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TRADE COSTS IN THE FIRST WAVE OF GLOBALIZATION

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ABSTRACT

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Abstract

We use a new measure of total trade costs at the bilateral country level to examine the change in international trade integration between 1870 and 1913. Trade costs are lowest amongst the most developed countries and highest in the peripheral and poor countries. On average, our measure declined by roughly ten percent during the period declining most slowly in the richest countries. Core-periphery dyads saw the fastest declines. We sort the determinants of trade costs into four main categories: geographic, political, transportation/communications and institutional/cultural. We find that all of these factors play a role in explaining the variation in the data. Transportation costs and other factors related to proximity seem to explain the largest fraction of the variance. Membership in the British Empire and a shared language are also of great importance. Tariffs, and increased exchange rate regime coordination play a strong role too. Finally we find that reductions in trade costs explain roughly 40 percent of the global trade boom. Economic expansion accounts for the rest.

1 Introduction

Trade costs impede international economic integration. They also drive many key findings in the contemporary open-economy macroeconomics literature. Amazingly, economists know little about the magnitude, evolution and determinants of these obstacles to international trade. While research on the nineteenth century trade boom has tracked certain costs like freight rates and tariffs reasonably well, and proxies for information costs and monetary regimes have been examined, the magnitude and impact of a host of other important impediments to trade remain unexplored.

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In this paper, we present a new comprehensive measure of trade costs during the first wave of globalization from 1870 to 1913. We derive this from a micro-founded multiple-country general equilibrium model of trade in differentiated products based on Novy (2006) that incorporates 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. The outcome is a theoretically consistent measure of bilateral trade integration which can then be averaged over trading partners to provide a measure of overall integration with the global economy.

Measured trade costs exhibit considerable variation over time and space. The baseline findings demonstrate that the average level of trade costs fell by ten percent in the forty years before World War I. This decline explains nearly 40 percent of the total growth in bilateral exports. We attribute the rest of the growth of international trade to economic expansion. The fall in trade costs also fell much more quickly between 1870 and 1880 than between 1880 and 1913.

Trade costs dropped more slowly amongst the most advanced countries of the period than they did between core and periphery nations. Nearly all the increase in trade integration amongst the richest countries between 1870 and 1913 was due to economic expansion. Country pairs like France and the UK and the US and UK have flat or slightly rising measures of trade costs. Neither did these countries experience large declines in their trade costs after 1870 with their major trading partners. Nevertheless, the North Atlantic region had the lowest trade cost levels throughout the period. Conversely, declines in trade costs explain the majority of the increase in integration between the less developed and the richer countries in the same period. Different regions faced different drivers of trade.

Changes in trade costs were not as large as suggested by the roughly two percent annual decline in freight indexes between 1870 and 1913 investigated by Shah Mohammed and Williamson (2003) and Harley (1988). Our trade cost measure declined at a rate of about 0.2 percent per year for the average country pair. We argue that transportation costs are only one input into trade costs. The novel interpretation of the late nineteenth century is that changes in overall trade costs were ostensibly small. However, as Obstfeld and Rogoff (2000) have emphasized, large increases in trade can occur even when trade costs only change a little.

In terms of levels, the median country pair has a trade cost equivalent to imposing a tariff on the price reigning in the export market 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 most highly developed countries seem to have the lowest average trade costs. On the other hand, small, remote, and less developed countries seem to have the highest levels.

After examining these levels and trends, we turn to the determinants of trade costs. This exercise demonstrates the sensibility of our trade cost measure. Conventional wisdom is that transportation improvements were the key to the increase in international integration prior to 1913. But recent work by Jacks (2006) 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 these and other components including shipping costs, geographic constraints, institutions and cultural links, policies and non-tariff barriers.

Our evidence suggests proximity was the most important factor in explaining the variation in the data amongst all of the various determinants of integration. Secular reductions in maritime shipping costs and other overland freight costs 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 legal institutions and administrative practices that former Latin American colonies inherited from their colonial period did not lead to lower trade costs amongst them while a 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. It is possible that information flows, informal and formal contracting mechanisms, marketing techniques and financial factors also play a role, but only limited qualitative information is available so far. A sizeable fraction of trade costs remains unexplained by all of these observables and so this paper provides a challenge for further research on these issues.

2 Current Perspectives on Trade Costs

Trade costs can be defined as the costs of transaction and transport associated with the exchange of goods over and above the marginal cost of production. But economists still have a very limited understanding of their nature. 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).

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. 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 and argue that the representative tariff equivalent of international trade costs might be as much as 74 percent for a typical developed country. 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 and important welfare costs.

More generally trade costs 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 comprise a period of globalization akin to our own in many respects. The world economy witnessed increased integration of global commodity, capital, and labor markets (O'Rourke and Williamson, 1999 and Obstfeld and Taylor, 2004). 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. The increased use of steam ships, persistent improvements in this shipping technology and the international extension of the telegraph play 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 ocean 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, then 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 (2006) offers evidence from a number of important North Atlantic markets between 1800 and 1913 that freight costs can only explain a relatively modest fraction of 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) find that monetary regime coordination as well as cultural and political factors played a very important role in explaining global trade patterns.

In 1897 a contemporary study of the penetration into the British Empire of non-Empire goods was conducted and published by the British at the request of Joseph Chamberlain. This report surveyed colonial governors and illustrated that the factors driving trade patterns might be boiled down to technological, informational and institutional factors (Trade of the British Empire and Foreign Competition 1897). Within these broad categories it is obvious that determining total trade costs is more complex than adding together an ad valorem tariff value and unit 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 sailing ships, still in heavy use on many longer routes as late as 1894, favored others. Add to this government subsidies 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, credit practices, quality, appearance of goods, exchange rate stability, and even the precise weights and measures used in the marketing process helped determine trade flows. Moreover, Saul (1967) points out non-tariff barriers were a problem. Discriminatory railway tariffs, health and safety regulations, along with conditional clauses to trade treaties and problems interpreting them also appear to be part of the landscape in the late nineteenth century trading system. We now show how to generate a measure that captures all of these obstacles to international integration.

4 International Trade in General Equilibrium with Trade Costs

The model outlined in the following pages is based on Novy (2006). It is a general equilibrium model with monopolistic competition in goods differentiated by the country of origin, and it explicitly incorporates "iceberg" trade costs. Iceberg trade costs mean that for each good that is exported a certain fraction melts away during the trading process as if an iceberg were shipped across the ocean. The model gives rise to a micro-founded gravity equation from which the implied trade costs can be inferred in a simple and intuitive manner.

Numerous papers have developed gravity models of trade, and a few of the them have even focussed on trade in general equilibrium. An example is Baier and Bergstrand (2001) who study how increasing returns, transport costs, tariffs and imperfect substitutability across destination markets yield a gravity model of trade with bilateral trade costs, economic size and price indexes as determinants of trade. Anderson and van Wincoop (2003) also derive a gravity model that includes trade costs. Like Baier and Bergstrand their model generates a rather complicated gravity equation that is a function of inherently unobservable price indexes. The Anderson and van Wincoop model clearly highlights how the impact of a bilateral trade barrier varies depending on its relation to average or "multilateral" protection. But since their model relies on an exogenous allocation of production and consumption, it does not allow for valid comparative statics, for example if one wants to assess the effect of a change in trade barriers on aggregate production and consumption. We derive an intuitive gravity model that eliminates the complicated and inherently unobservable price index terms in Anderson and van Wincoop and Baier and Bergstrand but still takes bilateral and multilateral resistance into account.

Optimizing consumers and firms inhabit J countries with $j = 1, 2, ..., J$ and $J \geq 2$. The range of all consumers and of all goods produced in the world is the continuum $[0, 1]$. Country j comprises the consumer range $[n_{j-1}, n_j]$ and country-j monopolistic firms each produce one differentiated good on the same range, where $n_0 = 0$ and $n_J = 1$. We assume an exogenous 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 ($0 < s_j \leq 1$). These can be purchased by all consumers 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 available for purchase to country-j consumers only.

Exogenous bilateral "iceberg" trade costs $\tau_{j,k}$ are incurred when goods are shipped from country j to country k where

$$\tau_{j,k} \begin{cases} \in [0,1) & \text{for} \quad j \neq k \\ = 0 & \text{for} \quad j = k. \end{cases}$$

Iceberg trade costs mean that for each unit of goods that is shipped from j to k the fraction $\tau_{j,k}$ melts away as if an iceberg were shipped across the ocean. Note that bilateral trade costs can be asymmetric such that $\tau_{j,k} \neq \tau_{k,,j}$. The assumption of zero intranational trade costs (i.e., $\tau_{j,j} = 0$) is a normalization which can also be found in Baier and Bergstrand (2001).

4.1 Optimizing Consumers

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

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

where C_j and L_j denote per-capita consumption and labor input in country j. The parameter η is assumed to be 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. The country-j consumption index (2) is defined over all tradable goods produced in the world, which is the left most term in the sum and within the brackets of (2), plus all nontradable goods produced by country j, which are given by the right term within the brackets. The parameter $\rho > 1$ is the elasticity of substitution and it is assumed to be identical across countries.

4.2 Optimizing Firms

There is monopolistic competition such that each firm is the single producer of one differentiated good. This firm sets the profit-maximizing price. Not all firms within one country are symmetric since in country j the fraction s_j of firms produces tradable goods, whereas the fraction $(1 - s_j)$

produces nontradable goods. Let y_{ji}^{T} denote the output produced by country-j tradable firm i and y_{ji}^{NT} the output produced by country-j nontradable firm i. In addition, let $y_{ji,k}^{T}$ be the tradable output of firm i produced for country k so that

$$y_{ji}^{T} \equiv \sum_{k=1}^{J} y_{ji,k}^{T}. \tag{3}$$

All firms face a linear production function that has constant returns to scale and that operates with labor as the only input

$$y_{ji,k}^{T} = A_j L_{ji,k}^{T} \tag{4}$$

$$y_{ji}^{NT} = A_j L_{ji}^{NT} \tag{5}$$

where A_j is an exogenous and country-specific technology level that is assumed to be the same across the tradable and nontradable sectors. $L_{ji,k}^{T}$ and L_{ji}^{NT} denote the amount of labor used to produce $y_{ji,k}^{T}$ and y_{ji}^{NT} with

$$L_{ji}^{T} \equiv \sum_{k=1}^{J} L_{ji,k}^{T} \tag{6}$$

Since all consumers within one country are identical, they each spread their labor over all domestic firms according to how much labor input each firm needs. Since labor is assumed to be internationally immobile, domestic consumers do not work for foreign firms. It turns out that all country-j firms set the same price p_j, irrespective of whether they produce tradable or nontradable goods. The technical appendix shows that the model outlined above has a unique equilibrium solution.

4.3 A Gravity Equation with Trade Costs

As shown in the technical appendix, one can derive the following 'gravity' equation that incorporates trade costs

$$EXP_{j,k}EXP_{k,j} = s_j \left(GDP_j - EXP_j\right) s_k \left(GDP_k - EXP_k\right) \left(1 - \tau_{j,k}\right)^{\rho-1} \left(1 - \tau_{k,j}\right)^{\rho-1} \tag{7}$$

where GDP_j is real output of country j and $EXP_j \equiv \sum_{k \neq j} EXP_{j,k}$ are total real exports from j.

Of course, (the product of) bilateral trade, $EXP_{j,k}EXP_{k,j}$, decreases if bilateral trade costs $\tau_{j,k}$ and $\tau_{k,j}$ are higher. It also decreases if there are fewer firms that produce tradable goods, i.e. if the shares s_j and s_k are lower. Given these variables, bilateral trade is not solely determined by GDP as in traditional gravity equations, but by the terms $(GDP_j - EXP_j)$ and $(GDP_k - EXP_k)$. These terms can be interpreted as 'market potential' in the sense that $(GDP_j - EXP_j)$ is country-j output which is potentially tradable but not yet traded. It is obvious by inspection that trade is increasing in the size of each country's market potential.

Gravity equation (7) also captures what Anderson and van Wincoop (2003) call "multilateral resistance." Trade flows are determined by two countries' bilateral trade barriers (i.e., $\tau_{j,k}$ and $\tau_{k,j}$) relative to their trade barriers with other trade partners. For example, imagine that all trade barriers $\tau_{j,l}$ between j and all countries l with $l \neq k$ go down and all else is constant including $\tau_{j,k}$. Then total exports EXP_j increase but by equation (7) trade between j and k drops despite no absolute change in their trade costs. The total export terms EXP_j and EXP_k in (7) can therefore be referred to as multilateral resistance variables because they implicitly capture the trade barriers a country faces with all other partners. Note that gravity equation (7) captures multilateral resistance by directly observable variables and is therefore more practical than those which include unobservable price indices devised by Baier and Bergstrand (2001) and Anderson and van Wincoop (2003).

A major advantage of gravity equation (7) is that it allows for simple computation of the bilateral trade costs that are implied by observable trade flows. We derive a measure of symmetric trade costs where $\tau_{j,k} = \tau_{k,j}$, an assumption which is standard in the literature (cf. Anderson and van Wincoop, 2003). Non-symmetric trade costs are computable too, but turn out to be very noisy largely because of bilateral trade imbalances. Assuming symmetry of trade costs 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. It is also assumed that the fraction of firms producing tradable goods is the same across countries ($s_j = s_k = s$). Gravity equation (7) can then be rewritten as

$$\tau_{j,k} = \tau_{k,j} = 1 - \left(\frac{EXP_{j,k}EXP_{k,j}}{(GDP_j - EXP_j)(GDP_k - EXP_k)\, s^2} \right)^{\frac{1}{2\rho-2}} \tag{8}$$

Intuitively, if bilateral trade flows between j and k rise, all else being equal, then trade must have become less difficult between these two countries and trade costs must have gone down. Conversely, if output in either country increases without simultaneously leading to an increase in bilateral trade, then the implied trade costs must have gone up. The technical appendix shows that expression (8) still holds even when countries run trade deficits or surpluses. We use equation (8) to compute bilateral trade costs for as many dyads as possible between 1870 and 1913.

5 Trade Cost Estimates

5.1 Data and Methods

In this section, we provide an overview of trends in trade costs from 1870 to 1913. We make use of the trade cost expression given in (8) 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 account 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 imports to each country in the pair since this is how Barbieri reported the data. Here we use the shorthand that imports to k from j equal exports from j to k.

Barbieri's data set is also not complete, and it leaves out trade for colonial dependencies and a number of other observations for smaller countries. When data were missing from Barbieri's dataset, we relied on the data from López-Córdova and Meissner (2003) which reports the sum of exports and imports.[1] We also note that the full sample is unbalanced and somewhat at the mercy of the availability of Maddison's GDP data which is more plentiful in certain benchmark years. By including time dummies, country indicators and conditioning on a host of variables

[1] To approximate the product of imports, we divided the sum by two and then squared the quotient. The bias to trade costs is rarely large for such observations. Where we have both types of data (383 observations), we calculated trade costs in both ways. The median percentage difference is two percent, the mean is 3.1 percent, the standard deviation is 5.1, the first percentile is -12 percent, and the 99th percentile is 23 percent. Finally the correlation between the two measures is 0.98. The number of observations where this occurs is also relatively small and mainly occurs for country pairs with Australia, Canada and New Zealand. In the full sample of trade costs there are 321 observations out of 3,045 where the data was supplemented in this way. In the regressions, 259 out of 2,291 observations were supplemented in this way.

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, ρ, was set to eleven. 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 are preserved for alternative elasticities of substitution. Our results are robust to alternative assumptions about ρ. Indeed the estimated parameters in our regressions below are almost totally unaffected by the choice of ρ.

When the elasticity of substitution is set equal to eleven, this corresponds to a ten percent markup over marginal cost. Irwin (2003) shows rough evidence of a 9.8 percent markup in American steel and pig iron products in the late nineteenth century. Typical estimates in the contemporary literature, based on recent data comprising goods that are more differentiated and therefore less substitutable, are around seven or eight as noted in Anderson and van Wincooop (2004). Evenett and Keller (2002) suggest that the share of output in recent years that is tradeable is in the range of 0.3 to 0.8. Stockman and Tesar (1990) argue that the share of tradeable output would be in the range of 0.65 and 0.82. Moreover, it is decreasing in the size of the service and public sector which are typically nontradeable. Both sectors were much less significant in terms of total output in our period. Moreover, this is not exactly what our measure s captures, but the two values are somewhat related. 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 is quite similar for plausible ranges of either parameter again implying that any variation in out data is invariant to parameter assumptions.

As for the trade costs themselves, Figure 1 presents the global index of trade costs for the period. Although subject to some variation, most likely associated with the business cycle or simply noisy trade data, the general trajectory is clear: trade costs on average fell by nearly ten percent from 1870 to 1913. Our derived trade costs suggest most regions of the world clearly enjoyed lower trade costs at the end of the period. We 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 sub-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 (calculated as $\frac{\tau_{k,j}}{1-\tau_{k,j}}$) . These levels are based on the assumption that $\rho = 11$. Lower values would give rise to higher estimated trade costs. For instance when $\rho = 5$ the range of trade costs is 37 to 96 percent. If we re-calculate our trade costs based on an elasticity of substitution of 8 the first and 90th percentiles would be 30 and 80 percent in the full sample. We are struck by the similarity between our baseline 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., $\rho = 8$)".

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 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 was 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. 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, informational advantages, networks, etc.) and colonial ties (formal or informal) manifest themselves strongly in such examples.

Table 4 studies the ten country pairs with the largest declines and rises in their trade costs over the period. Here we take the percentage change between the average value of τ by country-pair in the period 1870 to 1879 and 1900 to 1913. The opening up of Japan is quite visible in this table. Trade cost changes between Japan 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 -21 percent and -16 percent respectively. 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.

6 The Determinants of Trade Costs

Recently researchers have focused on transportation, communications, tariffs, national borders, and currency unions as determinants of trade costs. Little consensus exists on the functional form that best describes trade costs. As our baseline, and following the bulk of previous work so as to provide a measure of comparability, we consider a log-linear specification of iceberg trade costs of the following form:

$$\tau_{jk} = Dist_{jk}^{\delta} \exp^{\beta_0+\beta_1 X_1+\beta_2 X_2+\beta_3 X_3+\beta_4 X_4} \tag{9}$$

where $\beta = [\beta_0, \beta_1, \beta_2, \beta_3, \beta_4]$ is a vector of coefficients, $Dist_{jk}$ 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:

$$\ln(\tau_{jkt}) = \beta_0 + \delta \ln(Dist_{jk}) + \beta_1 X_{1jkt} + \beta_2 X_{2jkt} + \beta_3 X_{3jkt} + \beta_4 X_{4jkt} + \varepsilon_{jk} + \varepsilon_{jkt} \tag{10}$$

where we now subscript for year t and allow for a composite error term. In various specifications we allow for country fixed effects or country-pair fixed effects. Country fixed effects allow for unobservables at the country level and control for factors affecting integration with all trade partners. Most of the variance in the data in this type of specification is in the cross-section. Country-pair fixed effects focus on the inter-temporal variation in the data. We also check the functional form and use the ad-valorem tariff equivalent rather than the iceberg trade cost as the dependent variable. We exclude zero trade pairs and assume the bias is small from doing so.

We break the potential determinants of trade costs into four groups: Policies (X_1), including trade policy and exchange rate regime coordination; Geography (X_2), 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 (X_3), which also lower information costs and the costs of contract enforcement; and finally shipping facilities (X_4) directly associated with navigable waterways within a country and the penetration of the railroad. We include a description of each of the variables we use in these categories in the data appendix and the variable descriptions in the left most column of Table 5.

In Table 5 we report three separate regression specifications of equation (10). The first column presents a random effects specification. Columns 2 and 2a report models with time-varying country fixed effects (i.e., country intercepts are interacted with "decade" indicators (1870-1879, 1880-1889, 1890-1899 ,and 1900-1913)). Country fixed effects control for unobservables or omitted factors at the country level that affect all trading partners such as uniform improvements in local infrastructure or freight rates. Allowing for an annual country-specific intercept would be ideal, but the dataset is too small for this to be feasible. We assume these unobservables are constant within each of the four periods. Columns 1a, 2a, and 3a standardize all variables to have a zero mean and standard deviation of one so that the relative impact of each regressor on the dependent variable can be gauged appropriately. In columns 3 and 3a we replace the country effects with non-time-varying country-pair fixed effects. In our discussion we focus on specifications with time-varying fixed effects (columns 2 and 2a), but report the other results in the tables so the reader can see our main conclusions are largely robust to other specifications.

Policies: Tariffs and Exchange Rate Regimes

In the full sample, tariffs appear to be positively associated with higher trade costs.[2] A one standard deviation increase in the log product of tariffs would yield a tenth of a standard deviation increase in the log of trade costs or a two percent increase in bilateral trade costs (column 2a Table 5).

We also added (but do not report) a control variable for whether a pair had implemented a most favored nation treaty or some other type of bilateral trade treaty based on Pahre (2007). When we drop the tariff measure and include this dyadic indicator of trade policy, we find it is positively related to trade costs and statistically significant at the 92 percent level of confidence. The reason the treaty variable might come in as positive is that treaties were often signed with countries with which nations had the weakest trade links but with which they would have liked to strengthen them. There seems to be little that would support the idea that integration actually improved after signing an trade treaty. Three lags of the treaty variable, along with a contemporaneous measure, find no statistically significant relationship. This echoes the finding by Accominotti and Flandreau (2005) that bilateral trade treaties did not promote trade prior to 1870. It could be argued that since treaties were signed in batches and most important countries ended up adhering to numerous treaties the bilateral impact would be very small. What matters is what happens relative to other trading partners. In this regard Saul (1967) claims that in 1908 the UK had 46 most-favored nation treaties, Italy had 45, the US and Germany had 30 each, and France, Japan, and Spain had between 20 and 30. Hence such treaties would cover the bulk of all trading partners for the important countries.

Adherence to the gold standard also appears to be consistently associated with lower trade costs. Adoption of the gold standard is associated with a roughly three percent decline in trade costs. The coefficient here is very similar in magnitude, but opposite in sign, to the impact of tariffs. Credible exchange rate stability seems to go along with greater 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 does not seem to have any associ-

[2] The tariff measure is total tariff revenue divided by total imports. This is not without the usual caveats.

ation with trade costs. The explanation lies in the fact that many of the 'volatile' observations are associated with paper or silver money depreciation in the late 1880s or severe financial crises. These ostensibly expansionary depreciations no doubt allow for greater exports in the short-run until the real-exchange rate can fully adjust to its equilibrium level. Meanwhile volatility as opposed to abrupt depreciations may have created uncertainty and increased the costs of trade. This could lead to a washout in the estimation.

The coefficient on monetary unions is negative and statistically insignificant. 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 and Switzerland in the Latin Monetary Union are missing due to missing tariff data or trade data.

Geography & Proximity

Nations further apart seem to have higher trade costs. Taking 0.15 as the distance elasticity from column 2a, the standardized coefficient for distance is measured as nearly 1.45. A one standard deviation increase in the distance between countries would be associated with more than a one standard deviation increase in trade costs.

Distance between countries seems to matter less in economic terms over time. In column 2 and 2a there is a significant decline in the coefficient on distance over time. It is quite high early on and its standardized coefficient is extremely large. By 1890-1899 the standardized coefficient has fallen by one third. A formal test of the null hypothesis that all the coefficients on distance are the same can be rejected. The coefficient for the years 1900-1913 is small and statistically insignificant but there appears to be a problem with collinearity with the country fixed effects, so we would not take this as hard evidence that the coefficient on distance is truly zero in this sub-period. Nevertheless, distance appears to matter less and less in the run up to 1913 probably in part because shipping costs continued to fall over the period.

In Table 6 we asked if there were non-linearities in the relationship between trade costs and distance or 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 5,380 kilometers. We found little difference in the point estimates of the slope parameters for any of these categories. Nevertheless the short distance parameter is very imprecisely estimated suggesting that it may be somewhat less costly to trade at very short distances. Beyond the nearest neighbors, our estimates suggest that the gains in shipping know-how applied equally or that information did not worsen more quickly at long distances.

In the decade after 1870, it does not appear that island nations had lower trade costs than others. These country pairs (i.e., those involving the UK, Japan, and Australia) would tend to use ocean-going vessels to transport goods and their commercial centers would more likely be closer to major ports.

It is little surprise that sharing a border seems to increase international integration. This variable appears to be associated with a decrease in trade costs of about 17 percent (column 2 of Table 5). The normalized size of the coastline appears to have a negative impact on trade and it is statistically significant. The negative coefficient implies that larger coastlines could contribute to a greater probability of having more or better port facilities and accessible markets which in turn enables trade.

Institutions and Shared Culture

We also find some evidence for institutional factors. There is a statistically significant and negative coefficient on the indicator for membership in the British Empire in column 2 of Table 5. We see that membership of both countries in the British Empire is associated with trade costs that are lower by 20 percent. Although special tariff privileges from the UK to the colonies, and vice versa, had largely died out by this time (Saul, 1967), those implemented by certain colonies may have mattered especially in Canada which gave preferential treatment to British goods. The conventional wisdom is that British competitors eroded British market share over time in almost all markets but alarmingly so in many outposts of the commonwealth. Even so our evidence suggests that there was still a substantial advantage for intra-Empire trade throughout the period.

We use a dummy variable to indicate whether two countries shared the same colonizing country as a proxy for similar inherited institutional and legal technologies. There is no evidence that these factors were important for trade costs since the coefficient on this indicator is statistically insignificant. Finally there is little clear 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). In column 2 of Table 5 sharing a common language is also associated with lower trade costs. Overall these results suggest a rather mixed association between trade costs and long-run cultural and historical factors that proxy for institutions and cultural heritage. Common languages and the British Empire seem to be the most convincing determinants of trade costs both of them decreasing trade costs.

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 infrastructure matters. In fact, we find a fairly significant role for the accumulation of railroad infrastructure and the length of waterways. The standardized coefficient on railroad density increases to -0.42. In other words a one standard deviation increase in the total length of a dyad's railway network (relative to land area) would have decreased trade costs by about one-half of a standard deviation. This impact is larger than either gold standard adherence or an increase in tariff revenues. Internal waterway connections also increased integration.

We also attempted to find a role for the telegraph. We have information on telegraph messages sent per person which is highly correlated with the density of the railroad network. When this measure of telegraph usage is substituted for railroad density, the coefficient is negative but statistically insignificant (p-value = 0.12). When entered in the same regression as the railroad variable, both are negative and statistically insignificant. Finally when we include both variables and an interaction term between them, the coefficient on telegraphs is associated with lower trade costs and the interaction term suggests that this reduction is smaller (in absolute terms) as railroad density increases. These results are similar to the findings of Lew and Cater (2006). In their gravity models, railroad density is not found to be a statistically significant determinant of bilateral trade while telegraph densi ty is. Both measures are correlated which makes identification of their parameters troublesome. But there is some evidence that both factors decrease trade costs.

6.1 Sensitivity: Functional Form and Alternative Dependent Variables

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 make the model additive in the arguments rather than exponential as before. The dependent variable is the level of trade costs. Qualitatively, results are parallel to those in columns 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 joint adherence to the gold standard was equivalent to a drop in tariffs of five percentage points or that a one percent increase in the product of railroad density was associated with a drop in tariffs of one percent.

6.2 The Reliability of τ: A Gravity Approach

In this section we propose a test of the validity of the derived gravity model. We can also derive an independent estimator of trade costs that does not impose any particular assumption on the exact value of the elasticity of substitution or the tradeable shares. With this we can show how much of the variance of the preliminary measure of trade costs, τ, is explained by our proposed trade cost function even when we make no assumptions about the key parameters, ρ and s.

Using equation (7), and assuming symmetry we have

(11)

$$\ln\left(EXP_{j,kt}EXP_{k,jt}\right) = (2\rho - 2)\ln\left(1 - \tau_{j,kt}\right) + \ln\left[\left(GDP_{jt} - EXP_{jt}\right)\left(GDP_{kt} - EXP_{kt}\right)\right] + \ln\left(s_i\right) + \ln(s_j)\,.$$

This is estimable by OLS using information on exports, GDP, total exports, and the determinants of trade costs listed above. To estimate the gravity equation, we impose the assumption we made above that the terms representing the tradable share of products, s, are time-invariant. We use country specific indicator variables (country fixed effects) in lieu of these terms and exclude the constant term.[3] Finally, we use the same set of determinants we used above in estimating the trade cost function. Here the interpretation is that the same factors affect integration defined as $\ln(1 - \tau_{jkt})$. Specifically we have

$$\ln(1 - \tau_{jkt}) = a_0 + a_1 \ln(Dist_{jk}) + a_2 Z_{jkt}. \tag{12}$$

The variables in the vector Z_{jkt} are the same as above in our trade cost regressions. Substituting equation (12) into (11) we can now proceed to estimation by OLS of our gravity equation. In doing so we shall estimate reduced form coefficients on the determinants of integration that are equal to $(2\rho - 2)\, a_n$ where a_n is a coefficient in the vector of structural coefficients a_0, a_1, a_2. Also a_2 is a $1 \times N$ vector of coefficients $[a_{21}, ..., a_{2N}]$ premultiplying our determinants of trade costs. The structural coefficients from the integration equation are found by dividing reduced form point estimates by $(2\rho - 2)$ and assuming an elasticity of substitution $\rho = 11$.

Table 7 presents the results of the estimation. 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 roughly 65 percent. Adherence to the gold standard is associated with an increase of slightly over 50 percent, and the elasticity of the product of bilateral trade flows with respect to the product of railroad mileage per square mile in partner countries is 0.12. These two coefficients are precisely estimated.

Overall our gravity approach seems to perform quite well in the data. The coefficient on the absorption term is estimated at 1.06, but we cannot reject the null hypothesis that the coefficient is the theoretically predicted value of one (p-value = 0.76). It appears that endogeneity or collinearity between economic expansion and the determinants of trade costs is minimal otherwise there would be a strong bias in the coefficients.

We now turn to the association between estimated trade costs and our accounting based

[3] Anderson and van Wincoop (2004) suggested substituting country-level intercepts for the GDP terms and the mulitlateral resistance terms and a trade cost function to estimate a cross-sectional gravity model corresponding to their expenditure system. Here country fixed effects will also lead to consistent estimation of the parameters in the trade cost function. At the same time, the country fixed effects may capture other unobservables besides the trade share so these are not identified.

measure τ. From the gravity regression, we recover the estimator of trade costs, $\widehat{\tau} = 1 - \exp\left\{\frac{\widehat{a}_0 + \widehat{a}_1 \ln(Dist) + \widehat{a}_2 Z}{2\rho - 2}\right\}$. Next we use our assumed value of 11 for the elasticity of substitution ρ. We then compare $\widehat{\tau}$ to the measure we calculated directly from the data. A regression of trade costs, τ, on $\widehat{\tau}$ finds a constant term of 0.33 (t-stat = 131.7) and a coefficient on $\widehat{\tau}$ of 0.54 (t-stat = 33.5). The R-squared from the regression is 0.33 which suggests that we capture about a third of the variance of τ with the included trade cost proxies and the chosen functional form. Above, in column 1 of Table 5, we found that we explained about 45 percent of the variance of the log of trade costs.

The correlation between the two estimators of trade costs increases markedly when we restrict attention to country pairs within Europe. Here we find a correlation of 0.9 and a regression of τ on $\widehat{\tau}$ exhibits a coefficient on $\widehat{\tau}$ of 0.71 (t-stat 41.82) and a constant term of 0.34 (t-stat = 161). The R-squared is also much higher than in the full sample at 0.82.

Finally, we ranked country pairs by their values of τ and $\widehat{\tau}$ and found a correlation between the two sets of rankings for pairs located in Europe of 0.9 but of only 0.53 in the entire sample. For the within-Europe pairs, the regression of the rank of the first measure on the latter measure provides a small constant term of 11 and a slope coefficient of 0.94. In the entire sample, the slope coefficient is 0.53 and the intercept is estimated at 535.

It also appears that our list of explanatory variables does a much better job of capturing the determinants of trade costs within Europe than outside of that sample. This could be the case if historical linkages, shared cultural norms or proximity via regional border effects were major determinants of trade costs. We control for none of these forces in our regressions because of the lack of detailed and agreed upon measures of these factors. Nevertheless the idea that different factors explain trade costs at different distances seems like an interesting avenue for further research.

7 Accounting for the Increases in Global Trade 1870-1913

Finally, we return to one of our key questions: what accounts for the marked increase in global trade flows between 1870 and 1913? The existing literature on the pre-World War I and post-World War II waves of globalization offer likely suspects. On the one hand, much of the historical literature has emphasized reductions in trade costs—specifically those arising from endogenous changes in commercial policy and exogenous changes in transport technology (see O'Rourke and Williamson, 1999). O'Rourke and Williamson (1999) argue "*all* of the commodity market integration in the Atlantic economy after the 1860s was due to the fall in transport costs between markets..." (p. 29 emphasis in original). On the other hand, much of the contemporary literature has emphasized secular patterns in income growth and convergence (see Baier and Bergstrand, 2001). What we aim for in this section is to simply relate changes in bilateral trade flows to changes in total market size and changes in trade costs in an accounting sense. Our gravity model provides a straightforward way to do this.

To arrive at a 'decomposition' of the factors affecting the growth of total trade we perform the following exercise. We take the first difference of equation (11) and then the sample average to arrive at

(13)

$$\overline{\Delta \ln (EXP_{j,kt} EXP_{k,jt})} = \overline{\Delta \ln (GDP_{jt} - EXP_{jt})} + \overline{\Delta \ln (GDP_{kt} - EXP_{kt})} + (2\rho - 2)\overline{[\Delta \ln (1 - \tau_{j,kt})]}$$

where Δ is the first difference operator, $\ln(s_i s_j)$ vanishes as s is assumed time invariant as before, and the bars denote sample averages of the expressions underneath them. The first two terms on the right hand side account for increases in trade due to 'market' expansion or economic growth. The last term, call it the integration measure, will increase in the face of a generalized fall in trade costs.[4] It accounts for the impact of changes in trade costs on trade. It is readily seen that the percentage of the change in trade due to changes in trade costs is invariant to the value of the elasticity of substitution as long as this elasticity is constant over time.

In columns 2, 3 and 4 of Table (8) we present the implied total contribution to the growth of trade made by the terms on the right hand side of equation (13). Beneath these figures

[4] This exercise does not readily give us a sense of the average change in actual trade costs which drive changes in the integration term $\ln(1-\tau)$. However, we note that within the sample the average change in $\ln(\tau)$ was -0.002.

we express these contributions as percentages of the total to be explained by dividing each of these contributions by $\overline{\Delta \ln \left(EXP_{j,kt} EXP_{k,jt}\right)}$. We carry out this exercise for various sub-samples of our data set. The first row presents results for the entire sample for which we have observations that can be first differenced. He we see that two-thirds of the expansion of trade can be accounted for by changes in trading partners' market capacity. Declines in trade costs account for about 42 percent of the observed increase in integration. Sampling error, sample composition, and approximation error due to using the logarithmic transformation account for the ten percent over-prediction listed in column 5.

Taken together with the coefficients, decreases in trade costs explain somewhere between 35 and 45 percent of the change in the product of exports for a broad sample of country pairs. The case for an overriding role for communication and transportation technologies in the first wave of globalization is muted here. Instead, we are suggesting a view in which the primary mover of increased trade volumes is secular increases in income with ancillary contributions from policy and technology. If the relevant metric were trade flows relative to market capacity then transportation costs cannot be the only component driving trade. Under any plausible constellation of parameters, trade costs themselves do not fall nearly as much as the freight cost indexes did. Trade costs consist of many other factors besides transportation costs.

Our decomposition hinges on only three main assumptions: increases in bilateral trade can result only from increases in market potential or decreases in trade costs; increases in market size map one-for-one into increases in trade; and changes in trade costs are systematically unrelated to economic size. On the first point, given how broadly defined the terms of the argument are, it seems hard to come up with any other alternative—here, trade is ascribed to either a general demand effect (income) or the frictions separating markets (trade costs). On the second point, it should be noted that unit income elasticity is specific to our particular model, but is often seen in the standard theoretical gravity literature. Evenett and Keller (2002) derive gravity models from several leading theories of international trade. All of them possess unit elasticities of output.[5] Thus, even if we allow for differences in the underlying modeling strategy, or the

[5] Anderson and van Wincoop (2003) allow for non-unitary elasticities of income by assuming the share of income spent on tradeables, ϕ, equals Y^{α}.This is despite the fact that they themselves argue "there is no clear

value of parameters underlying our estimates of the trade costs, the fact remains that changes in income will always explain a majority of the variation in the bilateral trade data for this period. On the third point, we found above that the coefficient on market potential was estimated at 1.06 and very precisely estimated even when we included various proxies of trade costs. If the determinants of trade costs and economic expansion were highly correlated we would have expected an imprecise estimate on the market potential variable and a highly biased coefficient.

Interestingly our baseline conclusion changes by sub-sample. The next seven calculations in Table 8 look at similar decompositions for various sub-samples. The key conclusion is that economic expansion explains a greater proportion of the increase in trade in the more economically advanced country pairs. We performed the decompositions for France and then the United Kingdom and the US. For the UK, 97 percent of the average increase in trade is accounted for by economic expansion at home and abroad. The term involving trade costs accounts for just under ten percent. In France trade costs *rose* on average thus counteracting the effect of economic expansion. If France and its partners had not grown in economic size, their trade would have been perhaps half of its 1870 value in 1913. The US exercise suggests that declines in trade costs account for roughly half the American expansion of international trade between 1870 and 1913. We do not report results by decade for the entire sample but remark that falling trade costs explain up to 80 percent of the increase in trade between 1870 and 1879. Between 1900 and 1913 they explain less than a third of the increase in trade.

Opposite to what happened within Europe, core-periphery trade increased largely due to declines in trade costs. The evidence is consistent with the idea that the expansion of trading networks through pro-active marketing strategies in new markets, the development of new shipping lines and better internal communications (e.g., railroads and telegraphs) in the periphery were the main drivers of core-periphery trade between 1870 and 1913.

theoretical foundation for specifying the fraction spent on tradables as Y^{α}." More alarmingly for proponents of the idea that trade costs are the key driver of integration is that Anderson and van Wincoop note α is likely to be greater than zero. This implies a unit elasticity of output *greater* than one. To the extent that there is any validity to their argument, an imposed unitary income elasticity provides an *upper* bound for the impact of trade costs. We also re-emphasize that ϕ is not the same as s.

8 Conclusions

We have studied the patterns, evolution and determinants of trade costs between 1870 and 1913. The theoretical foundation for these estimates presents a new way to explain international trade integration that is much easier to implement empirically than existing general equilibrium gravity models of international trade. The patterns we have found suggest that overall trade costs may not have declined dramatically after 1870 notwithstanding the manifest drop in shipping costs. Somewhere between 30 and 40 percent of trade costs appear to be explained by geographic factors, policies, technology and infrastructure, and gross tariffs. The explanatory power of these 'standard' explanations is much greater within the European core than outside of it.

Over time there is evidence that improvements in transportation contributed to lower trade costs so that distance mattered less and less for the degree of integration. But changes in the prevalence of monetary regime coordination and increases in tariffs also played a significant role in explaining trade patterns and the increase in international integration. Overall economic expansion appears to be more responsible for increasing international trade than changes in trade costs between 1870 and 1913.

Appendix A
Technical Appendix

This appendix outlines how we derive the theoretical results presented in section 4. Subsection A.1 focuses on the equilibrium solution of the model. Subsection A.2 derives the results of subsection 4.3. Subsection A.3 demonstrates that the trade cost expression (8) holds even when countries run trade deficits or surpluses. This appendix is based on Novy (2006). Since within one country all firms producing tradable goods are symmetric and all firms producing nontradable goods are also symmetric, the index i will be dropped in what follows.

A.1 Consumers

The consumption-based price index is defined as the minimum expenditure for one unit of C_j and can be derived from (2) as

$$P_j = \left[\sum_{k=1}^{J} \int_{n_{k-1}}^{n_{k-1}+s_k(n_k-n_{k-1})} (\xi_{ji})^{1-\rho} \, \mathrm{d}\, i + \int_{n_{j-1}+s_j(n_j-n_{j-1})}^{n_j} (\xi_{ji})^{1-\rho} \, \mathrm{d}\, i \right]^{\frac{1}{1-\rho}} \tag{14}$$

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

$$\xi_{ji} = \begin{cases} \frac{1}{1-\tau_{k,j}} p_{ki}^{T} & \text{for} \quad n_{k-1} \leq i \leq n_{k-1} + s_k(n_k - n_{k-1}) \quad \forall \quad j,k \\ p_{ji}^{NT} & \text{for} \quad n_{j-1} + s_j(n_j - n_{j-1}) \leq i \leq n_j \end{cases} \tag{15}$$

p_{ki}^{T} denotes the f.o.b. (free on board) price of the tradable good produced by country-k firm i and $p_{ki}^{T}/(1-\tau_{k,j})$ is the c.i.f. (cost, insurance, freight) price of the same good when traded with country j. The price of the nontradable good produced by firm i in country-j is p_{ji}^{NT}. All prices are denominated in one world currency.

The c.i.f. price is $1/(1-\tau_{k,j})$ times the f.o.b. price because when one unit of a tradable good produced by a country-k firm is shipped to country j, only the fraction $(1-\tau_{k,j})$ arrives at the destination. The tariff equivalent $\theta_{k,j}$ of iceberg trade costs can be expressed as

$$\theta_{k,j} = \frac{1}{1-\tau_{k,j}} - 1 = \frac{\tau_{k,j}}{1-\tau_{k,j}} \tag{16}$$

Maximizing consumption (2) subject to the minimum expenditure (14) yields the individual demand function

$$c_{ji} = \left(\frac{\xi_{ji}}{P_j} \right)^{-\rho} C_j \tag{17}$$

A.2 Firms

With clearing markets it follows from the demand function (17) for the tradable good produced by country-j firm i

$$(1-\tau_{j,k})\, y_{ji,k}^{T} = \left(\frac{\frac{1}{1-\tau_{j,k}} p_{ji}^{T}}{P_k} \right)^{-\rho} (n_k - n_{k-1}) C_k. \tag{18}$$

The right-hand side of (18) represents the amount of the tradable good i that the $(n_k - n_{k-1})$ consumers in country k demand. The left-hand side is the value of the same good that arrives in country k after being shipped there from country j. Accordingly, it follows for a country-j nontradable good

$$y_{ji}^{NT} = \left(\frac{p_{ji}^{NT}}{P_j}\right)^{-\rho} (n_j - n_{j-1})C_j \tag{19}$$

The profit function for tradable firm i in country j is

$$\pi_{ji}^T = \sum_{k=1}^{J} \left(p_{ji}^T y_{ji,k}^T - W_j L_{ji,k}^T\right) \tag{20}$$

where W_j is the nominal wage that is assumed to be the same in the tradable and nontradable sectors. Plugging the production function (4) and the market-clearing condition (18) into (20) and maximizing with respect to p_{ji}^T yields

$$p_{ji}^T = \frac{\rho}{\rho - 1}\frac{W_j}{A_j} \tag{21}$$

For nontradable firms the same procedure leads to

$$p_{ji}^{NT} = \frac{\rho}{\rho - 1}\frac{W_j}{A_j} \tag{22}$$

so that

$$p_{ji}^T = p_{ji}^{NT} \equiv p_j \tag{23}$$

A.3 Equilibrium of the Model

Each country-j consumer maximizes utility (1) subject to budget constraint given by

$$P_j C_j = W_j L_j + \pi_j \tag{24}$$

where W_j is the nominal wage and π_j denotes per-capita nominal profits made by country-j firms, which are fully redistributed to country-j consumers. This leads to the optimal labor supply condition

$$\frac{\eta}{1 - L_j} = \frac{W_j}{P_j C_j} \tag{25}$$

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

$$y_j \equiv s_j y_j^T + (1 - s_j) y_j^{NT} \tag{26}$$

$$L_j \equiv s_j L_j^T + (1 - s_j) L_j^{NT} \tag{27}$$

$$\pi_j \equiv s_j \pi_j^T + (1 - s_j) \pi_j^{NT}$$

where y_j^T is the same as y_{ji}^T from (3), L_j^T is the same L_{ji}^T as from (6) and π_j^T is the same as π_{ji}^T from (20). The remaining right-hand side variables are the corresponding variables for nontradable firm i. Using the production functions (4) and (5) as well as the price markups (21)-(23) it follows

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

Combined with budget constraint (24) and the optimal labor supply condition (25) this yields the optimal per-capita labor supply

$$L_j = \frac{\rho - 1}{\rho - 1 + \rho\eta} \tag{28}$$

Express nominal wages across countries as

$$\alpha_1 W_1 = \alpha_2 W_2 = ... = \alpha_j W_j = ... = \alpha_J W_J$$

where the α's are auxiliary parameters yet unknown. It follows from the price markups (21)-(23) that

$$p_k = p_k^T = \frac{\rho}{\rho - 1}\frac{W_k}{A_k} = \frac{\rho}{\rho - 1}\frac{\alpha_j}{\alpha_k}\frac{W_j}{A_k} \tag{29}$$

Use (29) in price index (14) to derive

$$P_j = \omega_j^{\frac{1}{1-\rho}} \frac{\rho}{\rho - 1} W_j$$

where

$$\omega_j \equiv \left(\sum_{k=1}^{J} s_k (n_k - n_{k-1}) (A_k (1 - \tau_{k,j}) \frac{\alpha_k}{\alpha_j})^{\rho-1} \right) + (1 - s_j)(n_j - n_{j-1}) A_j^{\rho-1} \tag{30}$$

An expression for the real wage follows directly as

$$\frac{W_j}{P_j} = \frac{\rho - 1}{\rho} \omega_j^{\frac{1}{\rho-1}} \tag{31}$$

Using budget constraint (24) and the optimal labor supply condition (25), expressions for consumption and real profits follow as

$$C_j = L_j \omega_j^{\frac{1}{\rho-1}} \tag{32}$$

$$\frac{\pi_j}{P_j} = \frac{L_j}{\rho} \omega_j^{\frac{1}{\rho-1}} \tag{33}$$

as well as

$$C_k = C_j \left(\frac{\omega_k}{\omega_j} \right)^{\frac{1}{\rho-1}}. \tag{34}$$

To solve for the α's in (30), start off with (26) and plug in the market-clearing conditions (18) and (19). Then substitute in for prices and consumption using (21)-(23), (29), (31) and (34) to yield

(35)

$$\begin{aligned} \frac{y_j}{A_j} = \; & C_j \omega_j^{\frac{-\rho}{\rho-1}} \left\{ \left(\sum_{k=1}^{J} s_k (n_k - n_{k-1}) (A_k (1 - \tau_{k,j}))^{\rho-1} \left(\frac{\omega_j}{\omega_k} \frac{s_j}{s_k} \left(\frac{A_j}{A_k} \frac{(1-\tau_{j,k})}{(1-\tau_{k,j})} \right)^{\rho-1} \right) \left(\frac{\alpha_k}{\alpha_j} \right)^{-\rho} \right) \right. \\ & \left. + (1 - s_j)(n_j - n_{j-1}) A_j^{\rho-1} \right\} \end{aligned}$$

From the production functions (4) and (5), definitions (26) and (27) and expression (32) it follows

$$L_j = \frac{y_j}{A_j} = C_j \omega_j^{\frac{-1}{\rho-1}}$$

It must therefore be the case that the curly brackets in (35) are equal to ω_j as defined in (30). Setting the curly brackets equal to ω_j and using (30) yields

$$\frac{\alpha_k}{\alpha_j} = \left(\frac{\omega_j}{\omega_k} \frac{s_j}{s_k} \left(\frac{A_j}{A_k} \frac{(1-\tau_{j,k})}{(1-\tau_{k,j})} \right)^{\rho-1} \right)^{\frac{1}{2\rho-1}} \tag{36}$$

Finally, plug (36) back into (30) to obtain

$$\omega_j = \left(\sum_{k=1}^{J} s_k (n_k - n_{k-1}) (A_k (1-\tau_{k,j}))^{\rho-1} \left(\frac{\omega_j}{\omega_k} \frac{s_j}{s_k} \left(\frac{A_j}{A_k} \frac{(1-\tau_{j,k})}{(1-\tau_{k,j})} \right)^{\rho-1} \right)^{\frac{\rho-1}{2\rho-1}} \right) + (1-s_j)(n_j - n_{j-1}) A_j^{\rho-1} \tag{37}$$

The system of polynomial equations represented by (37) for $j = 1, 2, ..., J$ cannot be solved analytically. However, it can be established numerically by repeated substitution that a unique solution exists for the ω's for all combinations of admissible exogenous parameter values. The admissible parameter values are $0 < n_k - n_{k-1} < 1$, $0 < s_k \leq 1$, $\rho > 1$, $A_k > 0$ and $0 \leq \tau_{k,j} < 1$ for all j, k. The implicit function theorem can be applied to compute the partial effects of changes in exogenous parameters on the ω's.

The ω's give rise to sensible general equilibrium effects for the real wage, consumption and real profits in equations (31)-(33). For example, a technology improvement in A_j increases ω_j and therefore the real wage, consumption and real profits for country-j citizens but, to a smaller extent, it also increases the other ω's and is thus also beneficial to foreign citizens.

A.4 A Gravity Equation with Trade Costs

In order to derive the results of subsection 4.3, plug the market-clearing condition (18) into the right-hand side of

$$EXP_{j,k} = s_j (n_j - n_{j-1}) y_{ji,k}^T \tag{38}$$

where $EXP_{j,k}$ denotes real exports from j to k. Since all country-j firms producing tradable goods are symmetric and since $s_j(n_j - n_{j-1})$ is the overall number of these firms and hence all goods that leave country j for destination country k are given by the right hand side of (38).

Next, use the country-j version of (29), (36) and the country-k versions of (31) and (32). Use production function (4) and rearrange to yield

$$\left(\frac{\omega_j}{\omega_k} \right)^{\frac{\rho-1}{2\rho-1}} = \frac{\omega_j L_{j,k}^T \left(\frac{A_j}{A_k} \frac{(1-\tau_{j,k})}{(1-\tau_{k,j})} \right)^{\frac{\rho(\rho-1)}{2\rho-1}}}{L_k \left(\frac{s_k}{s_j} \right)^{\frac{\rho}{2\rho-1}} (n_k - n_{k-1}) (A_j (1-\tau_{j,k}))^{\rho-1}} \tag{39}$$

Plug the left-hand side of (39) into the right-hand side of (37), noting that $L_j = L_k$ from (28) and using (6) and (27). Also note that $L_{j,j}^T = L_j^{NT}$ as $p_j^T = p_j^{NT}$ through (23). Solve for ω_j to obtain

$$\omega_j = \frac{(n_j - n_{j-1}) A_j^{\rho-1} L_j}{L_{j,j}^T} \tag{40}$$

Plug the country-j and country-k versions of (40) back into the right-hand side of expression (38) and then rearrange to obtain

$$\text{(41)} \qquad \begin{aligned} EXP_{j,k} = \; & (1-\tau_{j,k})^{\frac{(\rho-1)^2}{2\rho-1}} (1-\tau_{k,j})^{\frac{\rho(\rho-1)}{2\rho-1}} (s_j)^{\frac{\rho-1}{2\rho-1}} (s_k)^{\frac{\rho}{2\rho-1}} \times \\ & \left((n_j-n_{j-1})y^T_{j,j}\right)^{\frac{\rho}{2\rho-1}} \left((n_k-n_{k-1})y^T_{k,k}\right)^{\frac{\rho-1}{2\rho-1}} \left(\frac{n_k-n_{k-1}}{n_j-n_{j-1}}\right)^{\frac{1}{2\rho-1}} \end{aligned}$$

Finally, note that the population of country j is $POP_j = (n_j - n_{j-1})$ and the population of country k is $POP_k = (n_k - n_{k-1})$. Also note from (26) that $GDP_j = (n_j - n_{j-1})y_j$ and

$$(n_j - n_{j-1})y_j = s_j(n_j - n_{j-1})y^T_j + (1 - s_j)(n_j - n_{j-1})y^{NT}_j$$

and by definition (3)

$$s_j(n_j - n_{j-1})y^T_{j,j} = s_j(n_j - n_{j-1})y^T_j - s_j(n_j - n_{j-1})\sum_{k\neq j} y^T_{j,k}$$

Using $y^{NT}_j = y^{NT}_{j,j} = y^T_{j,j}$ as $p^{NT}_j = p^T_j$ it follows

$$(n_j - n_{j-1})y^T_{j,j} = (n_j - n_{j-1})y_j - s_j(n_j - n_{j-1})\sum_{k\neq j} y^T_{j,k} = GDP_j - EXP_j$$

The same applies to $GDP_k - EXP_k$. Now plug POP_j, POP_k, $GDP_j - EXP_j$ and $GDP_k - EXP_k$ into (41) to obtain the gravity equation

$$\text{(42)} \qquad \begin{aligned} EXP_{j,k} = \; & (1-\tau_{j,k})^{\frac{(\rho-1)^2}{2\rho-1}} (1-\tau_{k,j})^{\frac{\rho(\rho-1)}{2\rho-1}} (s_j)^{\frac{\rho-1}{2\rho-1}} (s_k)^{\frac{\rho}{2\rho-1}} \times \\ & (GDP_j - EXP_j)^{\frac{\rho}{2\rho-1}} (GDP_k - EXP_k)^{\frac{\rho-1}{2\rho-1}} \left(\frac{POP_k}{POP_j}\right)^{\frac{1}{2\rho-1}} \end{aligned}$$

The corresponding gravity equation for $EXP_{k,j}$ follows analogously.

As a special feature of gravity equation (42), the relative population of country k is a determinant of exports from j to k. Intuitively, the more people inhabit country k, the more imports they demand from country j.[6] Anderson (1979)Anderson (1979) points out that although most theoretical models do not lead to gravity equations that include population, in empirical applications population is nevertheless frequently used as a regressor and usually found to be significant. The present model provides a theoretical underpinning.

Given gravity equation (42) and the corresponding gravity equation for $EXP_{k,j}$ it becomes possible to solve for trade costs as

$$\text{(43)} \qquad \tau_{j,k} = 1 - \frac{(EXP_{k,j})^{\frac{\rho}{\rho-1}} \left(\frac{POP_k}{POP_j}\right)^{\frac{1}{\rho-1}}}{(EXP_{j,k})\,(GDP_k - EXP_k)^{\frac{1}{\rho-1}} (s_j)^{\frac{1}{\rho-1}}}$$

$$\text{(44)} \qquad \tau_{k,j} = 1 - \frac{(EXP_{j,k})^{\frac{\rho}{\rho-1}} \left(\frac{POP_j}{POP_k}\right)^{\frac{1}{\rho-1}}}{(EXP_{k,j})\,(GDP_j - EXP_j)^{\frac{1}{\rho-1}} (s_k)^{\frac{1}{\rho-1}}}$$

[6] If an additional country-k consumer is born, the marginal utility she derives from her first unit of a country-j good will be higher than for an existing country-j consumer, resulting in an increase in $EXP_{j,k}$.

Equations (43) and (44) illustrate that bilateral trade costs between two countries can differ depending on the direction of trade. For example, imagine that initially all right-hand side variables in (43) and (44) are symmetric ($EXP_{j,k} = EXP_{k,j}$, $POP_j = POP_k$ etc.) It follows $\tau_{j,k} = \tau_{k,j}$. Then suppose that all else being equal country k's market potential ($GDP_k - EXP_k$) increases, leading to $\tau_{j,k} > \tau_{k,j}$. Intuitively, if country k absorbs more goods domestically without simultaneously demanding more goods from j, then trade costs from j to k must have gone up.

Finally, in order to derive gravity equation (7), solve (43) and (44) for $(1 - \tau_{j,k})$ and $(1 - \tau_{k,j})$ and multiply them by each other.

A.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. In order to find out how trade imbalances affect our conclusions so far, we refer to Novy (2006) who incorporates trade imbalances into the model. The derivation is reproduced below. Our conclusion is that trade imbalances wash out when the focus lies on symmetric trade costs such that equation (8) remains unaffected.

The per-capita budget constraint (24) is generalized to

$$P_j C_j + \sum_{l=1}^{J} T_{j,l} = W_j L_j + \pi_j \tag{45}$$

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

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

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

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

with $\mu_{j,j} = 0$ for all j such that the budget constraint (45) can be rewritten as

$$\left(1 + \sum_{l=1}^{J} \mu_{j,l}\right) P_j C_j = W_j L_j + \pi_j \tag{46}$$

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

The optimal labor supply condition (25) becomes

$$\frac{\eta}{1 - L_j} = \frac{W_j}{\left(1 + \sum_{l=1}^{J} \mu_{j,l}\right) P_j C_j} \tag{47}$$

and consumption follows as

$$C_j = L_j \omega_j^{\frac{1}{\rho - 1}} \left(1 + \sum_{l=1}^{J} \mu_{j,l}\right)^{-1} \tag{48}$$

The markups (21)-(23), per-capita output (28), real wages (31) and real profits (33) are not affected. If j runs a surplus, this reduces per-capita consumption C_j. Intuitively, due to logarithmic utility in (1), output L_j is constant. If j transfers some of its produced wealth to other countries, then its consumption must fall.

Now use the notation

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

where CA_j denotes the nominal current account of country j and $CONS_j$ denotes the nominal consumption of country j. The equations corresponding to (43) and (44) are

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

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

For example, suppose that initially both j and k have a balanced current account ($CA_j = CA_k = 0$). If all else being equal j now becomes a surplus country ($CA_j > 0$), 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. But gravity equation (8) that make use of trade cost symmetry and from which empirical trade costs are computed is not affected by introducing trade imbalances. Assuming symmetry of trade costs 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

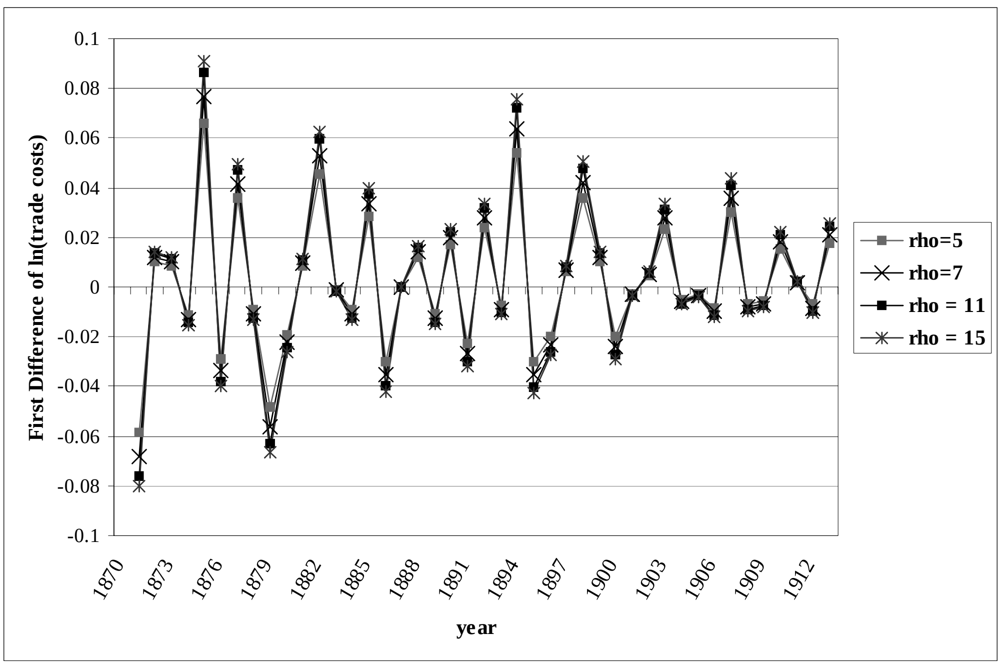
$$V_{j,k} \equiv \frac{p_j EXP_{j,k}}{p_k EXP_{k,j}} = \frac{1 + \frac{CA_j}{CONS_j}}{1 + \frac{CA_k}{CONS_k}}$$

What matters for the ratio $V_{j,k}$ is whether the two countries each run a net total deficit or a net total surplus. For example, 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 ($V_{j,k} < 1$). A country therefore runs either a surplus or a deficit against *all* its trading partners, regardless of the monetary flows from individual trading partners.

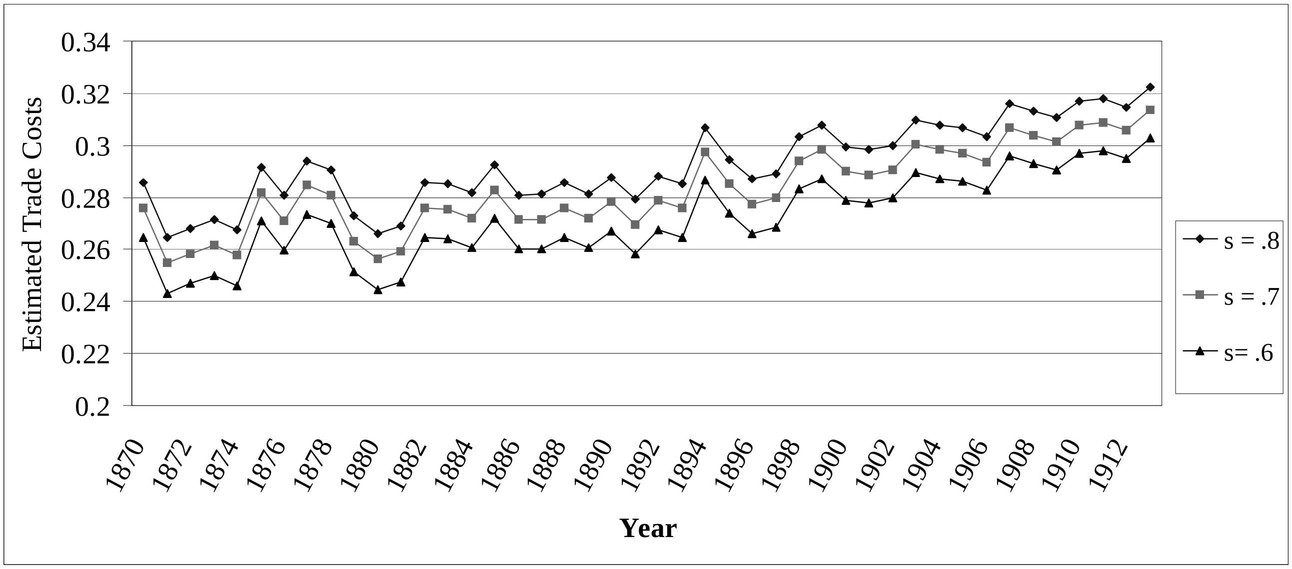
Appendix B
Sensitivity of Trade Costs Measure to Assumptions

Our estimates of the level and change in trade costs are somewhat sensitive to the assumed elasticity of substitution and the tradable shares. As mentioned the variance and the relative ordering of trade costs is fairly stable with respect to perturbations in both the elasticities of substitution and the tradable shares. For example the standard deviation of trade costs when $\rho = 11$ is 0.09 while when $\rho = 5$ it is 0.11. Our reported regression results are strongly robust to 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 in the range of 5 to 11 the log changes are never more than 37 percent apart. For reasonable perturbations in the tradable shares we see only slight variation in levels and little change in the first differences of trade costs for various values of tradable shares.



Sensitivity of Changes in Trade Costs to Elasticity of Substitution, US-UK, 1870-1913



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

Data Appendix

Bilateral Trade
1870-1913: Bilateral trade comes from sources described in López Córdova and Meissner (2003). Trade was made into real 1990 US dollars using a US CPI deflator. Much of the trade data is based on datasets made available by Barbieri (1996) though many supplementary national sources were used.

GDP
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 and data in Clemens and Williamson (2004).

Tariffs: Measured as total customs revenue divided by imports. Most observations come from data kindly provided to us by Michael Clemens and Jeffrey Williamson and are based on Clemens and Williamson (2004). Belgium is from Degrève (1982). Switzerland is from Ritzmann (1996).

Gold Standard Adherence is based on data underlying Meissner (2005) and equals one when both countries adhere to the gold standard.

Exchange Rate Volatility Exchange rate volatility is the standard deviation of the monthly log difference of nominal exchange rates over the previous three years. This is data from López Córdova and Meissner (2003).

Waterways and Coastline This data comes from that underlying Jacks (2005). The coastline variable is the length of the coastline divided by the total land area. Waterways is the total length of navigable waterways divided by land area.

Railroads Total length of railroads divided by land area.

Land Area This is measured as the logarithm of square kilometers. This comes mainly from Stinnett, Tir, Schafer, Diehl, and Gochman (2002) and López Córdova and Meissner (2003).

Bilateral Distance Measured as the logarithm of kilometers between capitals. López Córdova and Meissner (2003) much of which is based on Rose (2000) and also supplemented by indo.com.

Shared Border Indicators Data underlying López Córdova and Meissner (2003).

Landlocked Indicators Data underlying López Córdova and Meissner (2003).

Island Indicator Authors' calculations.

Common Language Data underlying López Córdova and Meissner (2003) and Rose (2000)

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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

1870-1879	Weighted	Unweighted	Partner-Years
Switzerland	0.22	0.36	3
Netherlands	0.23	0.35	75
Australia	0.25	0.29	5
Belgium	0.27	0.36	80
Argentina	0.27	0.34	3
Germany	0.27	0.33	77
United Kingdom	0.28	0.31	94
Austria-Hungary	0.28	0.47	4
New Zealand	0.28	0.35	6
US	0.28	0.42	85
Brazil	0.28	0.43	5
Russia	0.28	0.47	11
France	0.29	0.36	84
Portugal	0.29	0.50	7
Spain	0.30	0.45	5
Canada	0.31	0.47	10
Denmark	0.32	0.41	53
Sweden	0.33	0.41	75
Italy	0.33	0.44	68
Mexico	0.33	0.45	2
China	0.36	0.55	7
Japan	0.41	0.52	3

1890-1899	Weighted	Unweighted	Partner-Years
Switzerland	0.18	0.38	7
Netherlands	0.23	0.38	88
Brazil	0.25	0.38	8
Australia	0.25	0.48	25
Belgium	0.27	0.38	100
United Kingdom	0.28	0.32	104
New Zealand	0.29	0.47	13
Russia	0.29	0.47	13
Germany	0.30	0.34	100
US	0.30	0.40	97
Argentina	0.30	0.41	10
Spain	0.30	0.47	14
Denmark	0.31	0.42	71
Mexico	0.31	0.48	5
France	0.31	0.39	101
Sweden	0.32	0.39	67
Canada	0.32	0.50	22
Portugal	0.33	0.46	12
Italy	0.38	0.45	76
China	0.41	0.53	9
Japan	0.43	0.52	83
Thailand	0.53	0.53	1

1880-1889	Weighted	Un-weighted	Partner-Years
Netherlands	0.22	0.36	72
Australia	0.24	0.43	13
Belgium	0.26	0.36	76
Germany	0.27	0.33	79
United Kingdom	0.27	0.31	82
US	0.28	0.40	78
New Zealand	0.29	0.35	6
France	0.30	0.37	80
Canada	0.30	0.48	15
Denmark	0.32	0.41	64
Sweden	0.33	0.40	62
Italy	0.34	0.43	61
Japan	0.44	0.53	28

1900-1909	Weighted	Unweighted	Partner-Years
Netherlands	0.23	0.37	125
Austria-Hungary	0.24	0.49	21
Belgium	0.27	0.39	175
Australia	0.27	0.48	34
New Zealand	0.28	0.47	16
United Kingdom	0.29	0.34	186
Germany	0.29	0.34	177
Russia	0.30	0.46	16
Switzerland	0.30	0.42	106
Canada	0.30	0.51	41
Denmark	0.31	0.41	94
Argentina	0.31	0.39	97
US	0.31	0.40	184
Norway	0.31	0.40	49
Sweden	0.32	0.40	98
France	0.32	0.40	171
Chile	0.34	0.44	89
Portugal	0.35	0.49	17
Brazil	0.36	0.42	97
Spain	0.37	0.46	134
Italy	0.37	0.45	143
Mexico	0.37	0.49	77
Peru	0.39	0.54	12
Japan	0.41	0.52	106
Colombia	0.43	0.54	10
China	0.44	0.53	15
Venezuela	0.44	0.49	54
Thailand	0.57	0.59	2

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. The "weighted averages" column is the arithmetic average within the period of the annual trade weighted average trade costs.

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		Percentage Change	Top 10 Increases		Percentage Change
Italy	Brazil	-31	New Zealand	Australia	45
Germany	Italy	-27	France	Italy	21
Netherlands	US	-27	United Kingdom	US	15
US	Japan	-21	France	United Kingdom	13
Argentina	United Kingdom	-21	France	Switzerland	10
Belgium	Brazil	-21	Denmark	Sweden	8
United Kingdom	Japan	-20	United Kingdom	Brazil	6
Belgium	Netherlands	-19	Italy	Switzerland	6
Germany	Sweden	-17	France	Belgium	6
Mexico	US	-16	Argentina	France	5

Notes: Change refers to the percentage difference between the pair average of trade costs. The averages are taken at the country 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)* Random Effects	*(1a)* **Rnd. Effects std'zd.**	*(2)* Ctry FE	*(2a)* **Ctry FE Std'zd**	*(3)* Pair FE	*(3a)* **Pair FE Std'zd**
POLICIES						
ln (product of **TARIFFS**)	0.03	-0.15	0.02	0.11	0.04	0.21
	[0.01]***	[0.10]	[0.01]*	[0.07]*	[0.02]**	[0.08]**
Both on **GOLD STANDARD**	-0.03	-0.24	-0.02	-0.05	-0.03	-0.06
	[0.01]***	[0.05]***	[0.01]**	[0.02]**	[0.01]***	[0.02]***
Exchange rate **VOLATILITY**	-0.17	-0.05	-0.21	-0.01	0.00	-0.03
	[0.19]	[0.03]	[0.21]	[0.01]	[0.20]	[0.03]
Both in a **MONETARY UNION**	0.06	0.06	-0.02	-0.02	---	---
	[0.05]	[0.04]	[0.04]	[0.04]		
INFRASTRUCTURE						
ln (product of kms. of **WATERWAYS/AREA** in sq. kms)	-0.56	-0.25	-0.44	-0.14	---	---
	[0.29]*	[0.10]**	[0.24]*	[0.07]*		
ln (product of kms. of **RAILROAD TRACK/SQ. KM**)	-0.01	-0.05	-0.04	-0.42	-0.01	-0.11
	[0.00]***	[0.06]	[0.02]*	[0.26]*	[0.00]**	[0.05]**
GEOGRAPHY						
ln (**DISTANCE**) x indicator for 1870-1879	0.08	0.51	0.19	1.62	---	---
	[0.02]***	[0.23]**	[0.06]***	[0.54]***		
ln (**DISTANCE**) x indicator for 1880-1889	0.08	0.77	0.15	1.45	---	---
	[0.02]***	[0.26]***	[0.03]***	[0.32]***		
ln (**DISTANCE**) x indicator for 1880-1899	0.07	0.95	0.10	1.08	---	---
	[0.02]***	[0.27]***	[0.02]***	[0.25]***		
ln (**DISTANCE**) x indicator for 1900-1913	0.06	1.07	0.03	0.47	---	---
	[0.02]***	[0.35]***	[0.03]	[0.41]		
One country in pair is an **ISLAND**	-0.02	-0.21	-0.05	-0.09	---	---
	[0.04]	[0.08]**	[0.06]	[0.11]		
Both in pair are an **ISLAND**	-0.12	-0.11	-0.07	-0.04	---	---
	[0.10]	[0.05]**	[0.12]	[0.06]		
Countries share a **BORDER**	-0.20	-0.25	-0.17	-0.25	---	---
	[0.04]***	[0.08]***	[0.03]***	[0.05]***		
ln [prodcut of (1+ kms. of **COASTLINE**)/area in sq. kms]	0.30	0.10	-0.26	-0.11	---	---
	[0.19]	[0.10]	[0.09]***	[0.04]***		
INSTITUTIONS & CULTURE						
Both in pair had or have a common **COLONIZER**	0.04	0.02	0.13	0.04	---	---
	[0.15]	[0.03]	[0.09]	[0.03]		
Both in pair share a **COMMON LANGUAGE**	-0.04	-0.07	-0.09	-0.11	---	---
	[0.06]	[0.07]	[0.05]*	[0.06]*		
One in pair was a **COLONY** of the other prior to 1870	-0.21	-0.13	-0.00	-0.00	---	---
	[0.11]*	[0.06]**	[0.07]	[0.05]		
Both in the **BRITISH EMPIRE** or UK and a British Colony	-0.20	-0.03	-0.20	-0.07	---	---
	[0.14]	[0.05]	[0.09]**	[0.03]**		
Constant	-1.27	0.54	---	---	-0.78	0.25
	[0.18]***	[0.41]			[0.10]***	[0.08]***
Observations	2291	2291	2291	2291	2291	2291
Country-Pair Fixed Effects	**no**	no	**no**	**no**	**yes**	**yes**
Country Fixed Effects	**no**	no	**yes**	**yes**	**no**	**no**
R-Squared	0.45	0.54	0.99	0.85	0.14	0.14

Notes: Dependent variable is the natural logarithm of trade costs. Standard errors are in brackets. Year indicators are included but not reported. Estimation is by "random effects" (cols. 1 & 2) and OLS with heteroscedasticity and serial correlation robust standard errors (cols. 2 & 4). 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: Sensitivity Analysis for Trade Costs, 1870-1913

Regressors by category	*(1)* Random Effects Distance Spline	*(2)* Ctry Fixed Effects Distance Spline
POLICIES		
ln (product of **TARIFFS**)	0.03	0.02
	[0.01]***	[0.01]**
Both on **GOLD STANDARD**	-0.04	-0.03
	[0.01]***	[0.01]**
Exchange rate **VOLATILITY**	-0.13	-0.20
	[0.20]	[0.21]
Both in a **MONETARY UNION**	0.05	-0.03
	[0.05]	[0.04]
INFRASTRUCTURE		
ln (product of kms. of **WATERWAYS/AREA** in sq. kms)	-0.63	-0.54
	[0.28]**	[0.25]**
ln (product of kms. of **RAILROAD TRACK/SQ. KM**)	-0.01	-0.04
	[0.00]***	[0.03]
GEOGRAPHY		
Distance < 480 km.	0.04	0.06
	[0.03]	[0.04]
480 km. < distance < 5,380 km.	0.05	0.06
	[0.02]**	[0.03]**
distance > 5,380 km.	0.05	0.06
	[0.02]***	[0.03]*
One country in pair is an **ISLAND**	-0.01	-0.06
	[0.04]	[0.07]
Both in pair are an **ISLAND**	-0.10	-0.09
	[0.11]	[0.12]
Countries share a **BORDER**	-0.19	-0.18
	[0.04]***	[0.03]***
ln [prodcut of (1+ kms. of **COASTLINE**)/area in sq. kms]	0.28	-0.28
	[0.19]	[0.10]***
INSTITUTIONS & CULTURE		
Both in pair had or have a common **COLONIZER**	0.02	0.09
	[0.15]	[0.09]
Both in pair share a **COMMON LANGUAGE**	-0.02	-0.06
	[0.07]	[0.05]
One in pair was a **COLONY** of the other prior to 1870	-0.23	-0.01
	[0.10]**	[0.07]
Both in the **BRITISH EMPIRE** or UK and a British Colony	-0.19	-0.20
	[0.13]	[0.09]**
Constant	-1.00	---
	[0.17]***	
Observations	2291	2291
Country Fixed Effects	no	**yes**
R-Squared	0.46	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	0.00	0.02
	[0.00]**	[0.01]	[0.01]
Both on **GOLD STANDARD**	-0.01	-0.01	-0.05
	[0.00]***	[0.00]***	[0.02]***
Exchange rate **VOLATILITY**	-0.02	-0.07	0.08
	[0.09]	[0.09]	[0.35]
Both in a **MONETARY UNION**	0.00	-0.01	-0.02
	[0.02]	[0.01]	[0.06]
INFRASTRUCTURE			
ln (product of kms. of **WATERWAYS/AREA** in sq. kms)	-0.19	-0.07	-0.46
	[0.11]*	[0.08]	[0.36]
ln (product of kms. of **RAILROAD TRACK/SQ. KM**)	-0.00	-0.02	-0.01
	[0.00]**	[0.01]**	[0.01]**
GEOGRAPHY			
ln (**DISTANCE**) x indicator for 1870-1879	0.04	0.06	0.16
	[0.01]***	[0.02]***	[0.03]***
ln (**DISTANCE**) x indicator for 1880-1889	0.04	0.06	0.14
	[0.01]***	[0.01]***	[0.03]***
ln (**DISTANCE**) x indicator for 1880-1899	0.03	0.04	0.14
	[0.01]***	[0.01]***	[0.03]***
ln (**DISTANCE**) x indicator for 1900-1913	0.03	0.01	0.12
	[0.01]***	[0.01]	[0.02]***
One country in pair is an **ISLAND**	0.00	-0.01	0.10
	[0.02]	[0.03]	[0.08]
Both in pair are an **ISLAND**	-0.05	-0.02	-0.17
	[0.04]	[0.05]	[0.17]
Countries share a **BORDER**	-0.07	-0.06	-0.16
	[0.02]***	[0.01]***	[0.06]***
ln [prodcut of (1+ kms. of **COASTLINE**)/area in sq. kms]	0.15	-0.13	0.69
	[0.08]*	[0.03]***	[0.37]*
INSTITUTIONS & CULTURE			
Both in pair had or have a common **COLONIZER**	0.01	0.04	0.08
	[0.08]	[0.04]	[0.39]
Both in pair share a **COMMON LANGUAGE**	0.00	-0.03	0.04
	[0.02]	[0.02]*	[0.07]
One in pair was a **COLONY** of the other prior to 1870	-0.10	-0.00	-0.34
	[0.04]**	[0.02]	[0.14]**
Both in the **BRITISH EMPIRE** or UK and a British Colony	-0.07	-0.08	-0.22
	[0.05]	[0.03]***	[0.15]
Constant	0.23	---	-0.01
	[0.07]***		[0.26]
Observations	2291	2291	2291
Country Fixed Effects	no	**yes**	no
R-Squared	0.39	0.99	0.26

Notes: Dependent variable is the natural logarithm of trade costs cols (1)-(2). Dependent variable is listed above for cols. (3)-(5). Standard errors are in brackets.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)* Ctry Fixed Effects	*Strcutural Coeff.* rho = 11
POLICIES		
ln (product of **TARIFFS**)	-0.50 [0.19]***	-0.03
Both on **GOLD STANDARD**	0.46 [0.19]**	0.02
Exchange rate **VOLATILITY**	1.10 [2.73]	0.055
Both in a **MONETARY UNION**	0.53 [0.47]	0.03
INFRASTRUCTURE		
ln (product of kms. of **WATERWAYS/AREA** in sq. kms)	2.48 [2.66]	0.12
ln (product of kms. of **RAILROAD TRACK/SQ. KM**)	0.12 [0.06]**	0.006
GEOGRAPHY		
ln (**DISTANCE**) x indicator for 1870-1879	-0.69 [0.51]	-0.03
ln (**DISTANCE**) x indicator for 1880-1889	-0.66 [0.51]	-0.03
ln (**DISTANCE**) x indicator for 1880-1899	-0.66 [0.51]	-0.03
ln (**DISTANCE**) x indicator for 1900-1913	-0.61 [0.51]	-0.03
One country in pair is an **ISLAND**	0.66 [1.18]	0.033
Both in pair are an **ISLAND**	1.67 [2.23]	0.084
Countries share a **BORDER**	1.98 [0.49]***	0.10
ln [prodcut of (1+ kms. of **COASTLINE**)/area in sq. kms]	4.94 [1.06]***	0.25
INSTITUTIONS & CULTURE		
Both in pair had or have a common **COLONIZER**	-0.63 [1.97]	-0.03
Both in pair share a **COMMON LANGUAGE**	0.65 [0.52]	0.03
One in pair was a **COLONY** of the other prior to 1870	0.53 [0.64]	0.03
Both in the **BRITISH EMPIRE** or UK and a British Colony	2.75 [0.96]***	0.14
ln {(GDP-Exports)i * (GDP-Exports)j}	1.06 [0.20]***	---
Observations	2291	
Country Fixed Effects	**yes**	
R-Squared	0.98	

Notes: Dependent variable is the natural logarithm of the product of real exports. Estimation is by OLS with heteroscedasticity and serial correlation robust standard errors. Country fixed effects are included.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: Accounting for Changes in Trade by Region, 1870-1913

Sample	*(1)* *Avg. change in* ln(exports*exports) =	*(2)* *Avg. change in* ln (GDP1 -EXPORTS1)	*(3)* *Avg. change in* ln (GDP2 -EXPORTS2)	*(4)* *Avg. change in* {20 *x* ln (1-τ)}	*(5)* *Percentage of col. (1) explained: Sum of cols. (2)-(4)*
Global sample (*N* = 1780)	0.075	0.03	0.02	0.032	
	100	**40.00**	**26.67**	**42.67**	109.33
European Core (*N* = 481)	0.043	0.019	0.023	0.008	
	100	**44.19**	**53.49**	**18.60**	116.28
European Core and Periphery (*N* =1000)	0.049	0.020	0.024	0.011	
	100	**40.82**	**48.98**	**21.63**	111.43
One Country in European Core or Periphery	0.097	0.035	0.023	0.060	
with Partner outside Europe (*N* = 704)	**100**	**36.08**	**23.71**	**61.86**	121.65
Pairs which are both Non-European (*N* = 76)	0.221	0.036	0.03	0.14	
	100	**16.29**	**14.48**	**63.35**	94.12
All Pairs w/ United Kingdom (*N* =396)	0.044	0.022	0.02	0.004	
	100	**50.00**	**47.73**	**9.09**	106.82
All Pairs w/ France (*N* =380)	0.017	0.022	0.02	-0.02	
	100	**129.41**	**123.53**	**-117.65**	135.29
All Pairs w/ United States (*N=382)*	0.099	0.037	0.02	0.0480	
	100	**37.37**	**22.22**	**48.48**	108.08

Notes: Numbers in bold underneath the figures above are the percentages of the total average change of the product of bilateral exports from column (1) "explained" by the average change in each right hand side variable.

Figure 1: Global Index of Trade Costs, 1870-1913 (1913=100)