run comparative research.

Table 2 also readily demonstrates that countries in the heart of northwestern Europe had the lowest average trade costs while remote countries in the periphery exhibit the highest trade costs. Australia and New Zealand, the 'antipodes,' possess very low trading costs despite being very remote markets. This is *prima facie* evidence for the importance of colonial preferences and cultural ties. Weighting matters here because most of their trade is with the United Kingdom.

Table 3 presents the lowest and highest trade cost partner for each of three benchmark

years. Overall, countries appear to have minimum trade costs with their nearest neighbors. This suggests a major component of trade costs is shipping costs, although shared policies and institutions could also be playing a role here too. A few countries buck the trend and have very low trading costs with countries that are not so nearby. The UK frequently comes in as the lowest cost partner. This is so for Argentina, Australia, New Zealand, Canada, China and Japan in many of these years. This has to be taken as evidence that the tyranny of distance is often overstated. The development of trade networks and country-pair specific infrastructure (financial links, industrial links etc.) and colonial ties (real or quasi) manifest themselves strongly in such examples.

Table 4 studies the ten country pairs with the largest declines and increases in their trade costs over the period. Here we take the difference between the average value of  $\tau$  by country-pair in the period 1870 to 1879 and 1900 to 1913. Notably the opening up of Japan is quite visible in this table. Trade cost changes between the Empire of the Rising Sun and the US and the UK are two of the ten largest drops. Railroad development and the ability to market products in Mexico and Argentina appear to have led to some of the most significant falls in trade barriers as the Argentina-UK number and the Mexico-US numbers are  $-0.07$ . France and Italy's trade war of the 1880s and the long-shadow it cast on bilateral trade policy shows up with the pair having the second highest increase in trade costs. For that matter, the secular rise of protectionism throughout the end of the nineteenth century in France, Italy and even in Argentina and Brazil is apparent in the table. However, tariffs also rose in other countries like Germany, but it is a no-show in this table. This implies other factors were offsetting these rises. Blanket statements are dangerous here. Germany and Italy signed a trade treaty with reciprocal tariff reductions in 189. This could explain why this pair shows up with one of the largest decreases in trade costs.

Overall, more work at the country level is necessary to sort out the various channels by which trade costs rose or fell and to focus on the idiosyncrasies of the patterns. In future work we intend to look at the case of the US in detail. Such research will also be a test of the reliability of our composite trade costs measure. But to continue in realm of the aggregate, the

task at hand is to systematically analyze the various determinants of the observed trade costs in the pre-World War I period.

## 6 Empirical Results

Recently researchers have focused on transportation, communications, tariffs, national borders, and currency unions as determinants of trade costs. As Anderson and van Wincoop (2003) and Hummels (2001) illustrate, little consensus exists on the regularity conditions or the functional form that best describes trade costs. As our baseline, and following a the bulk of previous work, we consider a log-linear specification of iceberg trade costs of the following form

$$(31) \quad \tau_{jk} = Dist_{jk}^{\delta} \exp^{\beta_0 + \beta_1 A + \beta_2 B + \beta_3 C + \beta_4 D}$$

where  $\beta = [\beta_0, \beta_1, \beta_2, \beta_3, \beta_4]$  is a vector of coefficients that yields the percentage change in iceberg trade costs for a unit change in the determinants included in the vector  $X = [A, B, C, D]$ ,  $Dist_{jk}$  is the great circle distance between two countries' capitals and  $\delta$  is the elasticity of iceberg trade costs with respect to distance. This implies the following estimating equation

$$(32) \quad \ln(\tau_{jkt}) = \beta_0 + \delta \ln(Dist_{jk}) + \beta_1 A_{jkt} + \beta_2 B_{jkt} + \beta_3 C_{jkt} + \beta_4 D_{jkt} + \varepsilon_{jk} + \varepsilon_{jkt}$$

where we now subscript for year  $t$  and allow for a random effects error composite in order to pool the year-by-year data as a panel. In various specifications we allow for country fixed effects or country-pair fixed effects, check the functional form and use the tariff rather than the iceberg trade cost as the dependent variable.

In the following systematic look at the determinants of trade costs, we break potential determinants into four classes: Policies ( $A$ ), including trade policy and exchange rate regime coordination; Geography ( $B$ ), which should interact with technological advances in shipping over time but which could also reflect the fact that information is more abundant at closer proximity; Institutions and Cultural Heritage ( $C$ ), which also lower information costs and legal non-tariff

barriers to trade; And finally Shipping Costs ( $D$ ) directly associated with the penetration of the railroad and as a function of navigable waterways within a country.

Since the idea that exchange rate regimes are intimately related to trade costs is perhaps the most novel we note previous work by López-Córdova and Meissner (2003), Estevadeordal, Frantz, and Taylor (2003) and Flandreau and Maurel (2001). All suggest that coordination on the gold standard helped reduce the transaction costs of trade. This is backed up techniques comparable to contemporary work along the lines of Rose (2000), Glick and Rose (2002) and Klein and Shambaugh (forthcoming). All of these provide consistent empirical evidence that exchange rate pegs are associated with significantly higher trade volumes.

In Table 5 we report three separate regression specifications of equation (32). The first column is a random effects specification. Column 2 and 2a report models with country fixed effects that are interacted with decadal indicators. This controls for unobservables at the country level that affect all trading partners in each of four periods. Column 2a standardizes all variables to have a mean zero and standard deviation of one so that the relative impact of each regressor on the dependent variable can be gauged appropriately. In column 3 and 3a we replace the country effects with non-time-varying country-pair fixed effects.

### **Policies: Tariff Revenue and Exchange Rate Regimes**

In the full sample, tariffs appear to be associated with higher trade costs.<sup>5</sup> Using the point estimate from column 2a of Table 5, a one standard deviation increase in the log product of tariffs would yield only a tenth of a standard deviation increase in the log of trade costs or a two percent increase in bilateral trade costs. This is so whether we pool the data or use country fixed effects. With country-pair fixed effects the effect is larger at 0.20. In the decade-by-decade samples of Table 6, tariffs seem only to deter trade in the 1880s and 1890s but in none of the periods are the coefficients statistically significant. Tariffs are self-evidently a trade cost. However, our measure is loaded with measurement problems which might make for the downward bias in the decadal regressions.

Adherence to the gold standard also appears to be consistently negatively related to trade costs. Statistical significance also varies by decade, perhaps due to small sample problems or

changing sample composition. A lower bound for the impact of adoption of the gold standard is a roughly three percent decline in trade costs. The economic significance of this similar to the impact of tariffs. (i.e., a one standard deviation increase in the measure is associated with a 0.06 standard deviation decrease of the dependent variable). Credible exchange rate stability seems to improve trade as previous work has shown.

Interestingly exchange rate volatility (measured as the standard deviation of the log change in the trade weighted nominal monthly exchange rate) itself seems to have a mixed impact on trade costs. We see that mild exchange rate volatility (defined as that lying in the 25th to 90th percentile and being equal to 0.2 and 2.5 percent) has a decrease on trade costs relative to pairs that have very low nominal exchange rate volatility. High volatility (that above the 90th percentile with a maximum of 15 percent) seems to have no statistically significant impact on trade costs compared to dyads that experience low volatility, but the point estimate is actually negative. The explanation lies in the fact that many of the observations are associated with Japanese paper money depreciation in the late 1880s and an Italian depreciation in midst of a severe financial crisis in the early 1890s. These ostensibly expansionary depreciations no doubt allow for greater integration in the short-run until the real-exchange rate can fully adjust to its equilibrium level. Many dyads with high volatility also include Brazil. We see a large nominal appreciation in the first five years of the twentieth century as the country recovers from a decade of economic crisis that culminated in a significant default on foreign debt in 1898.

The coefficient on monetary unions is negative in column 2 but it is not statistically significant. Previous studies by López Córdova and Meissner (2003) and Flandreau and Maurel (2001) have argued that monetary unions may have decreased trade costs, but they have not controlled for as many factors that affect trade costs. Doing so severely limits the number of observations compared to previous studies. In the 1870s there are only eleven out of 95 observations which share a common currency. Key pairs that include Norway in the Scandinavian Monetary Union, Belgium and Switzerland in the Latin Monetary Union are missing due to missing tariff data or trade data.

## **Geography & Trade Costs**

The role of the several geographic factors we control for seems mixed. We find no overwhelming evidence in column 1 of Table 5 that technological change affected the way geography mattered (n.b. we deal with distance below). Still, nations further apart seem to have higher trade costs. In column 2 there is a significant change in the parameters and it is downward. The coefficient on distance is quite high early on and its standardized coefficient is extremely large. These coefficients fall over the period. The interpretation is that after controlling for multilateral effects marginal increases in distance had less of a negative impact on integration compared to the early years of the period. Distance mattered less and less.

In the decade after 1870, it appears that island nations had lower trade costs than others. These country pairs (i.e., those involving the UK, Japan, and Australia but not New Zealand since information on waterways was not available) would tend to use ocean-going vessels to transport goods and their commercial centers would more likely be closer to major ports. When we allow for country fixed effects, the coefficient is large and implies a 30 percent reduction in trade costs when one country is an island and over double the effect if both are an island. Railroads in many peripheral countries were only coming online beyond the 1880s and so penetration into the hinterlands relied on more costly methods that might have involved transshipment from ocean vessels to canal ship and to railroads or horse-driven road transport. However, as the web of railroad networks expanded, the importance of such factors diminished. By the 1880s having one or two islands in the trade pair no longer has as large of an impact on trade costs as seen in its diminishing coefficient in Table 6.

Since many small countries share borders, it is little surprise that sharing a border seems to increase international integration. Sharing a border appears to be associated with a decrease in trade costs of about 16 percent (column 2 Table5). Notably the impact diminishes somewhat in size over time. We also see that countries with extensive coastlines in fact have higher trade costs in column 1.

The normalized size of the coastline appears to have a direct relationship to trade costs when country fixed effects are excluded. When we include these, the coefficient becomes negative and statistically significant. The change in sign is likely because of several outliers. The negative



coefficient implies that larger coastlines could contribute to a greater probability of having good port facilities and accessible markets which in turn enables trade.

### **Institutions and Shared Culture**

We also find mixed evidence for long-run shared institutional factors. It is not surprising that we find a negative coefficient on the indicator for membership in the British Empire. Although special privileges from the UK to the colonies had died out by this time, those implemented by the colonies themselves mattered. Moreover, third market effects on the margin seem to have made it relatively cheaper for Empire pairs to trade. Low political uncertainty and other shared institutions no doubt contributed to this effect. The small number of observations with a one here in the first two decades of the data most likely contributes to the positive coefficient in the 1870s and the statistically insignificant result in the 1880s. By the 1890s we see that membership in the British Empire is associated with trade costs that are lower by between 20 and 30 percent.

Having once shared the same mother country or still sharing the same colonial master however seems to be consistently associated with a large and statistically significant increase in trade costs. This variable no doubt proxies for inter-periphery trade and as such simply highlights the core-periphery and incipient core-core nature of international trade in the nineteenth century. To the extent that old colonies inherited similar institutional and legal technologies, there is no evidence that these factors were important for trade costs after controlling for other determinants. More precise measures would be appropriate here as newly established republics in South America for example followed extremely different paths of institutional change over the nineteenth century.

Finally there is little evidence for the persistence of special relationships between former colonial masters and their offshoots (e.g., Argentina and Spain or the UK and the US). The coefficient on the variable that controls for this is not statistically distinguishable from zero when controlling for country fixed effects or not.

Sharing a common language is also typically associated with much lower trade costs. In the pooled sample the decrease is on the order of a 12 percent drop in trade costs. Overall these

fixed factors and their large coefficients suggest that a substantial percentage of observed trade costs is accounted for by long-run cultural and historical factors that proxy for institutions and cultural heritage. We hesitate to take a strong stand on this yet as these could be proxies for elements that actually do drop the transaction costs of trade but it is quite possible these factors are proxies for similarities in tastes which we have assumed away in the model. More work along the lines of Rauch and Trindade (2002) would no doubt improve our understanding of these forces.

### **Technology and Transportation Costs**

The period we are looking at is widely regarded to be one of improved infrastructure and declining shipping costs. In our regressions we find evidence that transportation costs matter. As a matter of fact, we find a fairly significant role for the accumulation of railroad infrastructure. When we allow for country-specific factors, the beta coefficient increases to 0.20. In other words a one standard deviation increase in the total length of a dyad's railway network would have decreased trade costs by a minimum of one-fifth of a standard deviation. This impact is larger than either gold standard adherence or an increase in tariff revenues.

Distance between countries, as a crude proxy for transportation costs and possibly market information or familiarity, seems to matter less in economic terms over time when we allow for country-fixed factors. Not allowing for these controls suggests distance matters in a consistent way over the four decades we look at. The interactions of the logarithm of distance and indicators for the last three decades of the nineteenth century and the first 13 years of the twentieth century allow us to gauge whether distance grew less relevant over time or if decreases in shipping costs contributed to making distance less of an ingredient into overall trade costs. In column 1 we find no difference between the distance elasticity of trade costs in any of the sub-periods.<sup>6</sup> A formal test of the null hypothesis that all coefficients are the same in column 1 of Table 5 cannot reject the null.<sup>7</sup> Nevertheless, we can soundly reject such a hypothesis in column 2. Since this is a more general specification, we infer that declines in shipping costs due to improved productivity could have been responsible for a four-fold fall in the elasticity of trade costs with respect to distance.

Taking, 0.12 as the elasticity, the standardized coefficient for distance is measured as nearly 1.36. A one standard deviation increase in the distance between countries would be associated with a 1.3 standard deviation increase in trade costs. Distance also appears to be a large part of explaining the cross-sectional variation in trade costs. However, as time progresses its influence seems to decline relative to other factors. The spread of the steamship, productivity improvements and better information transmission are all likely to help explain this.

In Table 7 we also took a closer look at the relationship between trade costs and distance. The first question we asked was whether the distance elasticity might have been different at short, intermediate and long distances. To do this we interacted the distance measure with an indicator that was one if distance was less than 478 kilometers, between 478 and 5,377 kilometers and greater than 5,377 kilometers. We found no difference in the slope parameters for any of these categories even when controlling for fixed country factors. This suggests that the gains in shipping know-how applied equally to all countries and that there is little evidence of differential fixed costs that depend on shipping distances.

Finally we also wondered whether if there might have been increased regionalization rather than expansion of a truly global trading system. In other work, Novy has found that after 1960 trade costs seem to have fallen faster within regions than across regions. We estimate a difference-in-differences type equation of the following form

$$\begin{aligned} \ln(\tau_{ij1913}) - \ln(\tau_{ij1870}) &= \beta_1\{1 \cdot (478 \text{ km.} \leq \text{Distance}_{ij} < 5,377 \text{ km.})\} \\ &+ \beta_2\{1 \cdot (\text{Distance}_{ij} \geq 5,377 \text{ km.})\} + \varepsilon_i \end{aligned}$$

where 1 is an indicator function that is one when the expression is true and zero otherwise, and  $\varepsilon$  is a possibly heteroscedastic error term.

We find the following result (where standard errors of the coefficients are reported in parentheses beneath the coefficients)

$$\ln(\tau_{ij1913}) - \ln(\tau_{ij1870}) = \begin{array}{l} -0.02 \{1 \cdot (478 \text{ km.} \leq \text{Distance}_{ij} < 5,377 \text{ km.})\} \\ (0.05) \\ -0.11 \{1 \cdot (\text{Distance}_{ij} \geq 5,377 \text{ km.})\}. \\ (0.08) \end{array}$$

There seems to be no difference in the decline in trade costs between countries that were very close or at an intermediate distance. There is only weak evidence that costs declined faster for pairs that were very far apart compared to those that were close together. Here the point estimate is statistically significant at the 82 percent level of confidence. So in fact, while we might call the late twentieth century trade boom a series of regionalized globalizations, the late nineteenth century seems to be characterized by a process whereby very distant countries were brought into the global marketplace as least as quickly if not slightly faster than near neighbors. The vastly improved connections between western Europe and the Far East, Australasia, and South America are evident in the above regression but not in a decidedly strong way.

## 6.1 Sensitivity

Our baseline estimates provide suggestive results about the determinants of trade costs. Here we test the sensitivity of these results. Columns 3 and 4 of Table 7 makes the model additive in the arguments rather than multiplicative as in equation (32). The dependent variable is the level of trade costs. Qualitatively results are parallel to those in column 1 and 2 of Table 5. Column 5 uses the tariff equivalent as the dependent variable. Here coefficients are interpreted as the increase in the tax equivalent for a unit change in the explanatory variables. We see for example that sharing a gold standard was equivalent to a drop in tariffs of five percentage points and that being in the British Empire was worth a drop in tariffs of 37 percentage points. Other specifications and functional forms are possible along the lines of Hummels (2001). We view this as an interesting avenue for further research which should be coupled with realistic micro-founded models of trade costs.

## 6.2 A Gravity Approach

By looking at the log-linearization of our gravity equation we see that the factors that determine bilateral exports are the absorption factors, the logarithm of one minus iceberg trade costs and finally changes in the share of output attributable to tradable goods.

Specifically using equation (24) we have

(33)

$$\ln(EXP_{j,k}EXP_{k,j}) = (2\rho - 2) \ln(1 - \tau_{j,k}) + \ln(GDP_j - EXP_j) + \ln(GDP_k - EXP_k) + \ln(s_i) + \ln(s_j).$$

The equation is now estimable by OLS using information on exports, GDP, total exports, and the determinants of trade costs listed above. A few words on estimation of our gravity model are in order. First note that the absorption terms and the tradable share terms are time and country specific. One possible estimation strategy is to use year and country specific indicator variables. This avoids having to include the absorption terms which may be correlated with the error term and allows the tradable share to be estimated rather than imposed by assumption. Although providing unbiased estimates of the relevant coefficients using so many dummies is inefficient and in practice burns many degrees of freedom. It turns out that our data are too sparse to accommodate these demands, so we take three approaches. First we estimate the model with the observed absorption terms and time specific constants. This imposes the assumption that tradable shares are the same across countries. Next, we allow for country-specific indicators interacted with decade specific dummies, include the absorption terms and allow for time-specific intercepts to soak up changes in tradability. Finally, we drop the absorption terms and include country-specific indicators interacted with decadal dummies and time indicators.<sup>8</sup> Finally, we use a similar trade cost function as before but here the interpretation is that factors affect integration. Specifically we have

$$(34) \quad \ln(1 - \tau_{jkt}) = a_0 + a_1 \ln(Dist_{jk}) + a_2 Z_{jkt}.$$

Substituting equation (34) into (??) we can now proceed to estimation by OLS of our gravity equation. In doing so we shall recover reduced form coefficients on the trade cost determinants

that are equal to  $(2\rho - 2) a_n$ . We present both the reduced form coefficients and the structural coefficients. These are derived by dividing point estimates by  $(2\rho - 2)$  and assuming an elasticity of substitution  $\rho = 11$ .

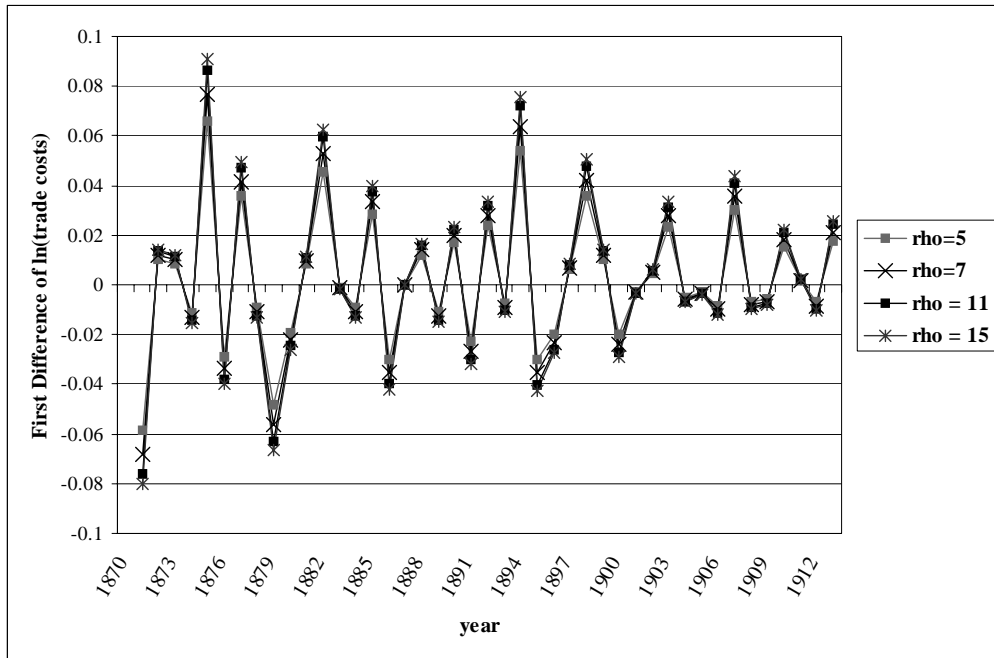
Table 8 presents the results of our gravity model estimations. Qualitatively speaking, our results on trade costs are very closely in line with our previous results. The reduced form implies that a doubling of effective distance decreases the product of trade by over 65 percent. Adherence to the gold standard is associated with an increase of over 100 percent, and the elasticity of trade flows with respect to the product of railroad mileage per square mile in partner countries is 0.27. All of these coefficients are precisely estimated. Lower elasticities of substitution would give correspondingly higher impacts on measured trade costs. We also see that by not including country-specific terms many of our elasticities seem to be biased downwards. This could be the case if measurement error was afflicting our control variables, although other possibilities are worth further investigation. Overall there is strong support for the gravity model and the estimated impact on trade costs on our key trade cost proxies we found earlier. By extension, our conclusions about the relative roles of transportation, tariff and commodity money regimes stand up to this alternative form of estimation.

## 7 Conclusions

We have studied the determination, patterns and evolution of trade costs between 1870 and 1913. The theoretical foundations for these estimates presents a new way to explain trade that is much simpler but just as rigorous as any model of international trade. The patterns we have found suggest that generalized trade costs did not decline dramatically after 1870 notwithstanding certain cases. Trade costs appear to be explained by geographic factors, policies, technology and infrastructure and tariff and non-tariff trade barriers. Over time however there is little evidence that improvements in transportation played a decreasingly key role in generating the late nineteenth century trade boom. Changes in the prevalence of monetary regime coordination, increases in tariffs also played a significant role in explaining trade patterns.

Appendix... to be done...

Figure 1: Sensitivity of Changes in Trade Costs to Elasticity, US-UK, 1870-1913



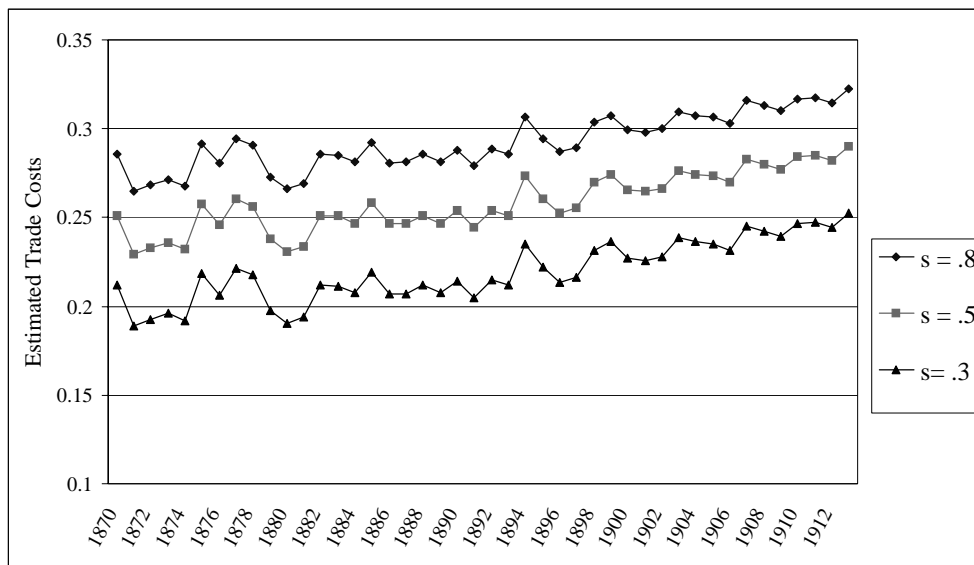
## Appendix C Sensitivity of Results to Assumptions

Our estimates of trade costs are somewhat sensitive to the assumed elasticity of substitution and the tradable shares. As mentioned the variance of the trade costs and the changes in trade costs are very stable with respect to perturbations in both the elasticities of substitution and the tradable shares. As such inference in our regression based tests is valid under almost any configuration of the parameters. The following two figures plot the evolution of the log change of trade costs for various values of the elasticity of substitution and tradable shares for the United States and the United Kingdom.

For elasticities of substitution above 10 trade costs appear to change nearly identically. When the elasticity is at 2 the level changes dramatically as does the level of the changes. For tradable shares we see slight variation in levels but little change in the first differences of trade costs for various values of tradable shares.



Figure 2: Sensitivity of Trade Costs to Tradable Share, US-UK 1870-1913



## Abridged Data Appendix

### **Bilateral Trade**

1870-1913: Bilateral trade comes from sources described in López Córdova and Meissner (2003). Trade was made into real values using US CPI deflators. Much of this data is based on datasets made available by Barbieri (1996) though many supplementary national sources were used.

### **GDP**

Numbers are from Maddison (1995).

### **Population**

1870-1913: Data come from López Córdova and Meissner (2003) supplemented by BR Mitchell's series of Historical Statistics for various regions.

**Land Area** This is measured as the logarithm of square kilometers.

1870-1913: López Córdova and Meissner (2003) which comes mainly from Stinnett, Tir, Schafer, Diehl, and Gochman (2002).

### **Bilateral Distance**

1870-1913: López Córdova and Meissner (2003) much of which is based on Rose (2001) and also supplemented by endo.com.

### **Shared Border Indicators**

1870-1913: López Córdova and Meissner (2003)

### **Landlocked Indicators**

1870-1913: López Córdova and Meissner (2003).

### **Island Indicator**

All years come from Rose (2003) and ocular inspection of basic maps.

### **Common Language**

1870-1913 López Córdova and Meissner (2003) and Rose (2001)

## Notes

<sup>1</sup>These numbers would suggest that shipping made up no more than 10 percent of total trade costs.

<sup>2</sup>Anderson (1979) points out that population is frequently used as a regressor in gravity equations although economic theory struggles to come up with a model that incorporates population. In contrast, the present model provides a theoretical underpinning for using population as a regressor.

<sup>3</sup>As shown in Appendix B,  $\theta_j$  is also affected by  $\sum_{l=1}^J \beta_{j,l}$  but this effect is weak compared to the direct effect of  $\sum_{l=1}^J \beta_{j,l}$  in (28).

<sup>4</sup>Irwin (2003) shows rough evidence of a 9.8 percent markup in American steel and pig iron products in the late nineteenth century.

<sup>5</sup>We measure tariffs as the total tariff revenue divided by total imports. This is not without the usual caveats.

<sup>6</sup>In the decade-by-decade regressions, one will notice that distance is estimated to be much smaller in size between 1870 and 1879 than in later decades. It is also statistically insignificant. Sample selection combined with collinearity between other controls is most likely to blame.

<sup>7</sup>The test yields a chi-squared statistic with 3 degrees of freedom of 4.19 and a p-value of 0.24.

<sup>8</sup>Anderson and van Wincoop (2004) suggested country-level intercepts and a trade cost function without GDP terms in a cross-sectional gravity model corresponding to their expenditure system.

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Table 1: Sample Countries, 1870-1913

Argentina	China	Mexico	Sweden
Australia	Colombia	Netherlands	Switzerland
Austria-Hungary	Denmark	New Zealand	Thailand (Siam)
Belgium	France	Norway	Turkey
Brazil	Germany	Peru	US
Bulgaria	Greece	Portugal	United Kingdom
Canada	Italy	Russia	Venezuela
Chile	Japan	Spain	

Table 2: Average Trade Costs By Country and Decade

<b>1870-1879</b>	Weighted	Unweighted	Partner-Years	<b>1880-1889</b>	Weighted	Un-weighted	Partner-Years
Netherlands	0.23	0.35	75	Netherlands	0.22	0.35	78
Australia	0.25	0.29	5	Australia	0.25	0.43	13
Belgium	0.27	0.36	80	Belgium	0.26	0.36	84
Germany	0.28	0.33	77	United Kingdom	0.27	0.31	91
United Kingdom	0.28	0.31	94	Germany	0.28	0.33	88
US	0.28	0.42	85	US	0.28	0.40	85
New Zealand	0.28	0.35	6	New Zealand	0.28	0.35	6
France	0.29	0.36	84	France	0.30	0.37	89
Canada	0.31	0.47	10	Canada	0.31	0.48	15
Denmark	0.32	0.41	53	Denmark	0.32	0.41	69
Brazil	0.32	0.43	5	Sweden	0.32	0.40	67
Sweden	0.33	0.41	75	Italy	0.35	0.43	67
Italy	0.33	0.44	68	Japan	0.45	0.53	34
Russia	0.33	0.47	11				
Switzerland	0.33	0.36	3	<b>1900-1913</b>	Weighted	Unweighted	Partner-Years
Argentina	0.35	0.34	3	Netherlands	0.23	0.37	180
Portugal	0.36	0.50	7	Australia	0.25	0.46	44
Spain	0.38	0.45	5	Austria-Hungary	0.27	0.47	38
China	0.41	0.55	7	Belgium	0.28	0.39	243
Mexico	0.45	0.45	2	New Zealand	0.28	0.46	24
Japan	0.52	0.52	3	Germany	0.30	0.34	249
Austria-Hungary	---	0.47	4	United Kingdom	0.30	0.35	258
				Argentina	0.30	0.39	154
<b>1890-1899</b>	Weighted	Unweighted	Partner-Years	Denmark	0.30	0.42	135
Switzerland	0.13	0.38	7	Canada	0.30	0.50	61
Netherlands	0.23	0.38	88	Switzerland	0.31	0.42	166
Australia	0.25	0.48	25	US	0.32	0.40	258
Brazil	0.27	0.38	8	Russia	0.32	0.46	35
Belgium	0.28	0.38	100	France	0.32	0.40	243
United Kingdom	0.29	0.32	104	Sweden	0.32	0.41	149
New Zealand	0.29	0.47	13	Norway	0.33	0.41	103
US	0.30	0.40	97	Chile	0.34	0.44	132
Germany	0.30	0.34	100	Brazil	0.35	0.41	150
Denmark	0.31	0.42	71	Italy	0.37	0.45	204
France	0.31	0.39	101	Mexico	0.37	0.49	97
Sweden	0.32	0.39	67	Spain	0.37	0.46	196
Canada	0.32	0.50	22	Turkey	0.38	0.44	13
Argentina	0.33	0.41	10	Peru	0.40	0.48	36
Russia	0.34	0.47	13	Portugal	0.40	0.49	34
Spain	0.34	0.47	14	Japan	0.41	0.51	149
Mexico	0.36	0.48	5	Venezuela	0.44	0.48	86
Portugal	0.38	0.46	12	Bulgaria	0.44	0.51	10
Italy	0.38	0.45	76	China	0.45	0.52	28
Japan	0.43	0.52	83	Colombia	0.45	0.52	18
China	0.44	0.53	9	Greece	0.46	0.51	12
Thailand	0.53	0.53	1	Thailand	0.49	0.53	11

Table reports averages of estimated trade costs by country. Weighted averages use the product of exports divided by the sum of the product of exports over all observed trading partners as weights. Averages (weighted and unweighted) are taken for all available observations in each decade of the sample. Missing values

Table 3: Minimum and Maximum Trade Cost Partners, 1870, 1890, 1910

1870 Country	Min.		Max.		1890 Country	Min.		Max.	
	Trade Cost	Partner	Trade Cost	Partner		Trade Cost	Partner	Trade Cost	Partner
Argentina (Arg)	0.33	FR	0.35	UK	Argentina	0.31	UK	0.50	Po
Australia (Austl)	0.22	NZ	0.52	China	Australia	0.26	UK	0.71	Ru
Austria-Hungary (AH)	0.36	Ital	0.59	Bel	Belgium	0.22	Neth	0.57	JP
Belgium (Bel)	0.26	Neth	0.59	AH	Brazil	0.27	US	0.51	It
Brazil (Br)	0.32	UK	0.61	It	Canada	0.31	UK	0.60	It
Canada(CA)	0.31	UK	0.70	China	China	0.43	UK	0.64	It
China	0.41	UK	0.70	CA	Denmark	0.28	Swd	0.63	JP
Denmark (Dmk)	0.32	Swd	0.47	Bel	France	0.28	Bel	0.50	CA
France (FR)	0.29	UK	0.53	China	Germany	0.23	Neth	0.49	JP
Germany (Ger)	0.26	Neth	0.54	Po	Italy	0.36	Ger	0.68	Mex
Italy (It)	0.33	CH	0.61	Br	Japan	0.44	UK	0.76	Swd
Japan (JP)	0.51	UK	0.52	US	Mexico	0.35	US	0.68	It
Mexico (Mex)	0.44	US	0.46	UK	Netherlands	0.22	Bel	0.67	JP
Netherlands (Neth)	0.26	Ger	0.48	US	New Zealand	0.28	UK	0.46	US
New Zealand (NZ)	0.22	Austl	0.54	US	Portugal	0.36	SP	0.71	JP
Portugal (Po)	0.35	UK	0.58	Bel	Russia	0.31	Ger	0.71	Austl
Russia (Ru)	0.32	Ger	0.62	China	Spain	0.33	FR	0.73	JP
Spain (SP)	0.38	UK	0.57	Ru	Sweden	0.28	Dmk	0.76	JP
Sweden (Swd)	0.32	Dmk	0.54	US	Thailand	0.53	UK	0.53	UK
Switzerland (CH)	0.30	FR	0.46	Bel	US	0.27	Br	0.58	Dmk
US	0.28	UK	0.56	Ru	UK	0.25	Neth	0.53	TH
United Kingdom (UK)	0.28	Neth.	0.51	JP					

Numbers reported are derived from trade costs derived as described in the text. The number of trading partners with observed data varies across countries.

Numbers reported are derived from trade costs derived as described in the text. The number of trading partners with observed data varies across countries.

1910 Country	Min.		Max.	
	Trade Cost	Partner	Trade Cost	Partner
Argentina	0.28	UK	0.48	NO
Australia	0.26	UK	0.53	Swd
Belgium	0.19	Neth	0.57	Ven (VE)
Brazil	0.30	UK	0.52	DMK
Canada	0.29	UK	0.58	VE
Chile	0.32	Ger	0.58	Swd
Denmark	0.30	Ger	0.63	JP
France	0.28	Bel	0.55	NZ
Germany	0.22	Neth	0.49	NZ
Italy	0.34	Ger	0.60	VE
Japan	0.41	UK	0.64	Mex
Mexico	0.37	US	0.64	JP
Netherlands	0.19	Bel	0.55	JP
New Zealand	0.26	UK	0.55	FR
Norway (NO)	0.32	Swd	0.60	JP
Spain	0.36	UK	0.61	JP
Sweden	0.32	Ger	0.64	VE
Switzerland	0.29	Ger	0.55	No
US	0.30	CA	0.50	Dmk
United Kingdom	0.26	Neth	0.44	VE
Venezuela (VE)	0.44	Neth	0.64	Swd

Numbers reported are derived from trade costs derived as described in the text. The number of trading partners with observed data varies across countries.



Table 4: Rising and Falling: The Top Ten

<b>Top 10 Drops</b>		<b>Change</b>	<b>Top 10 Increases</b>		<b>Change</b>
Italy	Brazil	-0.19	New Zealand	Australia	0.10
Germany	Italy	-0.13	France	Italy	0.07
Netherlands	US	-0.12	United Kingdom	US	0.04
US	Japan	-0.11	France	United Kingdom	0.04
United Kingdom	Japan	-0.10	France	Switzerland	0.03
Belgium	Brazil	-0.10	Denmark	Sweden	0.02
US	Sweden	-0.07	United Kingdom	Brazil	0.02
Argentina	United Kingdom	-0.07	Italy	Switzerland	0.02
Belgium	Spain	-0.07	Italy	United Kingdom	0.02
Mexico	US	-0.07	Argentina	France	0.02

Notes: Change refers to the difference between the pair average of trade costs. The averages are taken at the pair level between 1870 to 1879 and also 1910 to 1913. The difference between these two values is then presented. Pairs have uneven numbers of observations in each period and many of the possible country pairs do not have data in one or both periods. 53 country pairs out of the roughly 250 possible have at least one observation of trade costs in both periods and represent the sample for this statistic.

Table 5: The Determinants of Trade Costs, 1870-1913

Regressors by category	(1) Baseline	(2) Ctry FE	(2a) Ctry FE Std'zd	(3) Pair FE	(3a) Pair FE Std'zd
<b><u>POLICIES</u></b>					
In (product of <b>TARIFFS</b> )	0.02 [0.01]*	0.02 [0.01]	0.10 [0.07]	0.03 [0.02]*	0.17 [0.09]*
Both on <b>GOLD STANDARD</b>	-0.03 [0.01]***	-0.03 [0.01]***	-0.06 [0.02]***	-0.03 [0.01]**	-0.07 [0.03]**
Mild exchange rate volatility indicator	-0.01 [0.01]	-0.02 [0.01]***	-0.04 [0.02]***	-0.01 [0.01]	-0.03 [0.02]
Extreme exchange rate volatility	-0.01 [0.01]	-0.02 [0.01]	-0.03 [0.02]	-0.01 [0.01]	-0.01 [0.01]
Both in a <b>MONETARY UNION</b>	0.09 [0.05]*	-0.04 [0.06]	-0.04 [0.05]	---	---
<b><u>INFRASTRUCTURE</u></b>					
In (product of kms. of <b>WATERWAYS/AREA</b> in sq. kms)	-0.65 [0.56]	-0.15 [0.43]	-0.03 [0.10]	---	---
In (product of kms. of <b>RAILROAD TRACK/SQ. KM</b> )	-0.004 [0.002]**	-0.02 [0.01]**	-0.20 [0.08]**	-0.003 [0.001]*	-0.03 [0.02]*
<b><u>GEOGRAPHY</u></b>					
In ( <b>DISTANCE</b> ) x indicator for 1870-1879	0.09 [0.02]***	0.22 [0.07]***	1.92 [0.64]***	---	---
In ( <b>DISTANCE</b> ) x indicator for 1880-1889	0.09 [0.02]***	0.18 [0.04]***	1.76 [0.40]***	---	---
In ( <b>DISTANCE</b> ) x indicator for 1880-1899	0.09 [0.02]***	0.12 [0.03]***	1.36 [0.31]***	---	---
In ( <b>DISTANCE</b> ) x indicator for 1900-1913	0.08 [0.02]***	0.05 [0.03]*	0.75 [0.44]*	---	---
One country in pair is an <b>ISLAND</b>	-0.04 [0.04]	-0.36 [0.12]***	-0.61 [0.37]*	---	---
Both in pair are an <b>ISLAND</b>	-0.07 [0.07]	-0.68 [0.25]***	-0.39 [0.24]	---	---
Countries share a <b>BORDER</b>	-0.17 [0.04]***	-0.16 [0.04]***	-0.23 [0.06]***	---	---
In [prodcut of (1+ kms. of <b>COASTLINE</b> )/area in sq. kms]	0.31 [0.17]*	-0.22 [0.10]**	-0.10 [0.05]**	---	---
<b><u>INSTITUTIONS &amp; CULTURE</u></b>					
Both in pair had or have a common <b>COLONIZER</b>	0.26 [0.12]**	0.25 [0.08]***	0.11 [0.03]***	---	---
Both in pair share a <b>COMMON LANGUAGE</b>	-0.16 [0.05]***	-0.12 [0.04]***	-0.14 [0.05]***	---	---
One in pair was a <b>COLONY</b> of the other prior to 1870	-0.05 [0.10]	0.03 [0.05]	0.02 [0.05]	---	---
Both in the <b>BRITISH EMPIRE</b> or UK and a British Colony	-0.34 [0.13]***	-0.23 [0.08]***	-0.10 [0.03]***	---	---
Constant	-1.39 [0.19]***	---	---	-0.94 [0.07]***	0.35 [0.08]***
Observations	1928	1928	1928	1744	1928
Country-Pair Fixed Effects	no	<b>no</b>	<b>no</b>	<b>yes</b>	<b>yes</b>
Country Fixed Effects	no	<b>yes</b>	<b>yes</b>	<b>no</b>	<b>no</b>
R-Squared	0.38	0.99	0.83	0.15	0.14

Notes: Dependent variable is the natural logarithm of trade costs. Year indicators are included but not reported. Estimation is by "random effects" or OLS with heteroscedasticity and serial correlation robust standard errors. Column 2 uses country fixed effects. Column 3 uses country pair fixed effects. See the text for descriptions of the variables. \* significant at the 10% level; \*\* significant at the 5% level; \*\*\* significant at the 1% level.

Table 6: The Determinants of Trade Costs by Decade, 1870-1913

Regressors by category	(1) 1870-1879	(2) 1880-1889	(3) 1890-1899	(4) 1900-1913
<b><u>POLICIES</u></b>				
ln (product of <b>TARIFFS</b> )	-0.02 [0.02]	0.02 [0.04]	0.02 [0.02]	-0.01 [0.01]
Both on <b>GOLD STANDARD</b>	-0.04 [0.02]**	0.02 [0.04]	-0.01 [0.02]	-0.07 [0.01]***
Mild exchange rate volatility indicator	0.01 [0.01]	-0.01 [0.01]	0.01 [0.01]	-0.00 [0.01]
Extreme exchange rate volatility	0.04 [0.02]*	0.00 [0.01]	0.05 [0.03]	-0.03 [0.01]**
Both in a <b>MONETARY UNION</b>	-0.10 [0.06]*	0.13 [0.06]**	0.16 [0.02]***	0.09 [0.04]**
<b><u>INFRASTRUCTURE</u></b>				
ln (product of kms. of <b>WATERWAYS/AREA</b> in sq. kms)	-1.38 [0.75]*	0.39 [0.80]	-0.11 [0.56]	-1.11 [0.66]*
ln (product of kms. of <b>RAILROAD TRACK/SQ. KM</b> )	-0.01 [0.00]***	-0.03 [0.01]*	-0.01 [0.00]***	-0.01 [0.00]***
<b><u>GEOGRAPHY</u></b>				
ln ( <b>DISTANCE</b> )	0.004 [0.04]	0.14 [0.04]***	0.08 [0.02]***	0.09 [0.02]***
One country in pair is an <b>ISLAND</b>	-0.35 [0.06]***	-0.04 [0.11]	-0.03 [0.05]	-0.04 [0.03]
Both in pair are an <b>ISLAND</b>	-0.53 [0.06]***	-0.04 [0.18]	-0.09 [0.09]	-0.07 [0.06]
Countries share a <b>BORDER</b>	-0.26 [0.08]***	-0.14 [0.10]	-0.18 [0.06]***	-0.12 [0.04]***
ln [product of (1+ kms. of <b>COASTLINE</b> )/area in sq. kms]	0.20 [0.16]	0.23 [0.21]	0.39 [0.19]**	0.25 [0.19]
<b><u>INSTITUTIONS &amp; CULTURE</u></b>				
Both in pair had or have a common <b>COLONIZER</b>	---	0.56 [0.10]***	0.09 [0.09]	0.35 [0.11]***
Both in pair share a <b>COMMON LANGUAGE</b>	-0.05 [0.07]	-0.59 [0.10]***	-0.07 [0.04]	-0.20 [0.05]***
One in pair was a <b>COLONY</b> of the other prior to 1870	-0.09 [0.07]	---	-0.29 [0.09]***	0.04 [0.09]
Both in the <b>BRITISH EMPIRE</b> or UK and a British Colony	0.11 [0.06]*	-0.04 [0.12]	-0.19 [0.09]**	-0.35 [0.11]***
Constant	-0.36 [0.32]	---	---	-1.11 [0.15]***
Observations	208	244	343	1133
Country-Pair Fixed Effects	no	no	no	no
Country Fixed Effects	no	no	no	no
R-Squared	0.74	0.54	0.51	0.34

Notes: Dependent variable is the natural logarithm of trade costs. Year indicators are included but not reported. Estimation is by "random effects" and allows for heteroscedasticity and serial correlation robust standard errors. See the text for descriptions of the variables. \* significant at the 10% level; \*\* significant at the 5% level; \*\*\* significant at the 1% level.

Table 7: Sensitivity Analysis for Trade Costs, 1870-1913

Regressors by category	<i>Alternative Functional Forms (3)-(5)</i>		Regressors by category	(3) Dep. Var Level Trade Costs	(4) Dep. Var Level Trade Costs	(5) Dep. Var Tariff Equivalent
	(1) Distance Spline	(2) Ctry Fixed Effects Distance Spline				
<b><u>POLICIES</u></b>			<b><u>POLICIES</u></b>			
In (product of <b>TARIFFS</b> )	0.02 [0.01]	0.02 [0.01]	In (product of <b>TARIFFS</b> )	0.01 [0.01]	0.003 [0.01]	0.01 [0.02]
Both on <b>GOLD STANDARD</b>	-0.04 [0.01]***	-0.03 [0.01]***	Both on <b>GOLD STANDARD</b>	-0.01 [0.01]***	-0.01 [0.01]***	-0.05 [0.02]**
Mild exchange rate volatility indicator	-0.01 [0.01]	-0.02 [0.01]**	Mild exchange rate volatility indicator	-0.004 [0.002]	-0.01 [0.00]**	-0.01 [0.01]
Extreme exchange rate volatility	-0.01 [0.01]	-0.02 [0.01]	Extreme exchange rate volatility	-0.003 [0.01]	-0.01 [0.01]	-0.01 [0.02]
Both in a <b>MONETARY UNION</b>	0.08 [0.05]	-0.08 [0.05]*	Both in a <b>MONETARY UNION</b>	0.01 [0.02]	-0.02 [0.02]	-0.005 [0.05]
<b><u>INFRASTRUCTURE</u></b>			<b><u>INFRASTRUCTURE</u></b>			
In (product of kms. of <b>WATERWAYS/AREA</b> in sq. kms)	-0.65 [0.56]	-0.21 [0.42]	In (product of kms. of <b>WATERWAYS/AREA</b> in sq. kms)	-0.24 [0.20]	0.02 [0.12]	-0.82 [0.68]
In (product of kms. of <b>RAILROAD TRACK/SQ. KM</b> )	-0.004 [0.001]***	-0.01 [0.01]**	In (product of kms. of <b>RAILROAD TRACK/SQ. KM</b> )	-0.001 [0.0007]**	-0.01 [0.003]**	-0.01 [0.003]**
<b><u>GEOGRAPHY</u></b>			<b><u>GEOGRAPHY</u></b>			
Distance < 480 km.	0.07 [0.03]**	0.06 [0.04]**	In ( <b>DISTANCE</b> ) x indicator for 1870-1879	0.04 [0.01]***	0.06 [0.03]**	0.18 [0.03]***
480 km. < distance < 5,380 km.	0.08 [0.02]***	0.07 [0.03]**	In ( <b>DISTANCE</b> ) x indicator for 1880-1889	0.04 [0.01]***	0.07 [0.01]***	0.17 [0.03]***
distance > 5,380 km.	0.08 [0.02]***	0.07 [0.03]**	In ( <b>DISTANCE</b> ) x indicator for 1880-1899	0.04 [0.01]***	0.05 [0.01]***	0.16 [0.03]***
One country in pair is an <b>ISLAND</b>	-0.04 [0.04]	0.40 [0.19]**	In ( <b>DISTANCE</b> ) x indicator for 1900-1913	0.04 [0.01]***	0.01 [0.01]	0.14 [0.03]***
Both in pair are an <b>ISLAND</b>	-0.07 [0.07]	0.86 [0.37]**	One country in pair is an <b>ISLAND</b>	-0.01 [0.02]	0.27 [0.06]***	0.04 [0.07]
Countries share a <b>BORDER</b>	-0.16 [0.05]***	-0.15 [0.04]***	Both in pair are an <b>ISLAND</b>	-0.03 [0.03]	0.55 [0.12]***	-0.13 [0.13]
In [product of (1+ kms. of <b>COASTLINE</b> )/area in sq. kms]	0.30 [0.17]*	-0.25 [0.11]**	Countries share a <b>BORDER</b>	-0.06 [0.02]***	-0.06 [0.01]***	-0.16 [0.07]**
<b><u>INSTITUTIONS &amp; CULTURE</u></b>			<b><u>INSTITUTIONS &amp; CULTURE</u></b>			
Both in pair had or have a common <b>COLONIZER</b>	0.24 [0.13]*	0.16 [0.10]*	Both in pair had or have a common <b>COLONIZER</b>	0.09 [0.05]*	0.08 [0.03]**	0.28 [0.24]
Both in pair share a <b>COMMON LANGUAGE</b>	-0.13 [0.07]*	-0.04 [0.05]	Both in pair share a <b>COMMON LANGUAGE</b>	-0.04 [0.02]**	-0.04 [0.02]**	-0.06 [0.06]
One in pair was a <b>COLONY</b> of the other prior to 1870	-0.07 [0.11]	-0.04 [0.07]	One in pair was a <b>COLONY</b> of the other prior to 1870	-0.04 [0.04]	0.01 [0.02]	-0.19 [0.14]
Both in the <b>BRITISH EMPIRE</b> or UK and a British Colony	-0.32 [0.13]**	-0.19 [0.08]**	Both in the <b>BRITISH EMPIRE</b> or UK and a British Colony	-0.12 [0.05]**	-0.09 [0.03]***	-0.37 [0.16]**
Constant	-1.26 [0.16]***	---	Constant	0.18 [0.08]**	---	-0.22 [0.28]
Observations	1928	1928	1928	1744	1744	1928
Country Fixed Effects	no	yes	no	yes	yes	no
R-Squared	0.38	0.99	0.34	0.99	0.99	0.23

Notes: Dependent variable is the natural logarithm of trade costs cols (1)-(2). Dependent variable is listed above for cols. (3)-(5). Year indicators are included but not reported. Estimation is by "random effects" or OLS with heteroscedasticity and serial correlation robust standard errors. Column 2 and 4 use country pair fixed effects. See the text for descriptions of the variables. \* significant at the 10% level; \*\*significant at the 5% level; \*\*\* significant at the 1% level.

Table 8: Gravity Regressions, 1870-1913

Regressors by category	(1)		(2)		(3)	
	Ctry Fixed Effects	Structural Coeff. rho = 11	Decadal Ctry Fixed Effects	Structural Coeff. rho = 11	Decadal Ctry Fixed Effects	Structural Coeff. rho = 11
<b><u>POLICIES</u></b>						
In (product of <b>TARIFFS</b> )	-0.42 [0.23]*	-0.02	-0.35 [0.20]*	-0.02	-0.58 [0.19]***	-0.03
Both on <b>GOLD STANDARD</b>	0.33 [0.21]	0.02	0.58 [0.20]***	0.03	0.79 [0.21]***	0.04
Mild exchange rate volatility indicator	0.26 [0.12]**	0.013	0.20 [0.10]*	0.010	0.10 [0.10]	0.005
Extreme exchange rate volatility	0.25 [0.25]	0.013	0.11 [0.22]	0.006	-0.04 [0.23]	-0.002
Both in a <b>MONETARY UNION</b>	1.27 [0.68]*	0.06	0.97 [0.71]	0.05	0.99 [0.71]	0.05
<b><u>INFRASTRUCTURE</u></b>						
In (product of kms. of <b>WATERWAYS/AREA</b> in sq. kms)	-1.09 [4.16]	-0.05	-2.05 [3.71]	-0.10	-1.85 [3.75]	-0.09
In (product of kms. of <b>RAILROAD TRACK/SQ. KM</b> )	0.01 [0.03]	0.001	0.27 [0.12]**	0.014	0.52 [0.14]***	0.026
<b><u>GEOGRAPHY</u></b>						
In ( <b>DISTANCE</b> ) x indicator for 1870-1879	-1.28 [0.57]**	-0.06	-1.95 [0.88]**	-0.10	-2.00 [0.90]**	-0.10
In ( <b>DISTANCE</b> ) x indicator for 1880-1889	-0.99 [0.53]*	-0.05	-2.19 [0.44]***	-0.11	-2.21 [0.44]***	-0.11
In ( <b>DISTANCE</b> ) x indicator for 1880-1899	-0.97 [0.54]*	-0.05	-1.67 [0.46]***	-0.08	-1.66 [0.46]***	-0.08
In ( <b>DISTANCE</b> ) x indicator for 1900-1913	-0.72 [0.51]	-0.04	-0.33 [0.56]	-0.02	-0.31 [0.56]	-0.02
One country in pair is an <b>ISLAND</b>	-0.26 [0.42]	-0.013	-3.50 [2.79]	-0.175	-1.80 [2.88]	-0.090
Both in pair are an <b>ISLAND</b>	0.00 [0.00]		-6.43 [5.84]		-3.13 [5.96]	
Countries share a <b>BORDER</b>	1.72 [0.57]***	0.09	1.78 [0.53]***	0.09	1.77 [0.53]***	0.09
In [product of (1+ kms. of <b>COASTLINE</b> )/area in sq. kms]	4.07 [1.41]***	0.20	4.17 [1.30]***	0.21	4.23 [1.30]***	0.21
<b><u>INSTITUTIONS &amp; CULTURE</u></b>						
Both in pair had or have a common <b>COLONIZER</b>	-1.52 [1.53]	-0.08	-2.31 [1.45]	-0.12	-2.30 [1.40]	-0.12
Both in pair share a <b>COMMON LANGUAGE</b>	1.07 [0.62]*	0.05	1.40 [0.64]**	0.07	1.40 [0.65]**	0.07
One in pair was a <b>COLONY</b> of the other prior to 1870	0.23 [0.75]	0.01	-0.44 [0.85]	-0.02	-0.49 [0.86]	-0.02
Both in the <b>BRITISH EMPIRE</b> or UK and a British Colony	2.56 [1.03]**	0.13	2.87 [1.04]***	0.14	2.82 [1.03]***	0.14
In (GDP-Exports) country i	0.46 [0.48]		2.57 [0.64]***		---	
In (GDP-Exports) country j	-0.11 [0.62]		-0.49 [0.61]		---	
Observations	1928		1928		1928	
Country-Pair Fixed Effects	no		no		no	
Country Fixed Effects	no		yes		yes	
R-Squared	0.97		0.98		0.98	

Notes: Dependent variable is the natural logarithm of the product of real exports. Year indicators are included but not reported. Estimation is by OLS with heteroscedasticity and serial correlation robust standard errors. Column 2 uses country pair fixed effects. Column 3 uses country fixed effects interacted with indicators for each "decade" between 1870 and 1913 (the last "decade" includes 1900-1913). See the text for descriptions of the variables. \* significant at the 10% level; \*\*significant at the 5% level; \*\*\* significant at the 1% level.

Figure 3: Global Index of Trade Costs, 1870-1913 (1913=100)

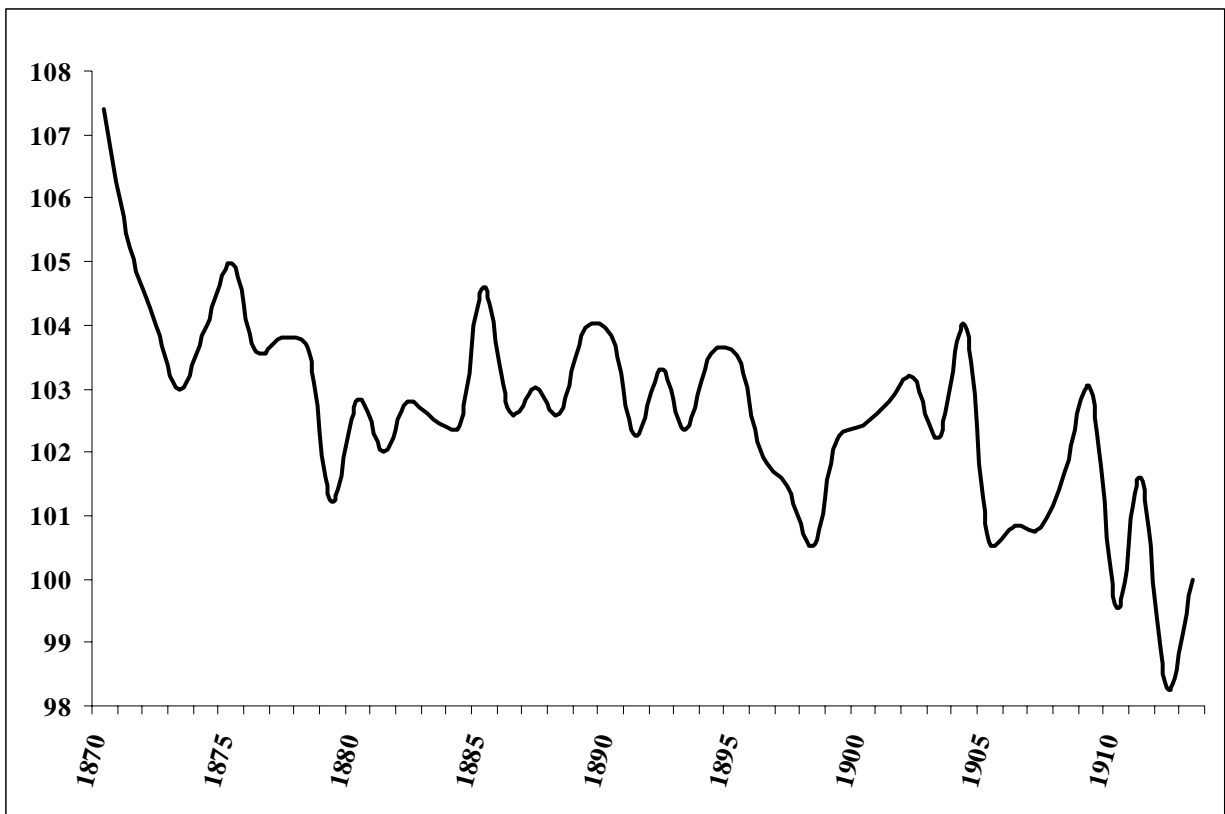


Figure 4: External Trade Costs, Europe, 1870-1913 (1913=100)

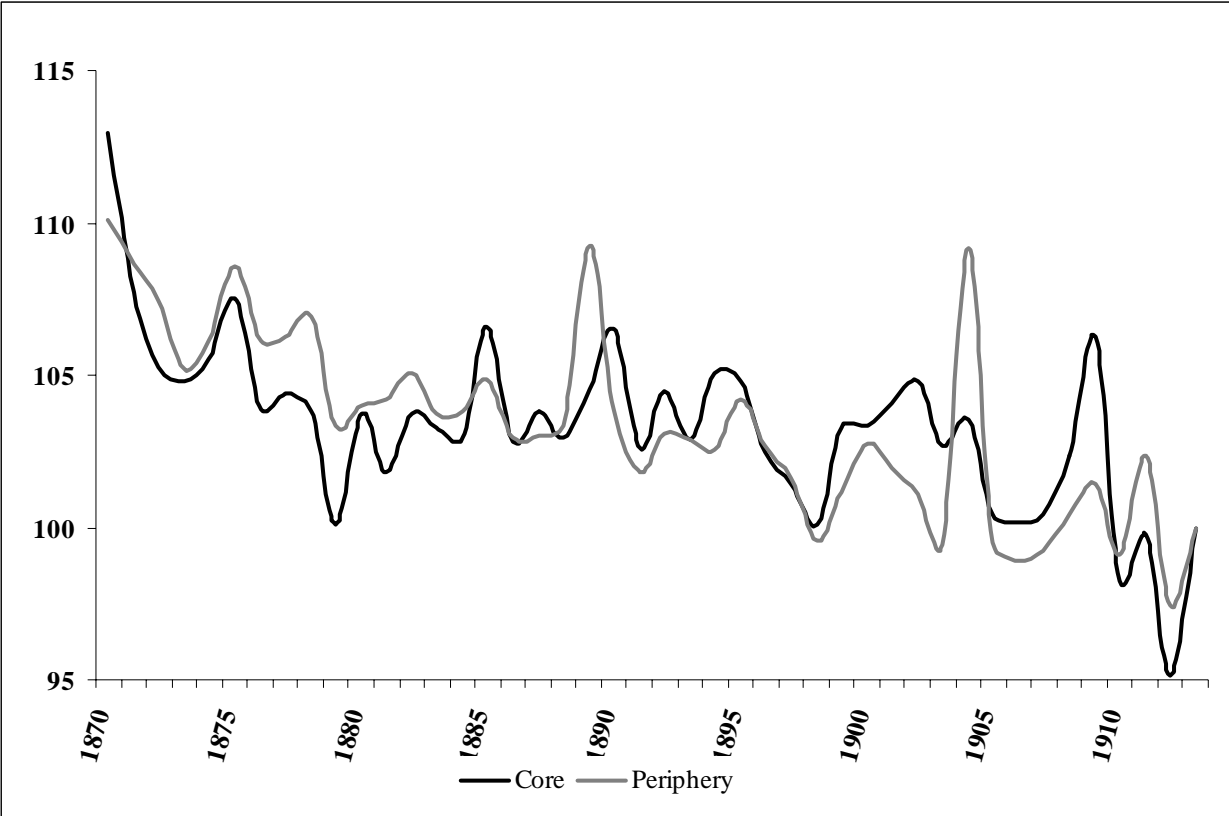


Figure 5: American Indices of External Trade Costs

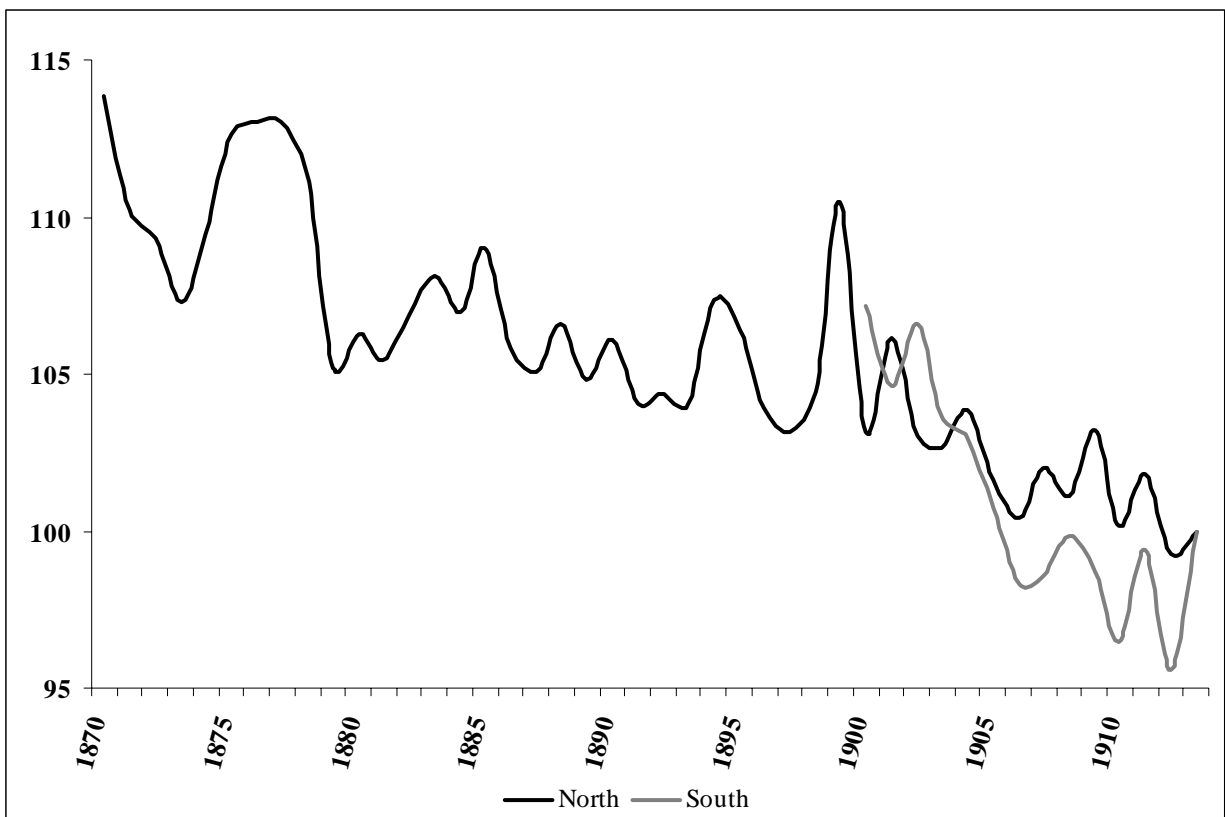




Figure 6: Asian/Oceanic Indices of External Trade Costs, 1870-1913 (1913=100)

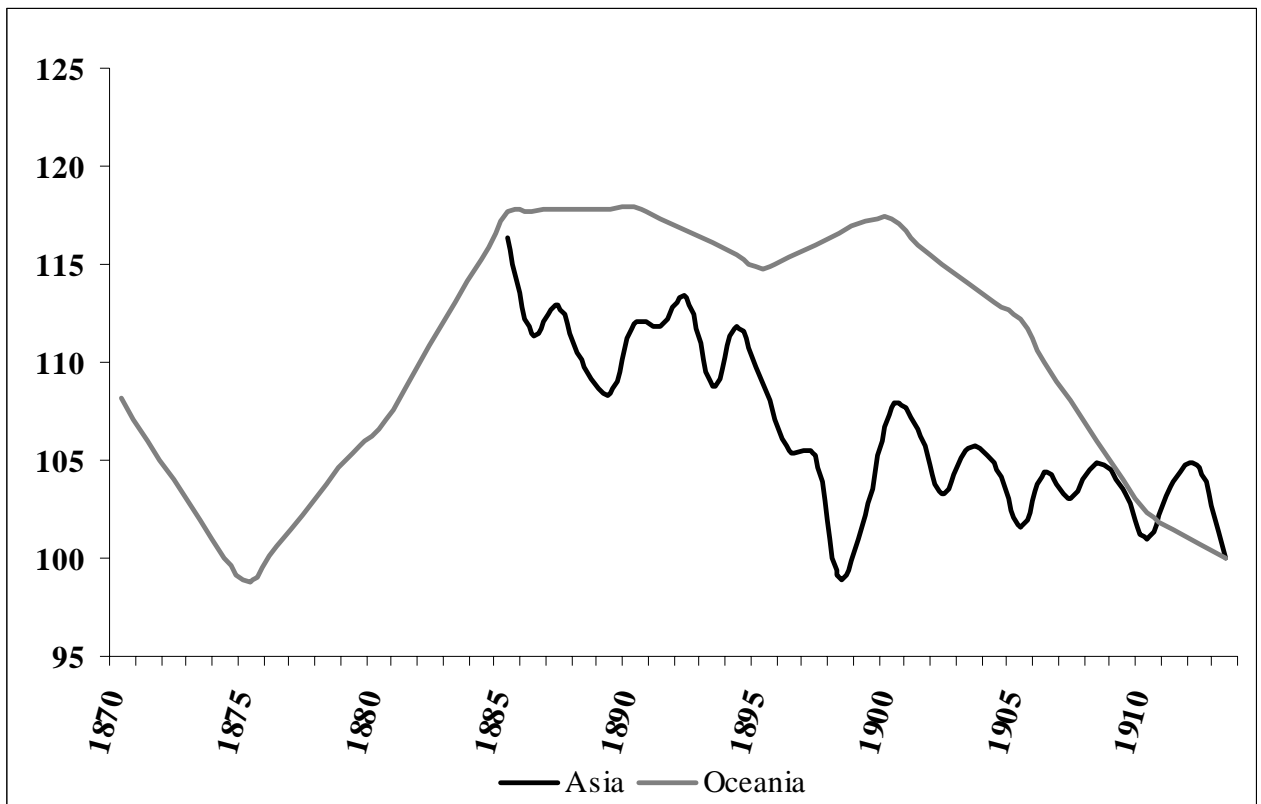


Figure 7: European Index of Internal Trade Costs, 1870-1913 (1913=100)

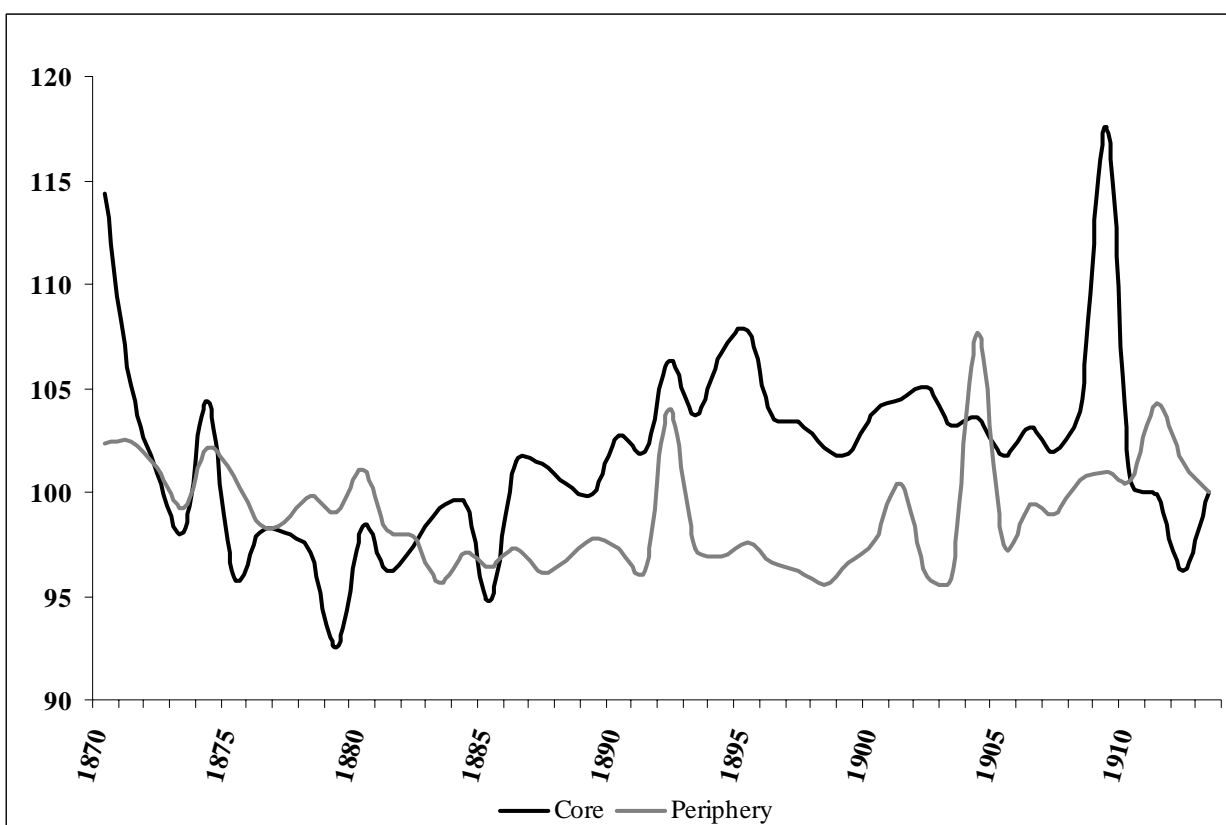


Figure 8: American Index of Internal Trade Costs, 1870-1913 (1913=100)

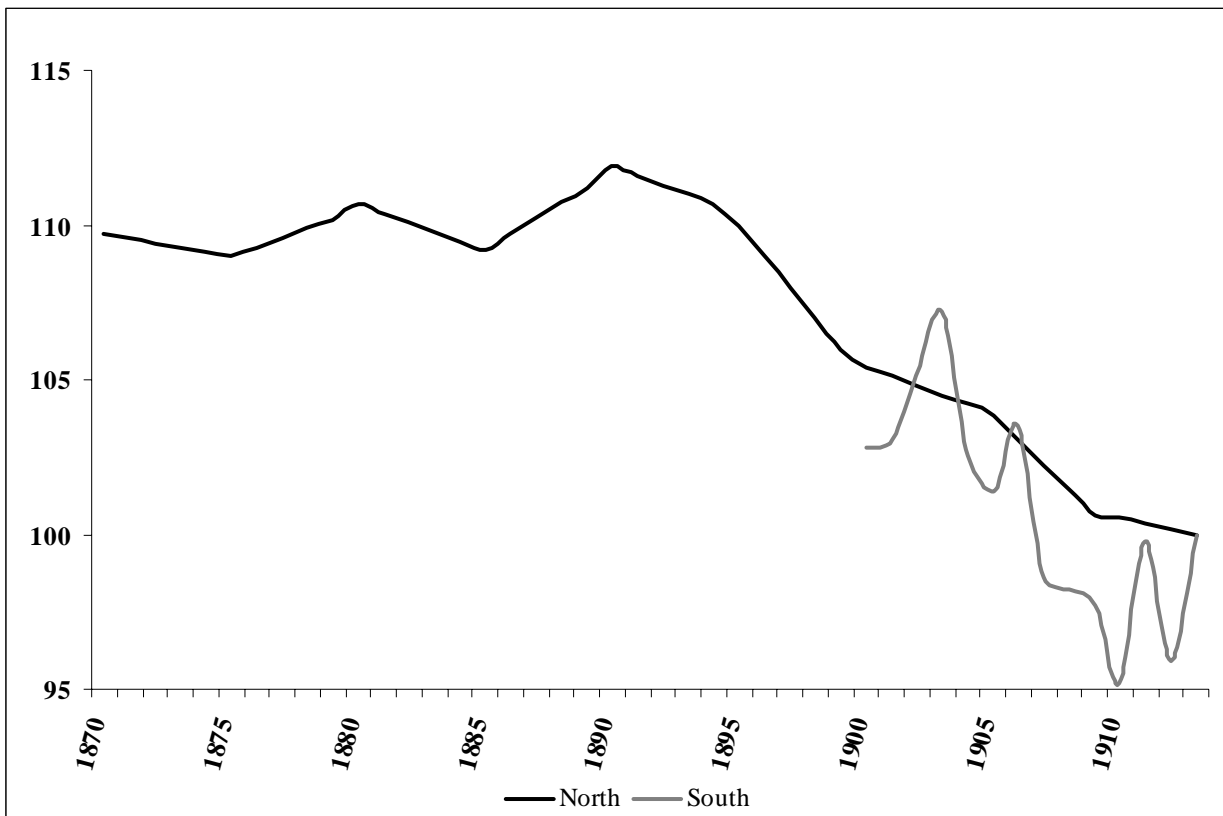


Figure 9: Asian/Oceanic Index of Internal Trade Costs, 1870-1913 (1913=100)

