International Trade Costs During the Late Nineteenth Century Trade Boom: What Role Did They Play and What Were Their Determinants?

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Very preliminary. Comments welcome. Please do not circulate.
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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. Membership in the British Empire, shared language and proximity explain a large proportion of the variation in levels of trade costs. In order of their importance, improvements in transportation, changes in tariffs, and increased exchange rate regime coordination explain the observed declines in trade costs.

1 Introduction

Trade costs are a key obstacle to international economic integration. In this paper, we study the evolution and the determinants of international trade costs at the bilateral level during the first wave of globalization from 1870 to 1913. Specifically, the paper takes an indirect approach to measuring trade costs which we define as the wedge between the price of a unit of a good in the home market and the price a foreign consumer pays. We present a micro-founded multiple-country general equilibrium model of trade in differentiated products based on Novy (2005)

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that incorporates iceberg trade costs. The model yields a gravity equation of international trade which we then use with trade and output data to compute implied bilateral iceberg trade costs.

The magnitudes of estimated trade costs exhibit considerable variation over time and space. Overall our findings confirm that trade costs fell prior to World War I, but not as dramatically as much of the literature would lead us to believe. Despite this, we find strong evidence that trade costs were very important in determining both the direction of trade and the overall level of international trade. On average these declined at a rate of about 0.2 percent per year. These changes do not seem dramatic when compared to the extraordinary increases in trade flows the world witnessed up to 1913. In our sample exports grew at an average rate of four percent per year while GDP grew at roughly 2.5 percent per year. Nevertheless, a large impact of small changes in trade costs is quite possible under plausible assumptions about the structure of the global economy as Obstfeld and Rogoff (2001) have highlighted.

In terms of levels, trade costs are relatively high in 1870. At the median they are equivalent to an increase in the FOB price of 90 percent. At the same time, their values range between 28 percent to nearly 228 percent. In 1913, the median trade cost had decreased slightly to 76 percent, and the bottom and top end fell somewhat to 25 percent and 199 percent.

Accordingly, we next turn to the determinants of trade costs. The 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 aggregate trade costs derived from the micro-founded model.

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. Institutions and a common languages seem to explain a large proportion of the variation of trade costs in levels. Our evidence also suggests that technological improvements in maritime shipping and the generalized diffusion of the railroad altered the impact of geography on the level of trade costs. These changes made distance less of a barrier over time and may play the largest role in explaining the nineteenth century trade boom. The increased prevalence of shared monetary regimes and free trade policies in big and important countries also help explain the fall in trade costs and the increase in integration.

Our main conclusion is that technology and policies were the important factors driving the historical increases in world trade. The implication is that a handful of specific policies may readily work to overcome geographic constraints on international trade and, thus, potentially contribute to economic growth. At the same time, historical linkages and cultural heritage seem to exert economically strong and persistent pressure on the direction of trade.

2 Current Perspectives on Trade Costs

Trade costs are simply 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. Trefler, 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. that 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 wholesale adoption of steam propulsion–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 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.

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 and transport, monetary standards and trade policy, and political and cultural linkages.

4 International Trade in General Equilibrium with Trade Costs

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 monopolisitc competition. Each country's production is restricted to certain varieties that are all mutually exclusive. 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 homogenous good 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 model of good differentiated by place of origin. We show how to derive an intuitive gravity model that eliminates the price index terms 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 $j = 1, 2, ..., J$. 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

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

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

$$U_j = \ln C_j + \eta \ln (1 - h_j) \tag{1}$$

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

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

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

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

Here ξ_{ji} denotes the prices of the individual goods as follows

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

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

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

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

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

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

$$P_j C_j = W_j h_j + \pi_j \tag{7}$$

where π_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

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

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

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

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

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

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

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

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

$$p_j^T = \frac{\rho}{\rho - 1} \frac{W_j}{A_j} \tag{12}$$

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

$$p_j^{NT} = \frac{\rho}{\rho - 1} \frac{W_j}{A_j} \tag{13}$$

so that

$$p_j^T = p_j^{NT} \equiv p_j \tag{14}$$

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

$$\frac{\eta}{1-h_j} = \frac{W_j}{P_j C_j} \tag{15}$$

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

$$h_j = \frac{\rho - 1}{\rho - 1 + \rho\eta} \tag{16}$$

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

$$\frac{W_j}{P_j} = \frac{\rho-1}{\rho}\theta_j^{\frac{1}{\rho-1}} \tag{17}$$

$$C_j = h_j \theta_j^{\frac{1}{\rho-1}} \tag{18}$$

$$\frac{\pi_j}{P_j} = \frac{h_j}{\rho}\theta_j^{\frac{1}{\rho-1}} \tag{19}$$

where θ_j is a highly nonlinear expression consisting of exogenous variables and parameters

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

Note that since $\frac{\partial\theta_j}{\partial\tau_{j,k}} < 0$, $\frac{\partial\theta_j}{\partial\tau_{k,j}} < 0$, $\frac{\partial\theta_j}{\partial A_j} > 0$ and $\frac{\partial\theta_j}{\partial A_k} > 0$, households are better off with low trade costs and high technology levels in terms of the real wage, consumption and real profits.[1]

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

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

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

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[2] is a determinant of trade. 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 τ_{kl} ,$l \neq j$, goes up. Total exports EXP_k from k drop but exports $EXP_{j,k}$ from j to k increase. Since the total export terms in (19) 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.

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

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

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

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 ($EXP_{j,k} = EXP_{k,j}$, $POP_j = POP_k$ etc.). It follows that $\tau_{j,k} = \tau_{k,j}$. Then assume that country k absorption ($GDP_k - EXP_k$) increases, all else being equal, resulting in a higher $\tau_{j,k}$ 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 $\tau_{j,k}$ 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 annual variation in exports at the country level. 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

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

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 example Australia and Canada persistently ran 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 can easily be incorporated into our analysis.

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

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

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

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

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

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

and consumption follows as

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

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

$$\begin{aligned} CA_j &= \text{nominal current account of } j \\ CONS_j &= \text{nominal consumption of } j \end{aligned}$$

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

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

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

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.

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 hope 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 (ρ) was set to 11. When the elasticity of substitution is set equal to eleven this corresponds to a ten percent markup over marginal cost.[4] Typical estimates in the contemporary literature range between 5 and 12 as noted in Anderson and van Wincooop (2004). In an appendix below, we present the results of a robustness check on derived trade costs for different values of s and ρ. The percentage change in trade costs or the log differences are quite stable for various configurations of the 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 ρ.

As to 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 10 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 is 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.

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 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 far-flung geographically challenged 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 τ 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 (see Federico (2000) on Italy's trade policy). 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.

Overall, we encourage more work at the country level 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. 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

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

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 δ is the elasticity of iceberg trade costs with respect to distance. This implies the following estimating equation

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

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 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 to the historical work we only cite in passing previous work by López-Córdova and Meissner (2003) and other that suggest that coordination on the gold standard helped reduce the transaction costs of trade. This is backed up by other historical work by Frantz et al. (2003) and Flandreau and Maurel (2001) and indeed contemporary work along the lines of Rose (2000), Glick and Rose and Klein and Shambaugh (2005). All of these provide consistent empirical evidence that exchange rate pegs are associated with significantly higher trade volumes.

Policies: Tariff Revenue and Exchange Rate Regimes

In the full sample, tariffs appear to be associated with higher trade costs. Using the point estimate from column 1 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, use country fixed effects or country-pair fixed effects. In the decade-by-decade samples of columns four through seven, tariffs seem only to deter trade in the 1880s and 1890s while in the first and last periods the coefficients are not statistically significant. Tariffs are self-evidently a trade cost. The econometric specification may not show this if there is enough collinearity in the data. Since the representativeness of the sample changes somewhat over each decade sample selection problems could be coming in here too. Overall however, there is evidence that trade policy matters.

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. A lower bound for the impact of adoption of the gold standard is a roughly 3 percent decline in trade costs. The economic significance of this is not extreme (i.e., it is roughly equal to a one-tenth of a standard deviation decrease of the dependent variable) but, nonetheless, 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. 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 no perceptible effect 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 reduce trade costs compared to dyads that experience low volatility. The explanation lies in the fact that the many of the observations are associated with Japanese paper money depreciation in the late 1880s and Italian exchange rate devaluation in midst of a severe financial crisis in the early 1890s associated with an inconvertible lira. These ostensibly expansionary depreciations no doubt allow for great 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 usually positive and varies in statistical significance. Previous studies by López Córdova and Meissner (2003) and Flandreau and Maurel (2001) have argued that monetary unions may have decreased trade cost, 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 that technological change affected the way geography mattered (n.b. we deal with distance below). 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 information on waterways was not available) would tend to use oceangoing 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 a statistically significant impact on trade costs.

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 15 percent. Notably the impact diminishes somewhat in size over time. We also see that countries with extensive coastlines in fact have higher trade costs.

The normalized size of the coastline appears to have a direct relationship to trade costs. If countries with extensive coastlines need to rely on water shipping and then trans-shipment to internal transportation networks this could explain the positive relationship. There is a strong possibility that the delays and costs associated with loading and unloading could contribute to higher shipping costs. Countries with smaller coastlines would be more likely to receive goods over land with the strong possibility that the communication infrastructure is more seamless. Of course being landlocked might not be the best outcome, but our data are not rich enough to allow for a landlocked control variable.

Institutions and Shared Culture

We also find mixed evidence for long-run shared institutional factors. It is not surprising that we find a strong negative coefficient on the indicator for membership in the British Empire. Although special privileges from the UK had died out by this time, those implemented by the colonies themselves mattered. 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 set 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 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 mixed 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 only statistically distinguishable from zero when controlling for country fixed effects.

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 25 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.

The "beta coefficient" in the pooled sample of column 1 of Table 5 is roughly $0.05 = \frac{-0.004*3.3}{.25}$. When we allow for country-specific factors, the beta coefficient increases to 0.25. In other words a one standard deviation increase in the total length of a dyads railway network would have decreased trade costs by a minimum of one-twentieth of a standard deviation or a maximum of one-quarter of a standard deviation. The minimum impact is a much smaller impact than either gold standard adherence or a large increase in tariff revenues would have been expected to give. The upper bound suggests railroads are more important for trade costs than these other factors.

Distance between countries, as a crude proxy for transportation costs, 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.[5] A formal test of the null hypothesis that all coefficients are the same in column 1 of Table 5 soundly rejects the null.[6] Nevertheless, we can 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 three-fold fall in the elasticity of trade costs with respect to distance.

Taking, 0.1 as the elasticity, the beta coefficient for distance is measured as nearly 0.46. A one standard deviation increase in the distance between countries would be associated with a one half standard deviation increase in trade costs. Distance also appears to be a large part of explaining the cross-sectional variation in trade costs and also the decline in costs over time.

In Table 6 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 (log) distance measure with an indicator that was one if distance was less than 478 kilometer, between 478 and 5,377 kilometers and greater than 5377 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

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

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

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

$$\begin{aligned} \ln(\tau_{ij1913}) - \ln(\tau_{ij1870}) &= \underset{(0.04)}{-0.02}\{1 \cdot (478 \text{ km.} \leq \text{Distance}_{ij} < 5,377 \text{ km.})\} \\ &\quad \underset{(0.06)}{-0.11}\{1 \cdot (\text{Distance}_{ij} \geq 5,377 \text{ km.})\}. \end{aligned}$$

There seems to be no difference in the decline in trade costs between countries that were very close or at an intermediate distance. However it appears that trade costs declined significantly faster in pairs that were very far apart compared to those that were close together. So in fact while we might call the 1960s trade boom a series of regionalized globalization the late nineteenth century seems to be characterized by a process whereby very distant countries were brought into the global marketplace. The vastly improved connections between western Europe and the Far East, Australasia, and South America are what we are describing in the equations above.

6.1 Accounting for the Increases in Global Trade 1870-1913

We turn to the question of accounting for the increase in bilateral trade flows between 1870 and 1913. We aim to simply assess the relative roles of various determinants in changes in trade costs. We decompose the variance in the estimation sample of the dependent variable into its various components. Since many determinants are constant over time we restrict attention to time-varying explanatory variables and gauge their relative importance. Three key variables changed over time: tariffs, commodity money regime coordination and railroad mileage. The average change in these variables between the years 1870-79 and 1900-13 was -0.72, 0.24 and 2.24 in their respective units. Taking the estimated coefficients from column 2 of Table 5 the product of these changes and the coefficients are: -.02, -.007, and -.04. Together the sum of these products "explain" a decline in trade costs of roughly 0.07 points between the decade 1870-79 and 1900-13. The change in the average logarithm of trade costs between these two points in time was -.12. Increased railroad mileage, decreased tariff levels and increased regime coordination explain (on average) about 33.3 percent, sixteen percent and six percent of the observed average changes in trade costs.

In a similar spirit we could take the time-varying coefficients on the distance term as evidence of improvements in shipping unrelated to raw railroad network density. From column 2 of Table (5) we see the coefficient fell by 0.16 and, due to shifts in the sample, average distance increased by 0.62. This implies a fall in log trade costs of .1. Overall the previous three factors along with a changing elasticity of distance overexplain the average decrease in trade costs. This implies that other variables and possibly changes in the sample's composition worked against these catalysts for integration.[7] Improved transportation seems be the most important of the time-varying factors, and alone, this explains almost all of the observed fall in trade costs. Nevertheless trade policy and regime coordination seem to follow second and third in relative importance in explaining

6.2 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 6 makes the model additive 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 common language was equivalent to a drop in tariffs of 13 percentage points and that being in the British Empire was worth a drop in tariffs of 33 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.

6.3 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)

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

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.[8] Finally, we use the same trade cost function as before in place of the term $\ln(1-\tau_{j,kt})$. This works by assuming that

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

We can show that this is equivalent to our previous trade cost function by noting that (34) implies

$$\ln \tau_{jkt} = \ln\left(1 - a_0 Dist_{jk}^{a_1} \exp^{(a_2 Z_{jkt})}\right) \approx \ln(b_0 Dist_{jk}^{-b_1} \exp^{(-b_2 Z_{jkt})}.$$

If we write iceberg costs in percentage form so that they lie in the interval 0 to 100 we are able to make use of the approximation that $\ln(1+x) \approx \ln(x)$. We also replaced all coefficients $a_n = -b_n$ where b_n is a coefficient from the original trade costs equation (**??**). Substituting equation (34) into (6.1) 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 $\rho = 11$.

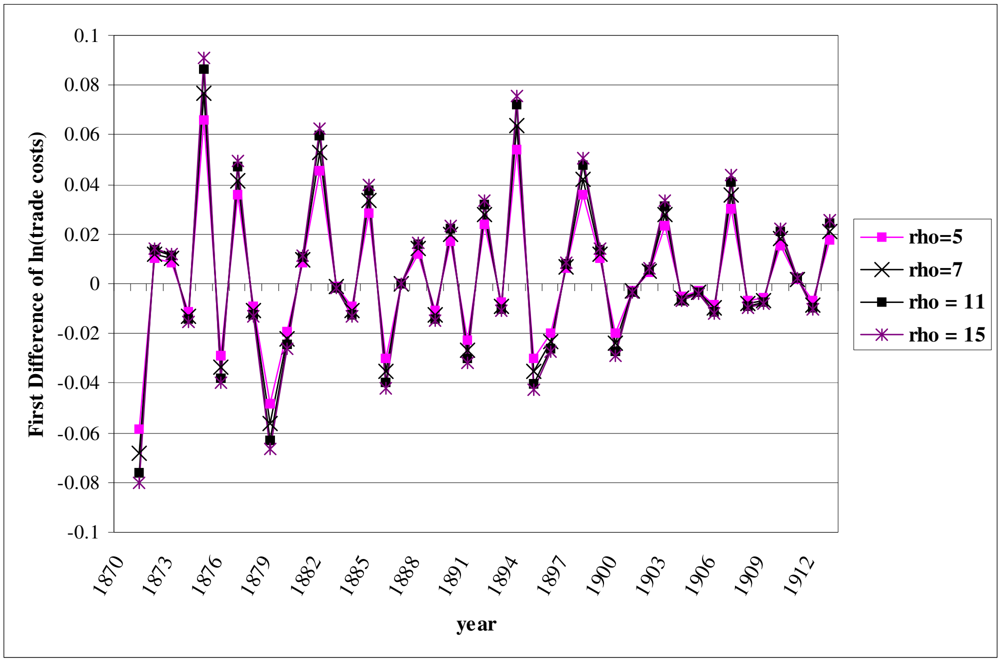
Table 7 presents the results of our gravity model estimations. Qualitatively speaking, our results on trade costs are very closely in line with our previous results. The reduced form implies that a doubling of effective distance decreases the product of trade by over 65 percent. Adherence to the gold standard is associated with an increase of over 100 percent, and the elasticity of trade flows with respect to an increase the product of railroad mileage per square mile in partner countries is 0.48. All coefficients are precisely estimated. Lower elasticities of substitution would give correspondingly lower impacts on trade, but higher impacts on trade costs. We also see that by not including country-specific terms many of our trade cost 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 bust 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 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.

Appendix... to be done...

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

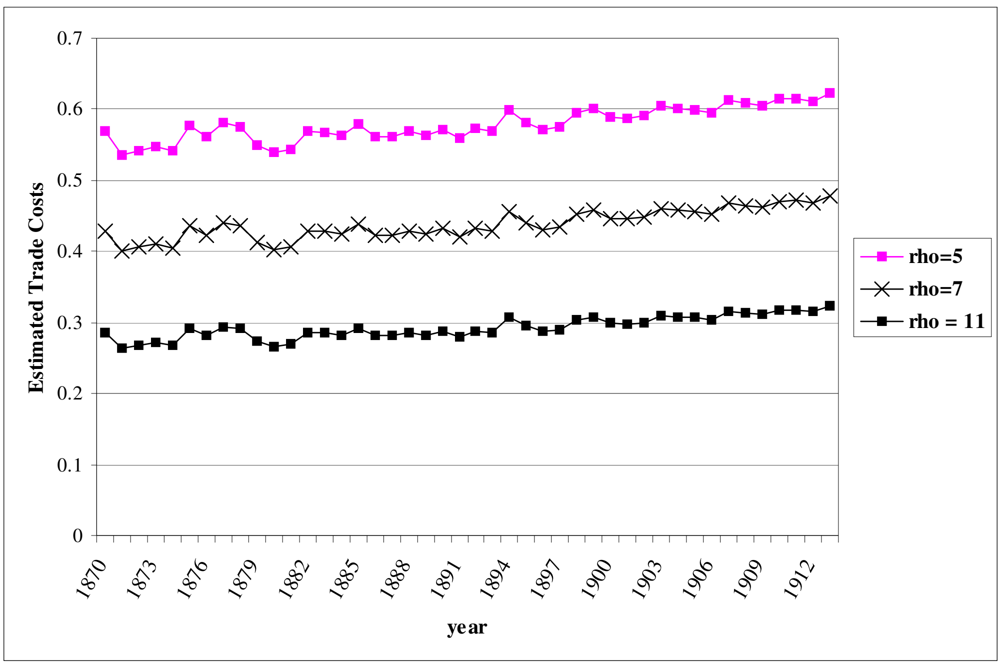


Appendix C
Sensitivity of Results to Assumptions

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

[1]The explicit solution to θ is the solution to a system of polynomial equations.

[2]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.

[3]As shown in Appendix B, θ_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).

[4]Irwin (2003) shows rough evidence of a 9.8 percent markup in steel and pig iron products.

[5]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 statisitically insignificant. Sample selection combined with collinearity between other controls is most likely to blame.

[6]The test yields a chi-squared statistic with 3 degrees of freedom of 3.09 and a p-value of 0.37.

[7]Mild exchange rate volatility decreased on average over time and has a negative coefficient implying a rise in log trade costs of about 0.01 points.

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

Table 2: Average Trade Costs By Country and Decade

1870-1879	Weighted	Unweighted	Partner-Years
Netherlands	0.23	0.35	75
Australia	0.25	0.29	5
Belgium	0.27	0.36	80
Germany	0.28	0.33	77
United Kingdom	0.28	0.31	94
US	0.28	0.42	85
New Zealand	0.28	0.35	6
France	0.29	0.36	84
Canada	0.31	0.47	10
Denmark	0.32	0.41	53
Brazil	0.32	0.43	5
Sweden	0.33	0.41	75
Italy	0.33	0.44	68
Russia	0.33	0.47	11
Switzerland	0.33	0.36	3
Argentina	0.35	0.34	3
Portugal	0.36	0.50	7
Spain	0.38	0.45	5
China	0.41	0.55	7
Mexico	0.45	0.45	2
Japan	0.52	0.52	3
Austria-Hungary	---	0.47	4

1890-1899	Weighted	Unweighted	Partner-Years
Switzerland	0.13	0.38	7
Netherlands	0.23	0.38	88
Australia	0.25	0.48	25
Brazil	0.27	0.38	8
Belgium	0.28	0.38	100
United Kingdom	0.29	0.32	104
New Zealand	0.29	0.47	13
US	0.30	0.40	97
Germany	0.30	0.34	100
Denmark	0.31	0.42	71
France	0.31	0.39	101
Sweden	0.32	0.39	67
Canada	0.32	0.50	22
Argentina	0.33	0.41	10
Russia	0.34	0.47	13
Spain	0.34	0.47	14
Mexico	0.36	0.48	5
Portugal	0.38	0.46	12
Italy	0.38	0.45	76
Japan	0.43	0.52	83
China	0.44	0.53	9
Thailand	0.53	0.53	1

1880-1889	Weighted	Un-weighted	Partner-Years
Netherlands	0.22	0.35	78
Australia	0.25	0.43	13
Belgium	0.26	0.36	84
United Kingdom	0.27	0.31	91
Germany	0.28	0.33	88
US	0.28	0.40	85
New Zealand	0.28	0.35	6
France	0.30	0.37	89
Canada	0.31	0.48	15
Denmark	0.32	0.41	69
Sweden	0.32	0.40	67
Italy	0.35	0.43	67
Japan	0.45	0.53	34

1900-1913	Weighted	Unweighted	Partner-Years
Netherlands	0.23	0.37	180
Australia	0.25	0.46	44
Austria-Hungary	0.27	0.47	38
Belgium	0.28	0.39	243
New Zealand	0.28	0.46	24
Germany	0.30	0.34	249
United Kingdom	0.30	0.35	258
Argentina	0.30	0.39	154
Denmark	0.30	0.42	135
Canada	0.30	0.50	61
Switzerland	0.31	0.42	166
US	0.32	0.40	258
Russia	0.32	0.46	35
France	0.32	0.40	243
Sweden	0.32	0.41	149
Norway	0.33	0.41	103
Chile	0.34	0.44	132
Brazil	0.35	0.41	150
Italy	0.37	0.45	204
Mexico	0.37	0.49	97
Spain	0.37	0.46	196
Turkey	0.38	0.44	13
Peru	0.40	0.48	36
Portugal	0.40	0.49	34
Japan	0.41	0.51	149
Venezuela	0.44	0.48	86
Bulgaria	0.44	0.51	10
China	0.45	0.52	28
Colombia	0.45	0.52	18
Greece	0.46	0.51	12
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	Min.		Max.	
Country	Trade Cost	Partner	Trade Cost	Partner
Argentina (Arg)	0.33	FR	0.35	UK
Australia (Austl)	0.22	NZ	0.52	China
Austria-Hungary (AH)	0.36	Ital	0.59	Bel
Belgium (Bel)	0.26	Neth	0.59	AH
Brazil (Br)	0.32	UK	0.61	It
Canada(CA)	0.31	UK	0.70	China
China	0.41	UK	0.70	CA
Denmark (Dmk)	0.32	Swd	0.47	Bel
France (FR)	0.29	UK	0.53	China
Germany (Ger)	0.26	Neth	0.54	Po
Italy (It)	0.33	CH	0.61	Br
Japan (JP)	0.51	UK	0.52	US
Mexico (Mex)	0.44	US	0.46	UK
Netherlands (Neth)	0.26	Ger	0.48	US
New Zealand (NZ)	0.22	Austl	0.54	US
Portugal (Po)	0.35	UK	0.58	Bel
Russia (Ru)	0.32	Ger	0.62	China
Spain (SP)	0.38	UK	0.57	Ru
Sweden (Swd)	0.32	Dmk	0.54	US
Switzerland (CH)	0.30	FR	0.46	Bel
US	0.28	UK	0.56	Ru
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 obvserved data varies across countries.

1890	Min.		Max.	
Country	Trade Cost	Partner	Trade Cost	Partner
Argentina	0.31	UK	0.50	Po
Australia	0.26	UK	0.71	Ru
Belgium	0.22	Neth	0.57	JP
Brazil	0.27	US	0.51	It
Canada	0.31	UK	0.60	It
China	0.43	UK	0.64	It
Denmark	0.28	Swd	0.63	JP
France	0.28	Bel	0.50	CA
Germany	0.23	Neth	0.49	JP
Italy	0.36	Ger	0.68	Mex
Japan	0.44	UK	0.76	Swd
Mexico	0.35	US	0.68	It
Netherlands	0.22	Bel	0.67	JP
New Zealand	0.28	UK	0.46	US
Portugal	0.36	SP	0.71	JP
Russia	0.31	Ger	0.71	Austl
Spain	0.33	FR	0.73	JP
Sweden	0.28	Dmk	0.76	JP
Thailand	0.53	UK	0.53	UK
US	0.27	Br	0.58	Dmk
UK	0.25	Neth	0.53	TH

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

1910	Min.		Max.	
Country	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 obvserved data varies across countries.

Table 4: Rising and Falling: The Top Ten

Top 10 Drops		Change	Top 10 Increases		Change
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 Fixed Effects	*(3)* Pair Fixed Effects	*(4)* *1870-1879*	*(5)* *1880-1889*	*(6)* *1890-1899*	*(7)* *1900-1913*
POLICIES							
ln (product of **TARIFFS**)	0.03	0.03	0.04	-0.01	0.02	0.02	-0.002
	[0.01]***	[0.02]*	[0.02]**	[0.03]	[0.04]	[0.02]	[0.01]
Both on **GOLD STANDARD**	-0.04	-0.03	-0.04	-0.04	0.02	-0.01	-0.07
	[0.01]***	[0.01]***	[0.01]***	[0.01]**	[0.04]	[0.02]	[0.01]***
Mild exchange rate volatility indicator	-0.01	-0.02	-0.01	0.002	-0.01	0.01	-0.004
	[0.01]	[0.01]***	[0.01]	[0.01]	[0.01]	[0.01]	[0.01]
Extreme exchange rate volatility	-0.02	-0.03	-0.02	0.01	0.002	0.05	-0.03
	[0.01]*	[0.02]**	[0.01]*	[0.03]	[0.01]	[0.03]	[0.01]**
Both in a **MONETARY UNION**	0.05	-0.01	---	-0.11	0.13	0.17	0.08
	[0.02]**	[0.07]		[0.07]	[0.06]**	[0.04]***	[0.02]***
INFRASTRUCTURE							
ln (product of kms. of **WATERWAYS/AREA** in sq. kms)	-0.23	-0.10	---	-1.20	0.39	-0.04	-0.80
	[0.51]	[0.46]		[0.78]	[0.80]	[0.56]	[0.65]
ln (product of kms. of **RAILROAD TRACK/SQ. KM**)	-0.004	-0.02	-0.003	-0.01	-0.03	-0.01	-0.01
	[0.002]**	[0.01]***	[0.002]*	[0.004]***	[0.01]*	[0.002]***	[0.004]***
GEOGRAPHY							
ln (**DISTANCE**) x indicator for 1870-1879	0.11	0.21	---	0.01	---	---	---
	[0.02]***	[0.07]***		[0.04]			
ln (**DISTANCE**) x indicator for 1880-1889	0.10	0.19	---	---	0.14	---	---
	[0.02]***	[0.04]***			[0.04]***		
ln (**DISTANCE**) x indicator for 1880-1899	0.10	0.12	---	---	---	0.08	---
	[0.02]***	[0.03]***				[0.02]***	
ln (**DISTANCE**) x indicator for 1900-1913	0.09	0.05	---	---	---		0.10
	[0.02]***	[0.03]*					[0.02]***
One country in pair is an **ISLAND**	-0.03	-0.36	---	-0.33	-0.04	-0.04	-0.04
	[0.04]	[0.13]***		[0.06]***	[0.11]	[0.05]	[0.04]
Both in pair are an **ISLAND**	-0.07	-0.70	---	-0.50	-0.04	-0.08	-0.07
	[0.07]	[0.28]**		[0.06]***	[0.18]	[0.09]	[0.07]
Countries share a **BORDER**	-0.16	-0.16	---	-0.23	-0.14	-0.18	-0.11
	[0.05]***	[0.05]***		[0.09]**	[0.10]	[0.06]***	[0.04]***
ln [prodcut of (1+ kms. of **COASTLINE**)/area in sq. kms]	0.39	-0.25	---	0.18	0.23	0.41	0.31
	[0.17]**	[0.10]**		[0.17]	[0.21]	[0.19]**	[0.19]*
INSTITUTIONS & CULTURE							
Both in pair had or have a common **COLONIZER**	0.33	0.42	---	---	0.56	0.38	0.42
	[0.11]***	[0.10]***			[0.10]***	[0.08]***	[0.10]***
Both in pair share a **COMMON LANGUAGE**	-0.22	-0.28	---	-0.08	-0.59	-0.35	-0.27
	[0.03]***	[0.08]***		[0.09]	[0.10]***	[0.08]***	[0.03]***
One in pair was a **COLONY** of the other prior to 1870	0.02	0.19	---	-0.10	---	---	0.10
	[0.09]	[0.08]**		[0.08]			[0.08]
Both in the **BRITISH EMPIRE** or UK and a British Colony	-0.30	-0.26	---	0.13	-0.04	-0.20	-0.33
	[0.11]***	[0.09]***		[0.07]*	[0.12]	[0.10]**	[0.10]***
Constant	-1.59	---		-0.49	0.00	-1.44	-1.18
	[0.20]***			[0.35]	[0.00]	[0.22]***	[0.16]***
Observations	1744	1744	1744	175	244	337	988
Country-Pair Fixed Effects	no	**no**	**yes**	no	no	no	no
Country Fixed Effects	no	**yes**	**no**	no	no	no	no
R-Squared	0.37	0.99	0.14	0.73	0.54	0.5	0.32

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 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: Sensitivity Analysis for Trade Costs, 1870-1913

Regressors by category	*(1)* Distance Spline	*(2)* Ctry Fixed Effects Distance Spline
POLICIES		
ln (product of **TARIFFS**)	0.03	0.03
	[0.01]***	[0.02]*
Both on **GOLD STANDARD**	-0.05	-0.03
	[0.01]***	[0.01]***
Mild exchange rate volatility indicator	-0.01	-0.02
	[0.01]	[0.01]**
Extreme exchange rate volatility	-0.02	-0.03
	[0.01]	[0.02]*
Both in a **MONETARY UNION**	0.05	-0.08
	[0.03]*	[0.06]
INFRASTRUCTURE		
ln (product of kms. of **WATERWAYS/AREA** in sq. kms)	-0.16	-0.12
	[0.47]	[0.45]
ln (product of kms. of **RAILROAD TRACK/SQ. KM**)	-0.005	-0.01
	[0.00]***	[0.01]**
GEOGRAPHY		
Distance < 480 km.	0.08	0.06
	[0.03]***	[0.04]*
480 km. < distance < 5,380 km.	0.09	0.08
	[0.02]***	[0.03]**
distance > 5,380 km.	0.09	0.07
	[0.02]***	[0.03]**
One country in pair is an **ISLAND**	-0.03	0.33
	[0.04]	[0.14]**
Both in pair are an **ISLAND**	-0.06	0.70
	[0.07]	[0.27]***
Countries share a **BORDER**	-0.15	-0.13
	[0.05]***	[0.05]**
ln [prodcut of (1+ kms. of **COASTLINE**)/area in sq. kms]	0.39	-0.29
	[0.17]**	[0.12]**
INSTITUTIONS & CULTURE		
Both in pair had or have a common **COLONIZER**	0.28	0.29
	[0.13]**	[0.11]***
Both in pair share a **COMMON LANGUAGE**	-0.18	-0.17
	[0.07]**	[0.07]**
One in pair was a **COLONY** of the other prior to 1870	-0.03	0.09
	[0.11]	[0.08]
Both in the **BRITISH EMPIRE** or UK and a British Colo	-0.28	-0.20
	[0.11]**	[0.09]**
Constant	-1.44	---
	[0.17]***	
Observations	1744	1744
Country-Pair Fixed Effects	no	**no**
Country Fixed Effects	no	**yes**
R-Squared	0.38	0.99

Alternative Functional Forms (3)-(5) Regressors by category	*(3)* Dep. Var Level Trade Costs	*(4)* Dep. Var Level Trade Costs	*(5)* Dep. Var Tariff Equivalent
POLICIES			
ln (product of **TARIFFS**)	0.01	0.01	0.03
	[0.00]**	[0.01]	[0.02]
Both on **GOLD STANDARD**	-0.02	-0.02	-0.06
	[0.004]***	[0.01]***	[0.02]***
Mild exchange rate volatility indicator	-0.003	-0.01	-0.01
	[0.003]	[0.002]*	[0.01]
Extreme exchange rate volatility	-0.01	-0.01	-0.01
	[0.005]	[0.01]	[0.02]
Both in a **MONETARY UNION**	0.003	-0.02	-0.03
	[0.01]	[0.02]	[0.05]
INFRASTRUCTURE			
ln (product of kms. of **WATERWAYS/AREA** in sq. kms)	-0.07	0.05	-0.28
	[0.18]	[0.13]	[0.63]
ln (product of kms. of **RAILROAD TRACK/SQ. KM**)	-0.002	-0.01	-0.01
	[0.0008]**	[0.00]**	[0.003]**
GEOGRAPHY			
ln (**DISTANCE**) x indicator for 1870-1879	0.05	0.07	0.21
	[0.01]***	[0.02]***	[0.03]***
ln (**DISTANCE**) x indicator for 1880-1889	0.05	0.07	0.19
	[0.01]***	[0.01]***	[0.03]***
ln (**DISTANCE**) x indicator for 1880-1899	0.05	0.05	0.19
	[0.01]***	[0.01]***	[0.03]***
ln (**DISTANCE**) x indicator for 1900-1913	0.04	0.02	0.16
	[0.01]***	[0.01]	[0.03]***
One country in pair is an **ISLAND**	-0.01	0.27	-0.49
	[0.02]	[0.06]***	[0.07]
Both in pair are an **ISLAND**	-0.03	0.54	-0.12
	[0.03]	[0.12]***	[0.13]
Countries share a **BORDER**	-0.06	-0.06	-0.14
	[0.02]***	[0.02]***	[0.07]**
ln [prodcut of (1+ kms. of **COASTLINE**)/area in sq. kms]	0.19	-0.12	0.83
	[0.07]**	[0.04]***	[0.33]**
INSTITUTIONS & CULTURE			
Both in pair had or have a common **COLONIZER**	0.12	0.15	0.35
	[0.05]**	[0.05]***	[0.24]
Both in pair share a **COMMON LANGUAGE**	-0.06	-0.11	-0.13
	[0.01]***	[0.03]***	[0.06]**
One in pair was a **COLONY** of the other prior to 1870	-0.02	0.08	-0.13
	[0.04]	[0.04]**	[0.14]
Both in the **BRITISH EMPIRE** or UK and a British Colony	-0.11	-0.09	-0.33
	[0.04]**	[0.03]***	[0.16]**
Constant	0.09	---	-0.49
	[0.08]		[0.30]*
Observations	1744	1744	1744
Country-Pair Fixed Effects	no	no	no
Country Fixed Effects	no	**yes**	no
R-Squared	0.34	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 7: Gravity Regressions, 1870-1913

Regressors by category	(1) Baseline	Structural Coeff. rho = 11	(2) Ctry Fixed Effects	Structural Coeff. rho = 11	(3) Decadal Ctry Fixed Effects	Structural Coeff. rho = 11
POLICIES						
ln (product of **TARIFFS**)	0.46	0.02	-0.37	-0.02	-0.45	-0.02
	[0.39]		[0.25]		[0.19]**	
Both on **GOLD STANDARD**	1.68	0.08	0.46	0.02	0.41	0.02
	[0.44]***		[0.21]**		[0.21]**	
Mild exchange rate volatility indicator	0.21	0.01	0.06	0.003	0.08	0.004
	[0.21]		[0.10]		[0.09]	
Extreme exchange rate volatility	0.29	0.01	0.04	0.002	0.02	0.001
	[0.47]		[0.27]		[0.24]	
Both in a **MONETARY UNION**	-0.35	-0.02	0.62	0.03	0.62	0.03
	[0.65]		[0.81]		[0.80]	
INFRASTRUCTURE						
ln (product of kms. of **WATERWAYS/AREA** in sq. kms)	3.42	0.17	-0.35	-0.02	-0.14	-0.01
	[7.37]		[4.54]		[4.54]	
ln (product of kms. of **RAILROAD TRACK/SQ. KM**)	0.03	0.002	-0.17	-0.01	0.09	0.005
	[0.09]		[0.44]		[0.37]	
GEOGRAPHY						
ln (**DISTANCE**) x indicator for 1870-1879	-1.49	-0.07	-2.06	-0.10	-2.17	-0.11
	[0.56]***		[0.95]**		[0.92]**	
ln (**DISTANCE**) x indicator for 1880-1889	-1.51	-0.08	-2.09	-0.10	-2.13	-0.11
	[0.46]***		[0.46]***		[0.47]***	
ln (**DISTANCE**) x indicator for 1880-1899	-1.50	-0.08	-1.53	-0.08	-1.57	-0.08
	[0.41]***		[0.47]***		[0.47]***	
ln (**DISTANCE**) x indicator for 1900-1913	-1.15	-0.06	-0.53	-0.03	-0.56	-0.03
	[0.42]***		[0.64]		[0.63]	
One country in pair is an **ISLAND**	0.78	0.04	-0.06	-0.003	0.01	0.001
	[0.70]		[0.48]		[0.48]	
Both in pair are an **ISLAND**	1.69	0.08	---		---	
	[1.39]					
Countries share a **BORDER**	1.00	0.05	1.89	0.09	1.90	0.10
	[0.86]		[0.55]***		[0.55]***	
ln [prodcut of (1+ kms. of **COASTLINE**)/area in sq. kms]	-0.82	-0.04	4.74	0.24	5.06	0.25
	[3.38]		[0.86]***		[0.85]***	
INSTITUTIONS & CULTURE						
Both in pair had or have a common **COLONIZER**	-9.26	-0.46	-16.13	-0.81	-16.10	-0.81
	[1.94]***		[1.35]***		[1.33]***	
Both in pair share a **COMMON LANGUAGE**	4.06	0.20	8.83	0.44	8.87	0.44
	[1.38]***		[1.26]***		[1.25]***	
One in pair was a **COLONY** of the other prior to 1870	-2.37	-0.12	-8.13	-0.41	-8.15	-0.41
	[1.54]		[1.24]***		[1.22]***	
Both in the **BRITISH EMPIRE** or UK and a British Colony	3.61	0.18	-0.27	-0.01	0.00005	0
	[1.23]***		[1.80]		[1.76]	
ln (GDP-Exports) country i	1.79	---	1.82	---	3.63	---
	[0.22]***		[1.05]*		[0.92]***	
ln (GDP-Exports) country j	1.78	---	-3.58	---	-1.56	---
	[0.24]***		[1.48]**		[0.73]**	
Observations	1483		1483		1483	
Country-Pair Fixed Effects	no		**no**		**no**	
Country Fixed Effects	no		**yes**		**yes**	
R-Squared	0.68		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 indictaors 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)

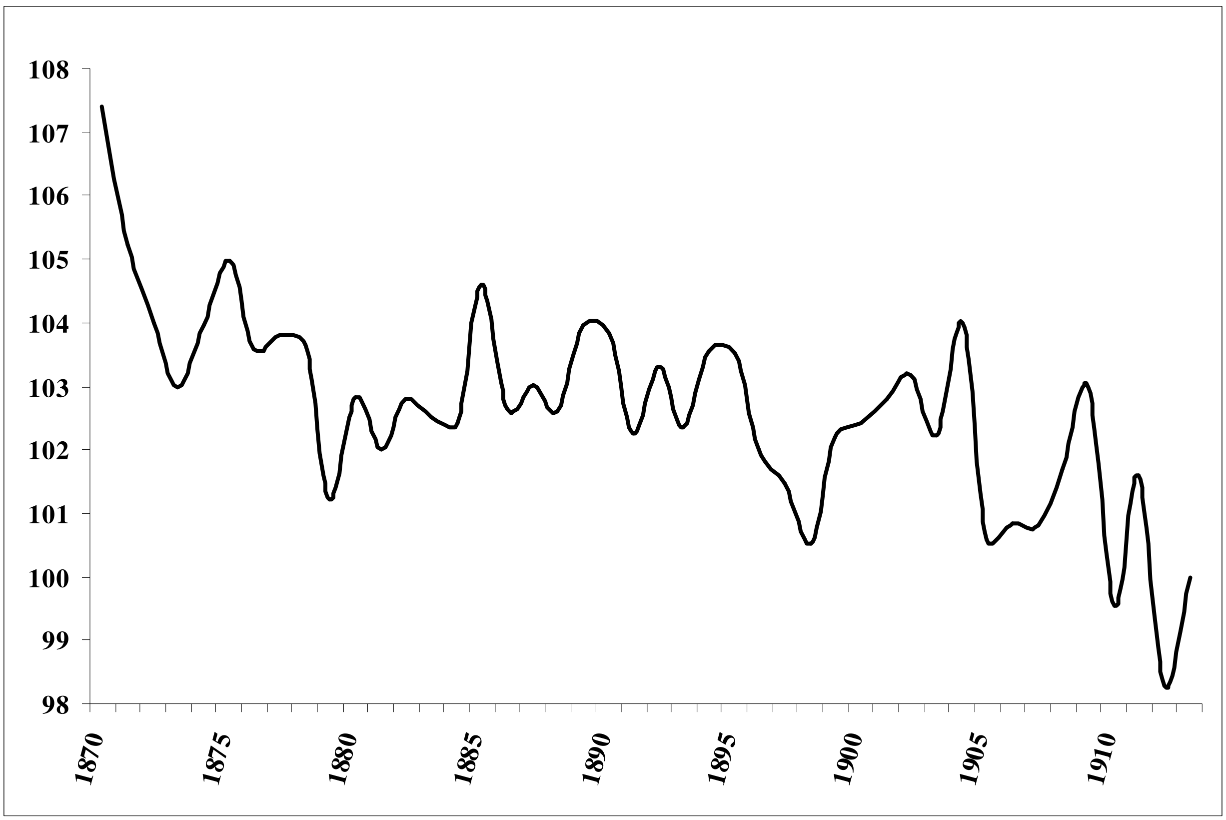

Figure 4: External Trade Costs, Europe,1870-1913 (1913=100)

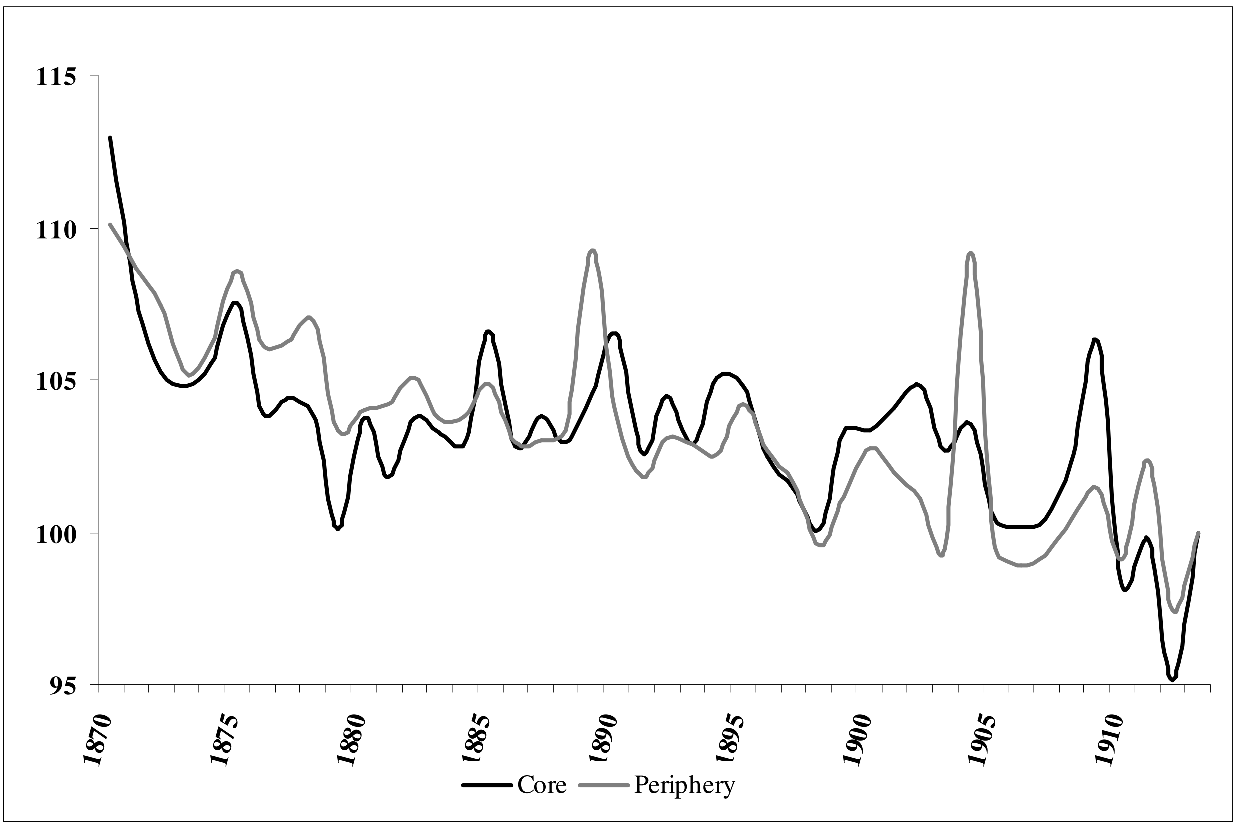

Figure 5: American Indices of External Trade Costs

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)

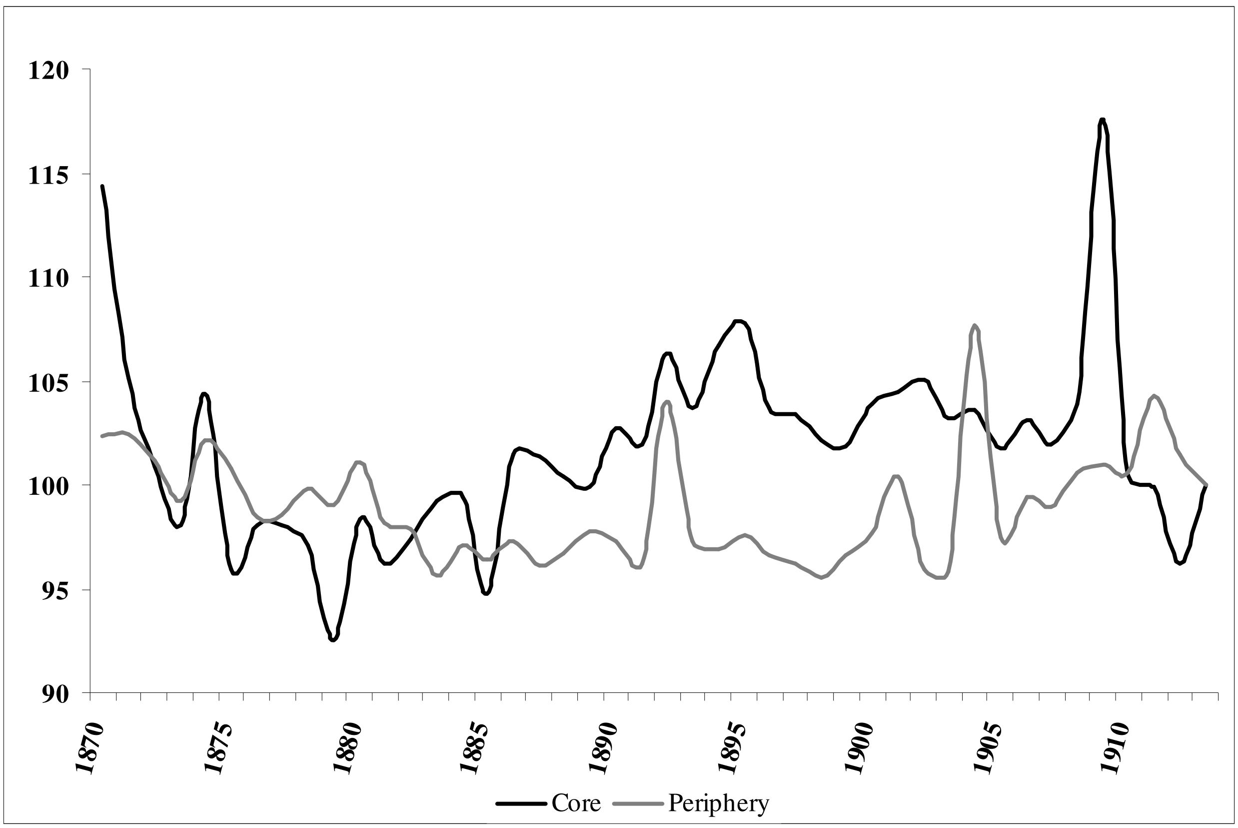

Figure 8: American Index of Internal Trade Costs, 1870-1913 (1913=100)

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