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TRADE BOOMS, TRADE BUSTS, AND TRADE COSTS

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ABSTRACT

What has driven trade booms and trade busts in the past and present? We derive a micro-founded measure of trade frictions from leading trade theories and use it to gauge the importance of bilateral trade costs in determining international trade flows. We construct a new balanced sample of bilateral trade flows for 130 country pairs across the Americas, Asia, Europe, and Oceania for the period from 1870 to 2000 and demonstrate an overriding role for declining trade costs in the pre-World War I trade boom. In contrast, for the post-World War II trade boom we identify changes in output as the dominant force. Finally, the entirety of the interwar trade bust is explained by increases in trade costs.

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I. Introduction

Over the past two centuries, the world has witnessed two major trade booms and one trade bust. Global trade increased at a remarkable pace in the decades prior to World War I as well as in decades following World War II. In contrast, global trade came to a grinding halt during the interwar period. What are the underlying driving forces of these trade booms and busts? The goal of this paper is to address this question head-on by examining new data on bilateral trade flows for a consistent set of 130 country pairs over the period from 1870 to 2000, covering on average around 70 percent of global trade and output. We explore three eras of globalization: the pre-World War I Belle Époque (1870-1913), the fractious interwar period (1921-1939), and the post-World War II resurgence of global trade (1950-2000). Thus, the paper is the first to offer a complete quantitative assessment of developments in global trade from 1870 all the way to 2000.[1]

Inevitably, any long-run view of international trade faces the notion that trade patterns can be driven by different reasons. For example, international trade during the nineteenth century is often viewed as being determined by relative resource endowments (Kevin H. O'Rourke and Jeffrey G. Williamson, 1999) or differences in Ricardian comparative advantage (Peter Temin, 1997).[2] More recently, international trade has been related to not only Ricardian factors (Jonathan Eaton and Samuel S. Kortum, 2002) but also to the activities of heterogeneous firms (Marc J. Melitz, 2003). The challenge for a long-run view is therefore to find a unifying framework that accommodates a variety of divergent explanations for international trade. We invoke the gravity equation to help us resolve this issue by exploiting the fact that gravity is consistent with a wide range of leading trade theories. While technical details might differ across models, all micro-founded trade models produce a gravity equation of bilateral trade. In turn, all gravity equations have in common that they relate bilateral trade to factors within particular countries such as size and productivity, and factors specific to country pairs such as bilateral trade costs. The intuition is that gravity is simply an expenditure equation that arises in any general equilibrium trade model. It describes how consumers allocate spending across

[1] We do, however, follow in the footsteps of other researchers that have looked at different periods in isolation. For instance, Antoni Estevadeordal, Brian Frantz, and Alan M. Taylor (2003) examine the period from 1870 to 1939. The work of Scott L. Baier and Jeffrey H. Bergstrand (2001) is the closest predecessor to our own. However, they only consider the period from 1958 to 1988. We also track changes in trade due to all trade costs while their data contained only rough proxies for freight costs and tariffs.

[2] In addition, John C. Brown (1995) has found evidence of international trade prior to World War I being driven by product differentiation and imperfect competition.

countries—regardless of the motivation behind international trade, be it international product differentiation or differences in comparative advantage. In Section II below, we run standard gravity regressions and demonstrate that gravity exerts its inexorable pull in all three sub-periods.

As a departure from previous work, we investigate the long-run evolution of trade costs. These are all the costs of transaction and transport associated with the exchange of goods across national borders. We define trade costs in a broad sense, including obvious barriers such as tariffs and transport costs but also many other barriers that are more difficult to observe such as the costs of overcoming language barriers and exchange rate risk. Even though trade costs are currently of great interest (James E. Anderson and Eric van Wincoop, 2004; Maurice Obstfeld and Kenneth S. Rogoff, 2000; David L. Hummels, 2007), little is known about the magnitude, determinants, and consequences of trade costs. In particular, there has been very little work on consistently measuring all of the trade barriers over the last two waves of globalization and the one intervening spell of de-globalization. This paper is the first step in filling the gap on both counts of comprehensiveness and consistency.

Specifically, we derive a micro-founded measure of aggregate bilateral trade costs that is consistent with leading theories of international trade. We are able to obtain this measure by backing out the trade cost wedge that is implied by the gravity equation. This wedge gauges the difference between observed trade flows and a hypothetical benchmark of frictionless trade. We, therefore, infer trade costs from trade flows. This approach allows us to capture the combined magnitude of tariffs, transport costs, and all other macroeconomic frictions that impede international market integration but which are inherently difficult to observe. In Section III below, we show that an isomorphic trade cost measure can be derived from a wide range of leading trade theories—including the consumption-based trade model by Anderson and van Wincoop (2003), the Ricardian model by Eaton and Kortum (2003), the heterogeneous firms model by Thomas Chaney (2008) and the heterogeneous firms model with non-CES preferences by Melitz and Gianmarco I.P. Ottaviano (2008). We emphasize that this approach of inferring trade costs from readily available trade data holds clear advantages for applied research: the constraints on enumerating—let alone, collecting data on—every individual trade cost element even over short periods of time makes a direct accounting approach impossible.

In Section IV, we take the trade cost measure to the data. We find that in the forty years prior to World War I, the average level of trade costs (expressed in tariff equivalent terms) fell by thirty-three percent. From 1921 to the beginning of World War II, the average level of trade costs increased by thirteen percent. Finally, average trade costs have fallen by sixteen percent in the years from 1950. After describing the trends in trade costs, in Section V we examine whether the trade cost measure is reliable. Our evidence suggests that standard trade cost proxies are sensibly related to our measure. Factors like geographic proximity, adherence to fixed exchange rate regimes, common languages, membership in a European empire, and shared borders all matter for explaining trade costs. These factors alone account for roughly 30 to 50 percent of the variation in trade costs. However, the three sub-periods exhibit significant differences, allowing us to document important changes in the global economy over time such as the growing importance of distance in determining the level of trade costs over time and the diminishing effects of fixed exchange rate regimes and membership in European empires.

In Section VI we return to the question of what drives trade booms and busts. We use our micro-founded gravity equation to attribute changes in global trade to two fundamental forces: changes in global output and changes in trade costs. For the pre-World War I period, we find that trade cost declines explain roughly sixty percent of the growth in global trade. Conversely, we find that only thirty-one percent of the present-day global trade boom can be explained by the decline in trade costs. This latter finding is consistent with previous studies for the post-World War II period (see Baier and Bergstrand, 2001; John Whalley and Xian Xin, 2009). The comparison of the two trade booms suggests that major technological breakthroughs in the nineteenth century such as the steamship, the telegraph, and refrigeration may have been relatively more important than technological innovations in the second half of the twentieth century such as containerization and enhanced handling facilities. Finally, we find that the entire interwar trade bust can be explained by the precipitous rise in trade costs associated with the Great Depression, highlighting the critical role of commercial policy, the collapse of the gold standard, and the evaporation of trade credit at the time.

II. Gravity in Three Eras of Globalization

An ever expanding literature documents the applicability of gravity over the long run. In chronological order, we can point to the recent work of Olivier Accominotti and Marc Flandreau

(2006) which considers bilateral trade flows in the period from 1850 to 1870, finding little role for bilateralism in promoting aggregate trade flows. J. Ernesto López-Córdova and Christopher M. Meissner (2003), David S. Jacks and Krishna Pendakur (2009), and Kris J. Mitchener and Marc D. Weidenmier (2008) all employ extensive datasets in the period from 1870 to 1913 to discern the effects, respectively, of the classical gold standard, the maritime transport revolution, and the spread of European overseas empires on bilateral trade flows. For the interwar period, Barry J. Eichengreen and Doug A. Irwin (1995) are able to document the formation of currency and trade blocs by using an early variant of gravity, while Estevadeordal, Frantz and Taylor (2003) trace the rise and fall of world trade over the longer period from 1870 to 1939, offering a revisionist history where the collapse of the resurrected gold standard and the increase in maritime freight costs all play a role in explaining the interwar trade bust. Finally, for the post-World War II period, a non-exhaustive list of nearly 100 gravity oriented papers is cataloged by Anne-Celia Disdier and Keith Head (2008).

It is clear that the validity of the gravity model of international trade has been firmly established theoretically and empirically, both now and in the past. But what has been lacking is a unified attempt to exploit gravity to explain the three eras of globalization. In what follows, we present the results of just such an attempt. A typical estimating equation for gravity models of trade often takes the form of:

(1) $\ln(x_{ijt}) = \alpha_i + \alpha_j + \gamma \ln(y_{it} y_{jt}) + z_{ijt}\beta + \varepsilon_{ijt}$

where x_{ijt} represents real bilateral exports from country i to j in time t; the α_i and α_j terms represent country fixed effects intended to capture differences in resource endowments, differences in productivity, and any other time-invariant country attributes which might determine a country's propensity for export or import activity; the y_{it} and y_{jt} terms represent gross domestic products in countries i and j; and z_{ijt} is a row vector of variables representing the various bilateral frictions that limit the flow of goods between countries i and j and includes familiar standbys in the literature such as the physical distance separating countries.

We use expression (1) along with the trade and output data detailed in Appendix I to chart the course of gravity in three eras of globalization: the pre-World War I Belle Époque (1870-1913), the fractious interwar period (1921-1939), and the post-World War II resurgence of global trade (1950-2000). The 27 countries in our sample include Argentina, Australia, Austria, Belgium, Brazil, Canada, Denmark, France, Germany, Greece, India, Indonesia, Italy, Japan,

Mexico, the Netherlands, New Zealand, Norway, the Philippines, Portugal, Spain, Sri Lanka, Sweden, Switzerland, the United Kingdom, the United States, and Uruguay. Figure 1 summarizes the sample graphically.[3] Finally, we incorporate measures for distance, the establishment of fixed exchange rate regimes, the existence of a common language, historical membership in a European overseas empire,[4] and the existence of a shared border.[5] Summary statistics and the results of this exercise of estimating gravity in the three sub-periods separately are reported in Tables 1 and 2, respectively.

In Panel A of Table 2, we estimate equation (1) by OLS, using GDP, the five variables proxying for trade costs mentioned above, and country fixed effects. The results are reassuring. The coefficients on GDP—although different across the three eras of globalization—are precisely estimated and fall within the bounds established by previous researchers. Likewise, distance is found to be negatively and significantly related to bilateral trade flows. Fixed exchange rate regimes, common languages, and shared borders are all found to be positively and significantly associated with bilateral trade flows. We also note that these regressions confirm the emerging story on the pro-trade effects of empires, specifically the very strong stimulus to trade afforded by European empires in the pre-World War I period (Mitchener and Weidenmier, 2008) which slowly faded in light of the disruptions of the interwar period and the decolonization movement of the 1950s and 1960s (Head, Thierry Mayer, and John Ries, 2008). In addition, this simple specification explains a high percentage of the variation in bilateral trade flows for each of the separate periods as the adjusted R-squared ranges from a low of 0.64 in the Belle Époque period to a high of 0.84 in the period from 1950 to 2000.

A more exacting specification consistent with the recent gravity literature (Anderson and van Wincoop, 2003 and Richard E. Baldwin and Daria Taglioni, 2007) would be that in Panel B. Along with the proxies for trade costs, this specification includes year fixed effects, allows the

[3] This sample constitutes, on average, 72% of world exports and 68% of world GDP over the entire period. We also note that the various sub-samples are highly balanced. Given the 130 country pairs in our sample, there are 14,820 possible bilateral trade observations (130 times 114 years) of which we are able to capture fully 99.9%.

[4] For all intents and purposes, this may be thought of as an indicator variable for the British Empire. The sole exception in our sample is the case of Indonesia and the Netherlands.

[5] Another obvious candidate is commercial policy, and especially tariffs. Only one consistent measure of tariffs is available for the period from 1870 to 2000 in the form of the customs duties to declared imports ratio as in Michael A. Clemens and Williamson (2001). This measure seems to be a reasonably good proxy for tariffs in the pre-World War I and interwar periods. However, after 1950 and the well-known rise of non-tariff barriers to trade, this measure becomes unreliable, sometimes registering unbelievably low levels of protection. The measure also—somewhat paradoxically—becomes less readily available after World War II; the United Kingdom, for instance, stops reporting the level of customs duties in 1965.

country fixed effects to change over time, and omits the GDP terms due to collinearity.[6] The sign and significance of the remaining variables is remarkably consistent across the panels.

To conclude, the fundamental result of this section has been the consistency of gravity in determining international trade flows, both in the past and the present. This is a key result which we argue motivates a common gravity framework for the three eras of globalization. We develop such a framework in the following section.

III. Gravity Redux

Our goal in the remainder of the paper is to study two fundamental drivers of trade—output and trade costs. To undertake such an analysis, we now introduce a theoretical gravity framework that incorporates trade costs and that is consistent with many classes of trade models.

As we demonstrate above, the standard gravity equation (1) holds up well in explaining trade flows over different periods. However, recent advances in theory have provided more solid foundations for empirical gravity equations. As a first step, we show that a gravity equation similar to equation (1) can be derived from a wide range of leading trade models developed in the last decade: (i) the Anderson and van Wincoop (2003) trade model that focuses on multilateral resistance, (ii) the Ricardian trade model by Eaton and Kortum (2002), (iii) the trade model with heterogeneous firms by Chaney (2008), based on Melitz (2003), and (iv) the heterogeneous firms model by Melitz and Ottaviano (2008) with a linear, non-CES demand structure.[7] This confirms the appeal of gravity: although the driving forces behind international trade differ across these models—say, Ricardian comparative advantage versus love of variety—they all predict a gravity equation for international expenditure patterns.[8] Most important for our analysis, the different models treat bilateral trade costs in a similar way.

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[6] For the period from 1870 to 1913, there are 44 years and 27 countries, yielding 1188 country-specific annual fixed effects. Likewise, there are 513 (=19*27) country-specific annual fixed effects for the period from 1921 to 1939 and 1377 (=51*27) country-specific annual fixed effects for the period from 1950 to 2000.

[7] Earlier gravity contributions include the contribution of Anderson (1979) who explained the multiplicative form of the equation and allowed for disaggregation. Bergstrand (1985, 1989, 1990) established the applicability of the gravity equation to a number of preference and substitution structures and to alternate models of international trade: the Heckscher-Ohlin factor endowments approach, trade based on monopolistic competition, and a hybrid model of different factor proportions among monopolistically competitive sectors.

[8] Gene M. Grossman (1998, p. 29-30) neatly summarizes this situation: "*Specialization* lies behind the explanatory power [of the gravity equation], and of course some degree of specialization is at the heart of any model of trade…This is true no matter what supply-side considerations give rise to specialization, be they increasing returns to scale in a world of differentiated products, technology differences in a world of Ricardian trade, large factor

As a second step, we exploit the fact that these trade models predict similar gravity equations which suggest that trade booms and busts are driven by changes in output and changes in trade costs. In particular, we formally show that all the gravity equations can be solved for a common expression of implied trade costs.[9] These implied trade costs can be interpreted as the wedge between a hypothetical frictionless world as predicted by each model and the actual trade patterns observed in the data. We argue that these implied trade costs are an informative summary statistic to describe international trade frictions. In Section V, we also demonstrate this empirically.

(i) Gravity in Anderson and van Wincoop (2003)

Anderson and van Wincoop (2003) derive the following gravity equation:

$$(2)\quad x_{ij} = \frac{y_i y_j}{y^W}\left(\frac{t_{ij}}{\Pi_i P_j}\right)^{1-\sigma},$$

where y^W is world output and Π_i and P_j are outward and inward 'multilateral resistance' variables. The latter can be interpreted as average trade barriers. $t_{ij} \geq 1$ is the bilateral trade cost factor (one plus the tariff equivalent), and $\sigma > 1$ is the elasticity of substitution. In empirical applications, trade costs are typically proxied by variables such as bilateral distance and a border dummy. But it is difficult to find empirical proxies for the multilateral resistance variables. Anderson and van Wincoop (2003) caution against the use of price indices since they might not capture non-pecuniary trade barriers. Instead, the procedure that has been adopted most frequently in recent gravity applications is to include country fixed effects.

As an alternative, we follow Novy (2009) in eliminating the multilateral resistance variables from the gravity equation. The counterpart of equation (2) for domestic trade x_{ii} is

$$(3)\quad x_{ii} = \frac{y_i y_i}{y^W}\left(\frac{t_{ii}}{\Pi_i P_i}\right)^{1-\sigma}.$$

When equation (2) is multiplied by its counterpart for bilateral trade from j to i, x_{ji}, we obtain the product of all multilateral resistance variables on the right-hand side, $\Pi_i \Pi_j P_i P_j$. These

endowment differences in a world of Heckscher-Ohlin trade, or (small) transport costs in a world of any type of endowment-based trade." [Emphasis in original]

[9] Also see Dennis Novy (2009).

multilateral resistance indices can be eliminated by dividing by the product of domestic trade flows, $x_{ii}x_{jj}$:

$$(4)\quad \frac{x_{ij}x_{ji}}{x_{ii}x_{jj}} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{1-\sigma}.$$

We solve for the trade costs as the key parameters of interest. The parentheses on the right-hand side of equation (4) contain the product of two trade cost ratios. These ratios represent the extent to which bilateral trade costs t_{ij} and t_{ji} exceed domestic trade costs t_{ii} and t_{jj}. Finally, we take the square root to form their geometric average and subtract by one to get an expression for the tariff equivalent. The resulting expression is

$$(5)\quad \tau_{ij} \equiv \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{\frac{1}{2}} - 1 = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{2(\sigma-1)}} - 1,$$

where τ_{ij} is the trade cost wedge that captures bilateral relative to domestic trade costs.[10]

To grasp the intuition behind this trade cost measure, imagine the two extremes of a frictionless world and a closed economy. In a frictionless world, all trade cost factors t_{ij}, t_{ji}, t_{ii} and t_{jj} are equal to 1. It follows that $\tau_{ij} = 0$. In contrast, a closed economy is characterized by bilateral trade flows, $x_{ij}x_{ji}$, that are zero. In that case, τ_{ij} approaches infinity. τ_{ij} can therefore be interpreted as a trade cost wedge that measures just how far bilateral trade integration is away from a hypothetical frictionless world. Note that this trade cost measure does not impose bilateral trade cost symmetry. Bilateral trade costs, t_{ij} and t_{ji}, may differ under this framework but here, we can only identify their geometric average but not the extent to which they diverge. In addition, we do not impose zero domestic trade costs. Finally, we note that non-unitary income elasticities, as found by João M.C. Santos Silva and Silvana Tenreyro (2006), do not pose a problem for our methodology. It is easy to show that if the income elasticity in gravity equation (2) differed from unity, the trade cost measure in equation (5) would not be affected.

[10] Head and Ries (2001), Anderson and van Wincoop (2004), and Head and Mayer (2009) derive a similar expression but assume trade costs are symmetric. We do not make that assumption. In addition, we derive the expression from a number of different theories, not only from the CES monopolistic competition model. They estimate the ratio of trade flows, whereas we solve for the implied trade cost wedge according to equation (5). We refer to the robustness check in Appendix II where we allow for stochastic measurement error in the trade data and where we also estimate a version of equation (4).

We have derived the trade cost measure in equation (5) from the well-known Anderson and van Wincoop (2003) gravity model. An Armington assumption is imposed in their model so that countries are endowed with differentiated goods, and trade is driven by consumers' love of variety. To show that our trade cost measure τ_{ij} is not dependent on one specific trade model, we now derive this measure from other leading trade models.

(ii) Gravity in Eaton and Kortum (2002)

In the Ricardian model by Eaton and Kortum (2002), productivity in each country is drawn from a Fréchet distribution that has two parameters, T_i and ζ. T_i determines the location of the productivity distribution for country *i*, with a high T_i denoting high overall productivity. $\zeta > 1$ denotes the variation within the distribution and is treated as common across countries, with a high ζ denoting little variation. The model yields a gravity equation for an aggregate of homogeneous goods whose structure is related to equation (2). It is given by

$$(6)\quad \frac{x_{ij}}{x_j} = \frac{T_i\left(c_i t_{ij}\right)^{-\zeta}}{\sum_i T_i\left(c_i t_{ij}\right)^{-\zeta}},$$

where x_j denotes country *j*'s total expenditure and c_i denotes the input cost in country *i*.

As in the context of the Anderson and van Wincoop (2003) model, we are interested in the trade cost parameters. T_i and c_i are unobservable but cancel out once the ratio of domestic over bilateral trade flows is formed as in equation (5). This yields

$$(7)\quad \tau_{ij}^{EK} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{\frac{1}{2}} - 1 = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{2\zeta}} - 1.$$

Comparing equations (5) and (7), it is obvious that $\tau_{ij}^{EK} = \tau_{ij}$ if $\zeta = \sigma - 1$.[11]

(iii) Gravity in Chaney (2008)

Chaney (2008) builds on the seminal paper by Melitz (2003) and derives a gravity equation based on a model with heterogeneous productivities across firms and fixed costs of

[11] For more details on the comparison of Armington-type and Ricardian models, see Eaton and Kortum (2002, footnote 20) and Anderson and van Wincoop (2004, pp. 709-710).

exporting. In contrast to previous trade models, the two assumptions of heterogeneous firms and fixed costs of exporting introduce an extensive margin of trade. Not only do exporters vary the size of shipments (the intensive margin) in response to changes in trade costs, but also the set of exporters changes (the extensive margin). Chaney derives the following industry-level gravity equation

$$(8)\quad x_{ij} = \frac{y_i y_j}{y^W}\left(\frac{w_i t_{ij}}{\lambda_j}\right)^{-\gamma}\left(f_{ij}\right)^{-\left(\frac{\gamma}{\sigma-1}-1\right)},$$

where w_i is workers' productivity in country i, λ_j is a remoteness variable akin to multilateral resistance, and f_{ij} are the fixed costs of exporting from country i to j.[12] γ is the shape parameter of the Pareto distribution from which productivities are drawn, with a high γ denoting a low degree of heterogeneity and $\gamma > \sigma - 1$. Forming the ratio of domestic over bilateral trade flows yields

$$(9)\quad \tau_{ij}^{Ch} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{\frac{1}{2}}\left(\frac{f_{ij}f_{ji}}{f_{ii}f_{jj}}\right)^{\frac{1}{2}\left(\frac{1}{\sigma-1}-\frac{1}{\gamma}\right)} - 1 = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{2\gamma}} - 1.$$

τ_{ij}^{Ch} is a now function of both variable and fixed trade costs. Thus, under the assumptions of Chaney's (2008) model the interpretation of the trade cost wedge extends to fixed costs of exporting.

We note that for non-zero trade flows (as is generally the case in our sample), the heterogeneous firms model by Elhanan Helpman, Marc J. Melitz, and Yona Rubinstein (2008) is consistent with the same trade cost measure as in equation (9), that is, $\tau_{ij}^{HMR} = \tau_{ij}^{Ch}$.[13]

(iv) Gravity in Melitz and Ottaviano (2008)

Melitz and Ottaviano (2008) also model heterogeneous firms. Firms face sunk costs of market entry, f_E, that can be interpreted as product development and production start-up costs. In contrast to Melitz (2003) and Chaney (2008), exporting firms only face variable trade costs

[12] The economy is modeled as one industry.

[13] In the notation of Helpman, Melitz and Rubinstein (2008), non-zero trade flows imply $V_{ij}>0\ \forall\ i,j$. To obtain $\tau_{ij}^{HMR} = \tau_{ij}^{Ch}$ we also assume positive fixed costs for domestic sale, $f_{ii}>0$. We also need to allow for positive domestic variable trade costs, $t_{ii}\geq 1\ \forall\ i$, and, as in Appendix II of their paper, assume there is no upper bound in the support of the productivity distribution, $a_L=0$.

and no fixed costs of exporting. The model is based on non-CES preferences that give rise to endogenous markups. More specifically, markups tend to be low in large markets with many competitors.

The multiple-country version of their model leads to the following gravity equation:

$$(10)\quad x_{ij} = \frac{1}{2\delta(\gamma+2)} N_E^i \psi^i L^j \left(c_d^j\right)^{\gamma+2} \left(t_{ij}\right)^{-\gamma},$$

where δ is a parameter from the utility function that indicates the degree of product differentiation, with a higher δ meaning a higher degree of differentiation. N_E^i is the number of entrants in country *i*. An index of comparative advantage in technology is given by ψ^i with a high value meaning that entrants in country *i* have a high chance of obtaining favorable productivity draws. L^j denotes the number of consumers in country *j,* and c_d^j is the marginal cost cut-off above which domestic firms in country *j* do not produce. The intuition is that tougher competition in country *j*, reflected by a lower c_d^j, makes it harder for exporters from *i* to break into that market. Forming the ratio of domestic over bilateral trade flows yields

$$(11)\quad \tau_{ij}^{MO} = \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{\frac{1}{2}} - 1 = \left(\frac{x_{ii}x_{jj}}{x_{ij}x_{ji}}\right)^{\frac{1}{2\gamma}} - 1.$$

In contrast to τ_{ij}^{Ch} in equation (9), neither sunk nor fixed costs enter τ_{ij}^{MO} because all firms face identical entry costs, f_E, and no fixed costs of exporting. Variable trade costs are sufficient to induce selection into export markets because of bounded non-CES marginal utility

(v) Gravity in Deardorff (1998)

Finally, Alan V. Deardorff (1998) argues that in a Heckscher-Ohlin world with bilateral trade barriers, a model similar to the one by Anderson and van Wincoop (2003) applies. The intuition is that bilateral trade barriers prevent factor price equalization between two countries that trade with each other. If factor prices were equalized, final goods prices would also be equalized and neither country could overcome the trade barriers. In a world with a large number of goods and few factors it is, therefore, likely that one country will be the lowest-cost producer. Trade in a Heckscher-Ohlin world would, thus, resemble trade in an Armington world and could be characterized by a standard gravity equation.

In summary, our trade integration measure τ_{ij} is consistent with a broad range of trade models since they all lead to gravity equations that have a similar structure as equation (2). In a similar vein, Robert C. Feenstra, James R. Markusen, and Andrew K. Rose (2001) and Simon J. Evenett and Wolfgang Keller (2002) also show that earlier gravity equations are consistent with various competing trade models. Intuitively, the gravity equation simply indicates how consumers allocate their expenditure across countries subject to trade frictions (Baldwin and Taglioni, 2007). Gravity equations arise regardless of why consumers want to buy goods from foreign countries. In an Armington world, consumers buy foreign goods because those goods are inherently different and consumers prefer variety. In a Ricardian world, countries produce goods according to comparative advantage and consumers buy foreign goods because they are cheaper. It turns out that the particular motivation behind foreign trade is not crucial to understand the role of bilateral trade frictions.

IV. Trade Costs over Time

We use equation (5) along with the trade and output data detailed in Appendix I to construct bilateral trade costs for the 130 country pairs in our sample. Lacking consistent data on domestic trade, we use GDP less aggregate exports instead. A potential problem arises: the GDP data are value-added whereas trade data typically reported as gross values. For the post-World War II period, it becomes possible to track how well this proxy performs by comparing it to domestic trade constructed as total manufacturing production less total exports. The results are favorable in that although the level of bilateral trade costs is affected by the way domestic trade is measured, the change over time is remarkably similar (Novy, 2009). For example, in the case of U.S.-Canadian trade costs over the period from 1970 to 2000, the correlation between the measure based on GDP data and the one based on production data is 0.96. [14]

The elasticity of substitution, σ, typically falls in the range (5,10) as surveyed by Anderson and van Wincoop (2004). As $(\sigma-1)$ in equation (5) corresponds to the Fréchet parameter ζ in equation (7) and the Pareto parameter γ in equations (9) and (11), it is instructive to also consider estimates for those parameters. Eaton and Kortum (2002) report a baseline estimate of 8.3 for ζ. Chaney (2008) estimates the ratio $\gamma/(\sigma-1)$ to be near two, which suggests a

[14] The intuition for the high correlation is that the increase in the (gross) production data is approximately matched by the increase in the (value-added) GDP data because the latter includes the growth of the services sector. See Novy (2009).

value of γ above σ. We set the value of σ to eight, which roughly corresponds to the midpoint of the range (5,10). But we show in Appendix III that although the level of inferred trade costs is sensitive to the assumed parameter value, the change of trade costs over time is hardly affected.

We generate average trade cost series for each of the three eras of globalization by regressing the constructed bilateral trade costs on a set of year fixed effects. We repeat this exercise for both global trade and six sub-regions: within the Americas, within Asia/Oceania, within Europe, between the Americas and Asia/Oceania, between the Americas and Europe, and between Asia/Oceania and Europe. Figures 2 through 4 track these averages over time. There, the averages have all been normalized to 100 for the initial observation in each period, i.e. 1870, 1921, and 1950, so that they are not strictly comparable in terms of levels across periods. Our goal instead is to highlight the changes within a given period. We are also trying to avoid pressing too hard on the assumption that the substitution elasticity (or alternatively, the Fréchet or Pareto parameters) have remained constant over the entire 130 years under consideration.[15] We weight these averages by GDP to reduce the influence of country pairs which trade infrequently or inconsistently.[16]

Thus, for the first wave of globalization from 1870 to 1913, we document an average decline in international trade costs relative to domestic trade costs of thirty-three percent.[17] This was led by a fifty percent decline for trade between Asia/Oceania and Europe, probably generated from a combination of Japanese reforms that increased engagement with the rest of the world, the consolidation of European overseas empires, and radical improvements in communication and transportation technologies which linked Eurasia. These gains were apparently not limited to the linkages between the countries of Asia/Oceania and the rest of the world as intra-Asian/Oceanic trade costs declined on the order of thirty-seven percent. Thus, the late nineteenth century was a time of unprecedented changes in the relative commodity and factor prices of the region as has been documented by Jeffrey G. Williamson (2006).

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[15] See Appendix III for a robustness check.

[16] The obvious candidate for weights, the level of bilateral trade, is inappropriate in this instance. A quick look at equation (5) verifies that bilateral trade and trade costs are not independent. That is, a low trade cost measure is generated for a country pair with high bilateral trade, suggesting that the use of bilateral trade would impart systematic downward bias in the weighted average.

[17] The distribution of spikes in 1874 and 1881 in the Asia and Americas-Asia series may seem odd. However, these are explained by the small number of underlying observations (n=7 and n=6, respectively) and can be attributed to sporadic trade volumes for Japan as it integrated—sometimes by fits and starts—into the global economy.

Bringing up the rear was intra-American trade, albeit with a still respectable average decline of nineteen percent. This performance masks significant heterogeneity across North and South America: trade costs within North America declined twenty-nine percent, while trade costs between North and South America fell by only fifteen percent. Most likely, this reflects South America's continued orientation towards European markets and the fleeting connections uniting South America and North America—save the United States—at the time. Likewise, intra-European trade costs only declined twenty-one percent. This performance reflects the maturity as well as the proximity of these markets. We should also note that a substantial portion of the decline is concentrated in the 1870s. This was, of course, a time of simultaneously declining freight rates and tariffs as well as increasing adherence to the gold standard. In subsequent periods, the decline in freight rates was substantially moderated, while tariffs climbed in most countries, dating from the beginning of German protectionist policy in 1879.

Turning to the interwar period from 1921 to 1939, we can see that the various attempts to restore the pre-war international order were somewhat successful at reining in international trade costs. A fitful return to the gold standard was launched in 1925 when the United Kingdom returned to gold convertibility at the pre-war parity. By 1928, most countries had followed its lead and stabilized their currencies. At the same time, the international community witnessed a number of attempts to normalize trading relations, primarily through the dismantling of the quantitative restrictions erected in the wake of World War I (Ronald Findlay and Kevin H. O'Rourke, 2007). As a result, trade costs fell on average by seven percent up to 1929. Although much less dramatic than the fall for the entire period from 1870 to 1913, this average decline was actually twice as large as that for the equivalent period from 1905 to 1913, pointing to a surprising resilience in the global economy of the time. The leaders in this process were again trade between Asia/Oceania and Europe with a respectable fifteen percent decline and intra-European trade with a ten percent decline. On the other end of the spectrum, trade costs within the Americas and between the Americas and Europe barely budged, both registering a three percent decline. And again, these aggregate figures for the Americas mask important differences across North and South America: trade costs within North America ballooned by eight percent—reflecting the adversarial commercial policy of Canada and the United States in the 1920s—while trade costs between North and South America declined by seven percent.

The Great Depression marks an obvious turning point for all the series. It generated the most dramatic increase in average trade costs in our sample as they jump by twenty-one percentage points in the space of the three years between 1929 and 1932. This, of course, exactly corresponds with the well-documented implosion of international trade in the face of declining global output (Angus Maddison, 2003), highly protectionist trade policy (Jakob B. Madsen, 2001), tight commercial credit (William Hynes, David S. Jacks, and Kevin H. O'Rourke, 2009), and a generally uneasy trading environment. Trade costs within Asia/Oceania, within Europe, and between Asia/Oceania and Europe experienced the most moderate increases at eighteen percentage points each. Trade costs within the Americas rose very strongly by thirty-five percentage points, driven more by the trade disruptions between North and South America (+38 percentage points) than within North America (+28 percentage points). Over time though, trade costs declined from these heights just as the Depression slowly eased from 1933 and nations made halting attempts to liberalize trade, even if only on a bilateral or regional basis (Findlay and O'Rourke, 2007). Yet these were not enough to recover the lost ground: average trade costs stood thirteen percent higher at the outbreak of World War II than in 1921.

Finally, the second wave of globalization from 1950 to 2000 registered declines in average trade costs on the order of sixteen percent. The most dramatic decline was that for intra-European trade costs at thirty-seven percent, a decline that is related to the formation of the European Economic Community and subsequently the European Union. The most recalcitrant performance was that for the Americas and Asia/Oceania, both of which registered small increases in bilateral relative to domestic trade costs over this period. In the former case, this peculiar result is solely generated by trade costs between North and South America which rose by twenty-two percent. This most likely reflects Argentina, Brazil, and Uruguay's adherence to import-substituting industrialization up to the debt crisis of the 1980s and the reorientation of South American trade away from its heavy reliance on the United States as a trading partner which had emerged in the interwar period. In contrast, trade costs within North America fell by a remarkable sixty percent, at least partly reflecting the Canada-U.S. Free Trade Agreement and the North American Free Trade Agreement. In the case of Asia/Oceania, the rise in trade costs is primarily generated by India which in its post-independence period simultaneously erected formidable barriers to imports and retreated from participation in world export markets. This

India effect is most pronounced for former fellow members in the British Empire, that is, Australia, New Zealand, and Sri Lanka.

Most surprisingly, the decline in international relative to domestic trade costs in the second wave of globalization is mainly concentrated in the period before the late 1970s. Indeed, in the global and all sub-regional averages—save the Americas—trade costs were lower in 1980 than in 2000. In explaining the dramatic declines prior to 1973, one could point to the various rounds of the GATT up to the ambitious Kennedy Round which concluded in 1967 and slashed tariff rates by 50% and which more than doubled the number of participating nations. Or perhaps, it could be located in the substantial drops—but subsequent flatlining—in both air and maritime transport charges up to the first oil shock documented in Hummels (2007). This phenomenon demands further attention but remains outside the scope of this paper.

V. The Determinants of Trade Costs

Having traced the course of trade costs, we now consider some of their likely determinants. This exercise serves two purposes. First, it addresses—albeit imperfectly—the natural question of what factors have been driving the evolution of trade costs over time. Second and more importantly, it helps further establish the reliability of our measure of trade costs—that is, are trade costs as constructed in this paper reasonably correlated with other variables commonly used as proxies in the literature? Below, we demonstrate that this is the case. We also refer the reader to Appendix II where we provide robustness checks confirming their reliability.

Trade costs in our model are derived from a gravity equation rather than estimated as is typically the case in the literature. Commonly, log-linear versions of equation (1) are estimated by substituting an arbitrary trade cost function for z_{ijt} and using fixed effects for the multilateral resistance variables. Such gravity specifications, to the extent that the trade cost function and the econometric model are well specified, could be used to provide estimated values of trade costs. In fact, as demonstrated above, such specifications are highly successful in explaining a significant proportion of the variance in bilateral trade flows. Nevertheless, there is likely a substantial amount of unexplained variation due to unobservable trade costs and, thus, potential omitted variable bias.

We consider a function for trade costs that is widely used in the gravity literature

(12) $\tau_{ijt} = \alpha \ \mathrm{dist}_{ij}^{\rho} \exp(x_{ijt}\beta + \varepsilon_{ijt}),$

where *dist* is a measure of distance between two countries, x is a row vector of observable determinants of trade costs, and ε is an error term composed of unobservables. We log-linearize equation (12). The determinants we consider are the same as those in Section II and include the distance between two countries, the establishment of fixed exchange rate regimes, the existence of a common language, membership in a European overseas empire, and the existence of a shared border. In all regressions, we include time-invariant country fixed effects as well as year fixed effects.[18] The reported regressions pool across all periods and then separate the data for the 130 dyads between 1870 and 1913, 1921 and 1939, and 1950 and 2000. The results are reported in Table 3.

Considering the pooled results first, we find that a one standard deviation rise in distance raises trade costs by 0.38 standard deviations. Fixed exchange rates, a common language, joint membership in a European empire, and sharing a border all decrease trade costs with the latter two coefficients being roughly double the estimated effect of fixed exchange rate or sharing a common language. This pooled approach demonstrates that standard factors that are known to be frictions in international trade are sensibly related to the trade cost measure. The results also show that the trade cost measure determines trade patterns in ways largely consistent with the gravity literature covering more geographically comprehensive samples.

At the same time, the pooled approach masks significant heterogeneity across the periods. Here, we highlight a few of these differences. First, fixed exchange rate regimes appear noticeably stronger in the pre-World War I and post-World War II environments—a result consistent with the tenuous resurrection of the classical gold standard in the interwar period (Natalia Chernyshoff, Jacks, and Taylor, 2009). Second, a common language seems to have exerted a slightly stronger force (roughly 75%) on trade costs in the period from 1870 to 1913 than subsequently. Third, we document a strongly diminished role for European empires in reducing trade costs: a coefficient of -0.46 from 1870 to 1913 is reduced to -0.15 in the period from 1950 to 2000—a result which is consistent with the recent work of Head, Mayer, and Ries (2008).[19] Finally, distance seems to have become more important in the post-1950 world economy, with the coefficient increasing by 50 percent as compared to 1870-1913 or almost

[18] By construction τ_{ij} nets out the multilateral resistance terms so that time-varying country fixed effects are not required.

[19] Interestingly, much of this decline had already happened prior to 1950 as the coefficient registers a value of -0.20 during the interwar period.

tripling when compared to 1921-1939. This result is in line with Disdier and Head (2008) who find that the estimated distance coefficient has been on the rise from 1950 in their meta-analysis of the gravity literature. Whether this reflects upward pressures in transport costs (Hummels, 2007), the regionalization of trade or changes in the composition of traded goods remains an open question, but it does accord with the empirical evidence on the decreasing distance-of-trade from the 1950s (Matias Berthelon and Caroline Freund, 2008; Celine Carrère and Maurice Schiff, 2005).

One way to get a sense of the relative contribution of the five variables to the variation in trade costs is to compare the R-squareds from a battery of regressions as in the work of Kalina Manova (2008). Specifically, one can generate an upper bound for the contribution of, say, distance by re-estimating (12) with only that variable but no other controls. Thus, the upper bound loads as much variation as possible onto distance. One can also generate a lower bound for the contribution of distance by using the difference between the R-squareds from the fixed effects specification with all variables of interest *including distance*—as in the corresponding panel of Table 3—and a fixed effects specification with all variables of interest *excluding distance*. Thus, the lower bound represents the marginal contribution of distance to an otherwise full specification.

In Table 4, we report the results of running such regressions and tabulating the R-squareds for each variable in each sub-period. Thus, we find that distance can explain between 2 and 14 percent of the variation in trade costs in the period from 1870 to 1913. What is apparent from Table 4 is that the relative contribution of the five variables remains highly consistent across the three sub-periods, with distance potentially explaining the most variation and historical membership in European overseas empires the least variation. The results in Table 4 also confirm the increasing explanatory power of distance over time—and especially in the post-1950 period—and the decreasing explanatory power of fixed exchange rate regimes and the historical membership in European overseas empires hinted at above.

VI. A Long-Run View of Trade Booms and Trade Busts

In order to determine what drives trade booms and busts, we now turn to a decomposition of the growth of trade flows in the three periods. We are interested in whether trade booms are mainly related to secular increases in output or falling trade costs. Similarly, we are interested in

whether trade busts are mainly related to output slumps or increasing trade costs. The gravity framework laid out above easily lends itself to answering these questions. Below, we outline our approach based on the Anderson and van Wincoop (2003) gravity model but we note that identical results can be obtained based on the models by Eaton and Kortum (2002), Chaney (2008), and Melitz and Ottaviano (2008).

We rewrite equation (4) as[20]

$$(13)\ x_{ij}x_{ji} = y_i y_j \left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)^{1-o} \frac{x_{ii}x_{jj}}{y_i y_j} = y_i y_j \left(1+\tau_{ij}\right)^{2(1-o)} \frac{x_{ii}x_{jj}}{y_i y_j}.$$

As we are interested in the growth of bilateral trade, we log-linearize equation (13) and take the first difference between years (denoted by Δ). This yields

$$(14)\ \Delta \ln\left(x_{ij}x_{ji}\right) = \Delta \ln\left(y_i y_j\right) + 2\left(1-\sigma\right)\Delta \ln\left(1+\tau_{ij}\right) + \Delta \ln\left(\frac{x_{ii}x_{jj}}{y_i y_j}\right).$$

Following Helpman (1987) and Baier and Bergstrand (2001), we split the product of outputs into the sum of outputs and output shares, $y_i y_j = \left(y_i + y_j\right)^2 s_i s_j$ with $s_i = y_i / \left(y_i + y_j\right)$, such that we obtain our final decomposition,

$$(15)\ \Delta \ln\left(x_{ij}x_{ji}\right) = 2\Delta \ln\left(y_i + y_j\right) + \Delta \ln\left(s_i s_j\right) + 2\left(1-\sigma\right)\Delta \ln\left(1+\tau_{ij}\right) + \Delta \ln\left(\frac{x_{ii}x_{jj}}{y_i y_j}\right).$$

Equation (15) decomposes the growth of bilateral trade into four components. The first term on the right-hand side represents the contribution of output growth to bilateral trade growth. The second term is the contribution of increasing income similarity, as first stated by Helpman (1987). All else being equal, two countries of the same size are expected to generate more international trade than two countries of unequal size. The third term reflects the contribution of changes in trade costs as measured by τ_{ij}.[21] The fourth term represents changes in multilateral factors. Its precise interpretation depends on the underlying trade model. For example, as equation (3) shows, if multilateral trade barriers fall over time, the ratio of domestic trade to output x_{ii} / y_i goes down so that the contribution of the fourth term to bilateral trade growth

[20] Also see Appendix II where we estimate a version of equation (4) and confirm the unit elasticity of domestic trade flows.

[21] Since (1-σ) is negative, a decline in τ_{ij} implies a positive third term on the right-hand side of equation (19).

becomes negative. This can be interpreted as a trade diversion effect that is consistent with the models by Anderson and van Wincoop (2003), Eaton and Kortum (2002), and Chaney (2008).[22]

We consider the growth of bilateral trade between the initial years (1870, 1921 and 1950) and the end years (1913, 1939 and 2000) of our three sub-periods. We compute GDP-weighted averages across dyads and report the results in Table 5 below. To be clear about our approach, we do not estimate equation (19). Instead, we decompose the growth of bilateral trade conditional on our theoretical gravity framework. The purpose of the decomposition is to uncover whether bilateral trade growth is mainly associated with output growth or changes in bilateral trade costs. We are also interested in how the relative contribution of changes in output and trade costs differs across the three sub-periods. We note that our results do not depend on the value of σ—even if it changes over time. The reason is that the first, second and fourth terms on the right-hand side of equation (19) are given by the data. As predicted by the models outlined in Section III, the trade cost term follows as the residual.[23]

As can be seen from the final column in Table 5, the percentage growth in trade volumes is highly comparable in the two global trade booms of the late 19th and 20th centuries at 486 and 484 percent, respectively. But the main insight is that the principal driving forces are reversed. In the period from 1870 to 1913, trade cost declines account for a majority (290 percentage points) of the growth in international trade, while in the period from 1950 to 2000 trade cost declines account for a distinct minority (148 percentage points) of trade growth. This is congruent with traditional narratives of the late nineteenth century as a period of radical declines in international transport costs and payments frictions as well as studies on the growth of world trade in the contemporary world which suggest that such changes may have been more muted (cf. Baier and Bergstrand, 2001; Hummels, 2007). The contributions of increasing income similarity and changes in multilateral factors are negligible throughout the entire period.

[22] In the Melitz and Ottaviano (2008) model, the fourth term would also capture changes in the degree of competition in a country as indicated by the number of entrants and the marginal cost cut-offs above which domestic firms decide not to produce.

[23] As in all of the standard gravity literature, an implicit assumption in our paper is that aggregate trade costs are exogenous to economic expansion and the growth of trade. If trade cost declines cause additional income growth, then the role of trade costs in explaining trade growth could, of course, be higher. This is an open question in the literature and remains outside the scope of this paper. However, the causal effect from lower trade costs to increased trade flows and, then, to economic growth would have to be fairly large at each step to have a large bearing on our results. At the same time, the exploration of endogenous trade costs is certainly a fruitful avenue for future research.

At the same time, both periods encompass a wide variety of experiences across regional subgroups. For 1870 to 1913, the average trade growth of 486 percent masks a relatively anemic growth of 324 percent within Europe versus an explosive growth of trade between Asia/Oceania and Europe of 647 percent. European trade growth is evenly associated with output growth and trade cost declines, while the overwhelming majority of trade growth between Asia/Oceania and Europe is related to trade cost declines. The former result is consistent with the fact that the majority of European communication and transport infrastructure was in place well before 1870 and that a "tariff backlash" in Europe increased trade costs (Jacks, Meissner, and Novy, 2009). The latter result is consistent with the idea that core-periphery trade between 1870 and 1913 was subject to much more radical changes: the expansion of trading networks through pro-active marketing strategies in new markets, the development of new shipping lines, and better internal communications.

For 1950 to 2000, the results for trade within Europe are reversed: intra-European trade is now in the lead at 633 percent, while intra-American growth lags at 363 percent. European trade growth is again equally associated with output growth and trade cost declines, whereas in all other regions changes in output clearly dominate. The results for the Americas are consistent with the evidence on trade costs documented above in light of South America's drive to self-sufficiency under import-substituting industrialization.

Finally, the role of trade costs is dominant in the interwar period. Based on output growth alone, one would have expected world trade volumes to increase by 88 percent. The fact that they failed to budge underlines the critical role of commercial policy, the collapse of the gold standard, and the lack of commercial credit in determining trade costs at the time. Yet again, the interwar trade bust was anything but uniform: there was impressive trade growth between the Americas and Asia/Oceania of 48 percent set against an actual contraction of trade between the Americas and Europe of 45 percent. Output growth dominates trade costs in the case of the Americas and Asia/Oceania. The opposite is true in the case of the Americas and Europe. Indeed, the increase in trade costs implies that barring output growth trade between the two would have ground to an absolute halt.

Figure 5 concentrates on the full sample and further disaggregates the sub-periods to the decadal level. It helps to more clearly illustrate the forces at work in the interwar period: whereas the 1920s witnessed significant and mainly output-related expansion in trade volumes, the 1930s

gave rise to a demonstrable trade bust in the context of positive, albeit meager output growth. In this sense, the 1930s share with the 1980s and 1990s the distinction of being the only periods in which output growth outstrips trade growth. In contrast, the 1870s and the 1970s are the periods in which the relative contribution of trade cost declines to world trade growth was at its greatest.

VII. Conclusion

In this paper, we have attempted to answer the question of what has driven trade booms and trade busts in the past 130 years. Our results assign an overarching role for trade costs in the nineteenth century trade boom and the interwar trade bust. In contrast, when explaining the post-World War II trade boom, we identify a more muted role for trade costs.

Thus, the role of trade costs in explaining trade has, if anything, diminished over the long run. Prior to World War II, eliminating the physical costs of distance and improving information seem to have mattered more than economic growth. Over the past fifty years, trade has increasingly sustained its growth due to economic expansion, and this process seems to have had a bigger impact than the transportation and communications revolutions of the last several decades. Unlocking the sources of this reversal remains for future work.

Another contribution of this paper has been—both in terms of theory and data—to consistently and comprehensively track changes in bilateral trade costs by using a newly compiled dataset on aggregate bilateral trade. The gravity model has been successful in the past, especially in providing estimates of the marginal impact of a range of trade costs. We build on this success to show how a large variety of general equilibrium models of international trade can be used to calculate a trade cost wedge akin to the Solow residual in growth models or the 'labor wedge' used in structural macro-labor models (e.g., Robert Shimer, 2009).

We have also been able to relate this trade cost measure to proxies suggested by the literature such as geographical distance and tariffs, confirming its reliability. Further work might investigate more closely other properties of the trade cost measure. Promising avenues for research include augmenting the list of trade cost proxies and studying their impact on trade costs, detailed case studies for particular countries to better illuminate the nature of trade costs, addressing the model uncertainty that surrounds the trade cost function, and studying the implications of vertical specialization for the relationship between trade costs and aggregate trade volumes. This is obviously not an exhaustive list but it should highlight one aspect: the

determinants of bilateral trade frictions are still poorly understood. This is problematic since trade costs may be as important as the traditional determinants of trade, if not more important. Further work on international trade—no matter the period—can no longer ignore these fundamental factors.

Appendix I: Data Sources

Bilateral trade: Converted into real 1990 U.S. dollars using the U.S. CPI deflator in Officer, Lawrence H. 2008, "The Annual Consumer Price Index for the United States, 1774-2007" and the following sources:

Annuaire Statistique de la Belgique. Brussels: Ministère de l'intérieur.
Annuaire Statistique de la Belgique et du Congo belge. Brussels: Ministère de l'intérieur.
Annual Abstract of Statistics. London: Her Majesty's Stationery Office.
Barbieri, Katherine. 2002. *The Liberal Illusion: Does Trade Promote Peace?* Ann Arbor: University of Michigan Press.
Bloomfield, Gerald T. 1984. *New Zealand, A Handbook of Historical Statistics*. Boston: G.K. Hall.
Canada Yearbook. Ottawa: Census and Statistics Office.
Confederación Española de Cajas de Ahorros. 1975. *Estadisticas Basicas de España 1900-1970*. Madrid: Maribel.
Direction of Trade Statistics. Washington: International Monetary Fund.
Historisk Statistik för Sverige. 1969. Stockholm: Allmänna förl.
Johansen, Hans Christian. 1985. *Dansk Historisk Statistik 1814-1980*. Copenhagen: Gylendal.
Ludwig, Armin K. 1985. *Brazil: A Handbook of Historical Statistics*. Boston: G.K. Hall.
Mitchell, Brian R. 2003a. *International Historical Statistics: Africa, Asia, and Oceania 1750-2000*. New York: Palgrave Macmillan.
Mitchell, Brian R. 2003b. *International Historical Statistics: Europe 1750-2000*. New York: Palgrave Macmillan.
Mitchell, Brian R. 2003c. *International Historical Statistics: The Americas 1750-2000*. New York: Palgrave Macmillan.
National Bureau of Economic Research-United Nations World Trade Data.
Ruiz, Elena Martínez. 2006. "Las relaciones economicas internacionales: guerra, politica, y negocios." In *La Economía de la Guerra Civil*. Madrid: Marcial Pons, pp. 273-328.
Statistical Abstract for British India. Calcutta: Superintendent Government Printing.
Statistical Abstract for the British Empire. London: Her Majesty's Stationery Office.
Statistical Abstract for the Colonies. London: Her Majesty's Stationery Office.
Statistical Abstract for the Principal and Other Foreign Countries. London: Her Majesty's Stationery Office.
Statistical Abstract for the Several Colonial and Other Possessions of the United Kingdom. London: Her Majesty's Stationery Office.
Statistical Abstract for the United Kingdom. London: Her Majesty's Stationery Office.
Statistical Abstract of the United States. Washington: Government Printing Office.
Statistical Abstract Relating to British India. London: Eyre and Spottiswoode.
Statistical Yearbook of Canada. Ottawa: Department of Agriculture.
Statistics Bureau Management and Coordination Agency. 1987. *Historical Statistics of Japan, vol. 3*. Tokyo: Japan Statistical Association.
Statistisches Reichsamt. 1936. *Statistisches Handbuch der Weltwirtschaft*. Berlin.
Statistisk Sentralbyrå. 1978. *Historisk statistikk*. Oslo.
Tableau général du commerce de la France. Paris: Imprimerie royale.
Tableau général du commerce et de la navigation. Paris: Imprimerie nationale.
Tableau général du commerce extérieur. Paris: Imprimerie nationale.

Year Book and Almanac of British North America. Montreal: John Lowe.
Year Book and Almanac of Canada. Montreal: John Lowe.

Fixed exchange rate regimes: Meissner and Nienke Oomes. 2009. "Why Do Countries Peg the Way They Peg?" *Journal of International Money and Finance* 28(3), 522-547.

GDP: Maddison, Angus. 2003. *The World Economy: Historical Statistics*. Paris: Organization for Economic Cooperation and Development.

Distance: Measured as kilometers between capital cities. Taken from indo.com

Appendix II: The Reliability of the Trade Cost Measure

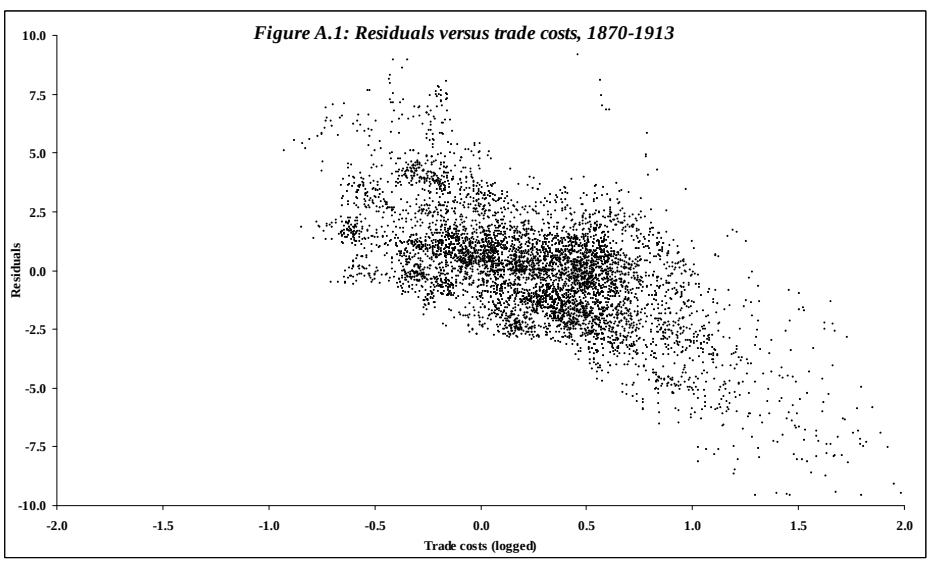
Trade costs versus gravity residuals: In a further attempt to establish the reliability of our trade cost measure, we present the results of comparing it to the residuals of a very general gravity equation. Bilateral trade can be attributed to factors in the global trading environment that affect all countries proportionately—for instance, global transportation and technology shocks; characteristics of individual countries—for instance, domestic productivity; and factors at the bilateral level including bilateral trade costs. To this end, we estimate the following regression equation:

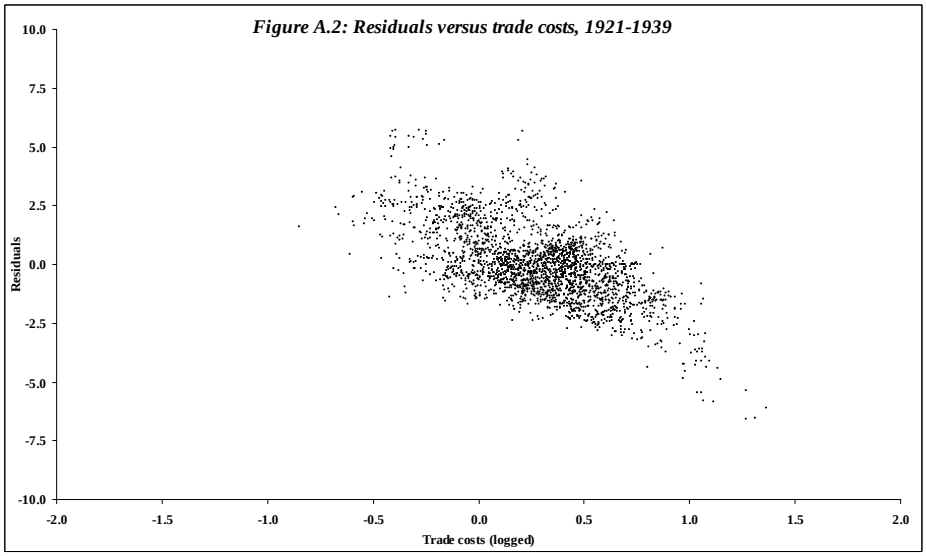
(A.1) $\ln(x_{ijt}x_{jit}) = \delta_t + \alpha_{it} + \alpha_{jt} + \varepsilon_{ijt}$,

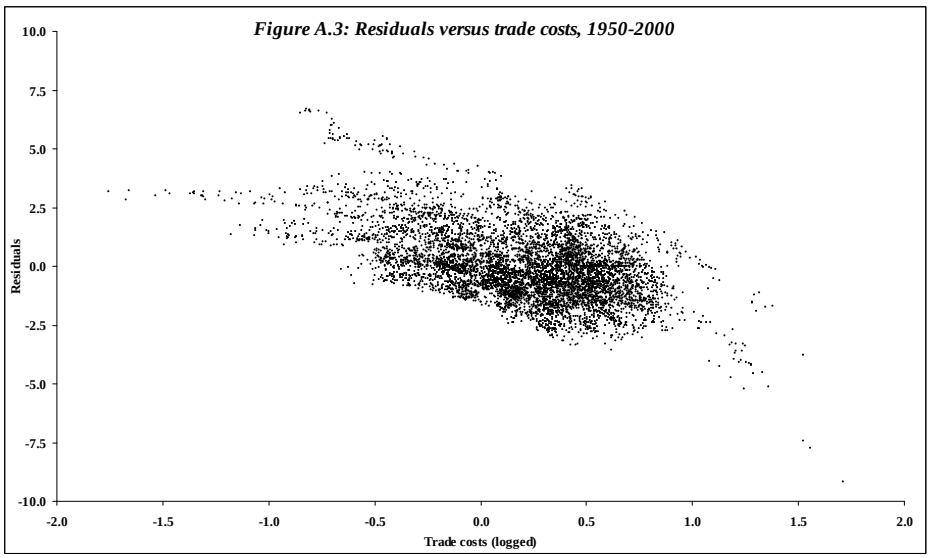
The first term captures factors in the global trading environment which affect all countries proportionately, while the second and third terms capture characteristics of individual countries over time. The residual term absorbs all country-pair specific factors including trade costs.

The correlation between the logged values of our trade cost measure and these residuals is consistently high: -0.64 for the period from 1870 to 1913; -0.62 for the period from 1921 to 1939; and -0.53 for the period from 1950 to 2000. The correlation has the expected (negative) sign. For example, if Germany and the Netherlands experience a particularly large volume of trade in a given year relative to past values or contemporaneous values for a similar country pair—say, Germany and Belgium—then the residual should be positive as the linear projection from the coefficients will underpredict the volume of trade between Germany and the Netherlands for this particular year. The primary means by which trade is stimulated in our model, holding all else constant, would be a lowering of bilateral trade costs. Thus, relatively higher trade volumes should be associated with lower trade costs.

Figures A.1 through A.3 plot the trade costs measure against the residuals from regression (A.1). Naturally, the magnitudes are different, but with appropriate adjustment of the scale it is clear that the correspondence between the two series is high, albeit not perfect.







Measurement error: The trade cost measure in equation (6) is computed on the basis of historical trade data. It might be a concern that these trade data are subject to measurement error, especially in the earlier period. Suppose that measurement error u enters the trade data as follows: $\ln(x_{ij}) = \ln(x_{ij}^*) + u_{ij}$ for all i,j where x_{ij}^* is the true trade flow value for pair i, j.

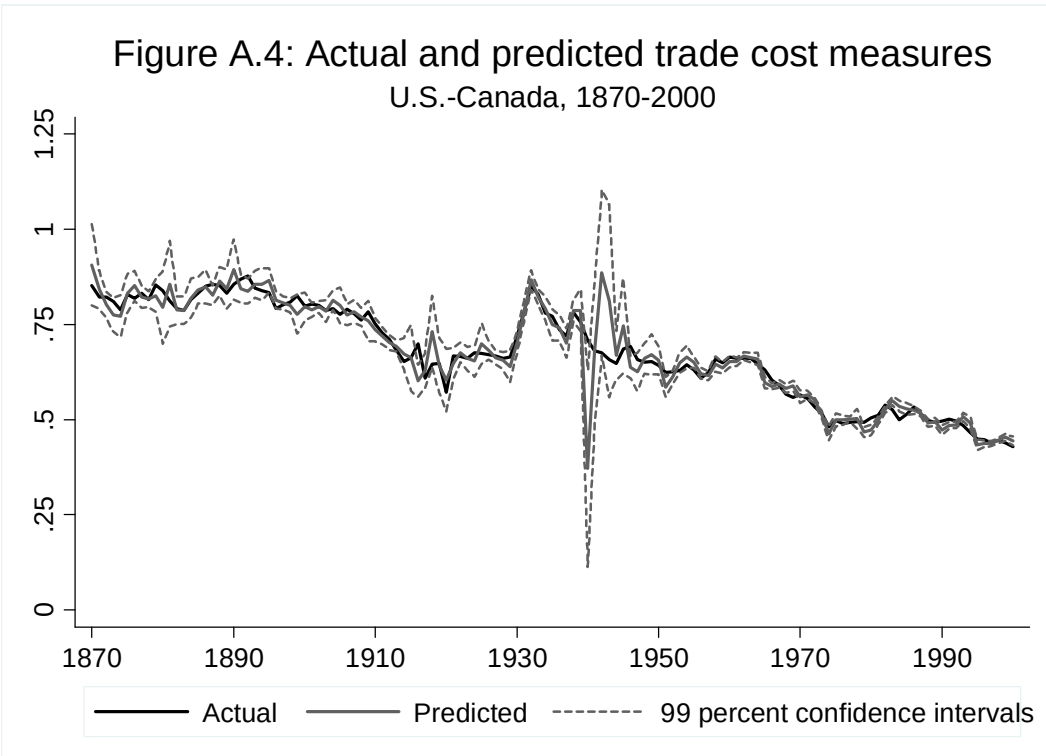
Based on equation (4) we allow for a stochastic element that can reflect measurement error by running the following regression:

(A.2) $$\ln\left(\frac{x_{ijt}x_{jit}}{x_{iit}x_{jjt}}\right) = \delta_t + \alpha_{ijs} + \varepsilon_{ijt}.$$

It follows from the measurement error specification that $\varepsilon_{ijt} = u_{ijt} + u_{jit} - u_{iit} - u_{jjt}$. The first term on the right-hand side of equation (A.2) represents annual time dummies. The second term denotes a set of country-pair fixed effects. Equation (4) implies that these country-pair fixed effects correspond to the trade cost parameters, $(t_{ij}t_{ji})/(t_{ii}t_{jj})$, multiplied by $(1-\sigma)$. As trade costs are likely to change over time, we allow the fixed effects to be time-varying. As annual fixed effects

would leave no degrees of freedom, we choose quinquennial variation instead (denoted by the *s* subscript). Other subperiod lengths, say, biennial or decadal, would also be possible but would lead to similar results. As the final step, we generate predicted values for the dependent variable of regression (A.2) based on the estimated coefficients, and then we construct a predicted trade cost measure, $\hat{\tau}_{ijt}$, based on equation (6). By construction the predicted measure strips out measurement error as it does not include the regression residual that corresponds to ε_{ijt}.

We run regression (A.2) for all available observations that involve the U.S. and Canada, including those during the world wars (4137 observations). Standard errors are robust and clustered around country pairs. The resulting regression has a high R-squared in excess of 95 percent. In Figure A.4 we plot the actual trade cost measure, τ_{ijt}, based on σ=8 for the U.S.-Canadian case against its predicted counterpart. We also plot the 99 percent confidence intervals around the predicted measure (computed with the delta method). The actual and predicted trade cost measures are generally not significantly different. We therefore deem it unlikely that measurement error severely distorts our trade cost measure. The confidence intervals are somewhat wider for the first half of the sample with clear spikes in the vicinity of World War II, suggesting more measurement error in the early period, but they are very tight after 1950.



Gravity based on equation (4): In this robustness test we present estimates by sub-period for the underlying gravity model used in our decomposition exercise. Equation (4) can be rewritten as:

$$\text{(A.3)}\quad \ln(x_{ij}x_{ji}) = \ln(x_{ii}) + \ln(x_{jj}) + (1-\sigma)\ln\left(\frac{t_{ij}t_{ji}}{t_{ii}t_{jj}}\right)$$

To estimate this equation, we substitute for the trade cost function from equation (12), add year fixed effects and a white noise error term at the country-pair year level. Results are provided in Table A.1. The R-squareds are excellent, never explaining less than 99 percent of the variance. The signs of the coefficients on the trade cost proxies are as expected from Table 2. In the post-World War II period, and the interwar period, we cannot reject the null hypothesis that the coefficients on the size terms are equal to one. In the pre-World War I period, we cannot reject the hypothesis that the size term for country *j* is one but we do so for country *i*. This result could easily be due to the weakness in the GDP data in that period. In any case, when we form the log of product of the size terms in this period, the estimated coefficient is 1.167 and we cannot reject the hypothesis that this coefficient is one (p-value = 0.23). The main message is that the gravity equation above, which is consistent with all the models explored earlier, is reliable and provides a good basis for the decomposition exercise.

Table A.1: Gravity Based on Equation (4)

Dependent variable: ln(xijxji)

	1870-1913		1921-1939		1950-2000	
	Coefficient	Std. Err.	Coefficient	Std. Err.	Coefficient	Std. Err.
ln (xii)	**1.59**	**0.19**	**1.02**	**0.12**	**1.11**	**0.10**
ln (xjj)	**0.69**	**0.20**	**1.08**	**0.15**	**1.20**	**0.12**
ln (Distance)	**-1.16**	**0.23**	**-0.65**	**0.18**	**-1.67**	**0.13**
Fixed exchange rate regime	**1.73**	**0.37**	**1.47**	**0.29**	**1.75**	**0.43**
Common language	0.14	0.75	1.18	0.54	0.96	0.43
Imperial membership	2.61	1.33	0.47	1.11	0.17	0.83
Shared border	**1.92**	**0.69**	0.88	0.51	0.68	0.53
Observations	5709		2470		6628	
R-squared	0.99		0.99		0.99	
Test ln (xii) = 1 (p-value)	0.00		0.87		0.27	
Test ln (xjj) = 1 (p-value)	0.17		0.62		0.11	

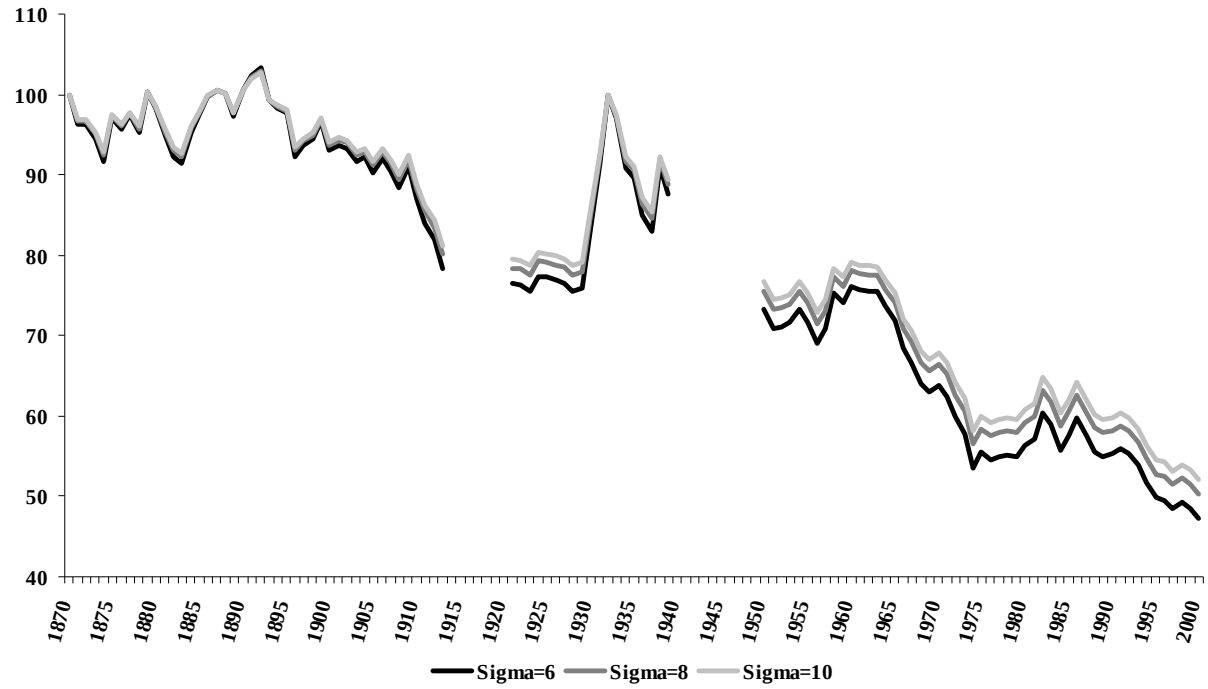
NB: Year fixed effects not reported; robust standard errors; bold values significant at the 1% level.

Appendix III: Sensitivity to Parameter Assumptions

This appendix is intended to demonstrate that our results are not highly sensitive to the assumed value of the elasticity of substitution in our model—or alternatively, the Fréchet and Pareto parameters in the Eaton and Kortum (2002) and Chaney (2008) models. The relative ordering of trade costs is stable across all dyads with respect to uniform changes of the elasticity of substitution. Our reported regression and decomposition results are also strongly robust to shifts in this parameter.

To demonstrate this property, we recalculate our trade cost measure using three distinct values of the elasticity of substitution which roughly span the range suggested by Anderson and van Wincoop (2004), namely six, eight (our preferred value), and ten. In Figure A.5, bilateral trade costs between Canada and the United States are plotted for the years from 1870 to 2000 with all values normalized to 1870=100. The three series are highly correlated. What is more, the proportional changes in the series are very similar: the cumulative drop from 1870 to 2000 is calculated at 53% when sigma equals six versus 48% when sigma equals ten.

Figure A.5: Bilateral Trade Costs, Canada and the United States, 1870-2000 (1870=100)



Another concern may be that sigma is changing over time. To explore that possibility, we consider two scenarios, one where sigma is smoothly trending upwards over time and one where sigma is smoothly trending downwards over time. Although differences in the level of trade costs naturally emerge, the proportionate changes over time are once again very similar. Figure A.6 demonstrates this graphically by considering the annual change in logged bilateral trade costs for Canada and the United States for the years from 1870 to 2000.

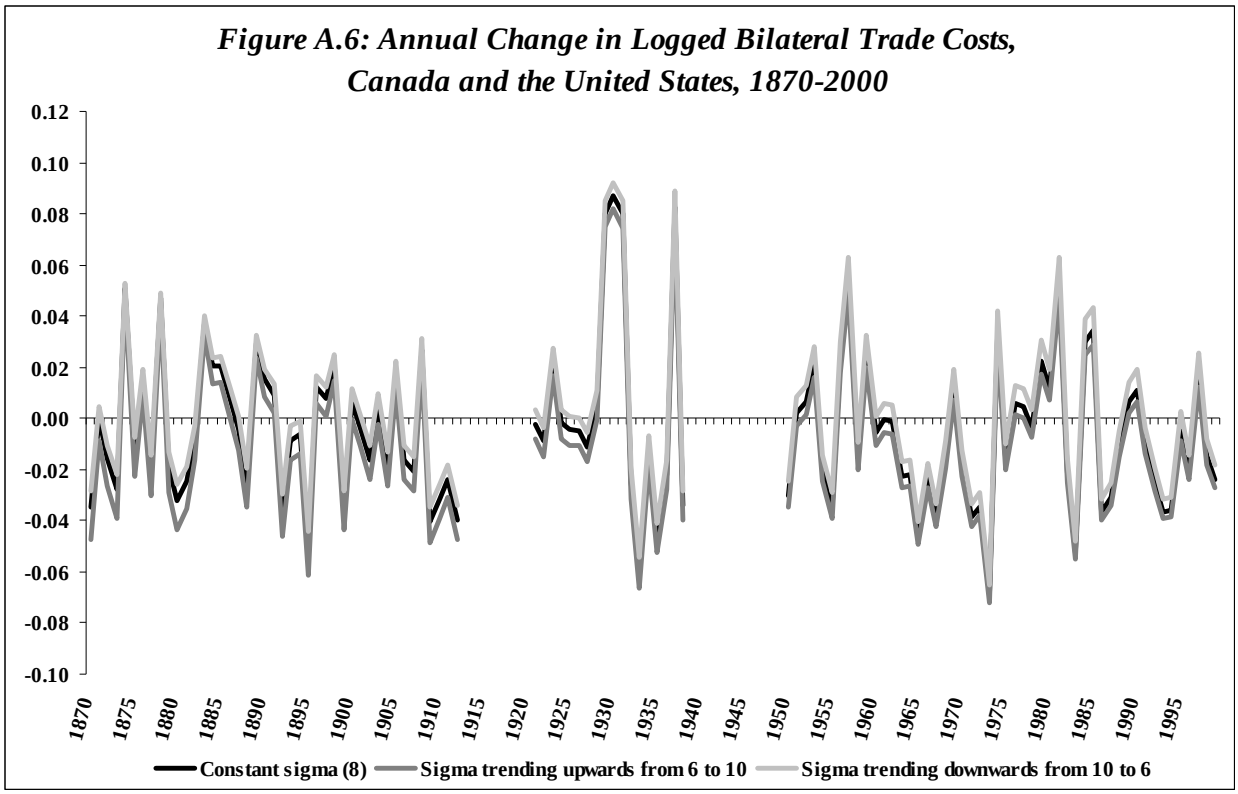


Figure A.6: Annual Change in Logged Bilateral Trade Costs, Canada and the United States, 1870-2000
0.12
0.10
0.08
0.06
0.04
0.02
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
1870
1875
1880
1885
1890
1895
1900
1905
1910
1915
1920
1925
1930
1935
1940
1945
1950
1955
1960
1965
1970
1975
1980
1985
1990
1995
Constant sigma (8)
Sigma trending upwards from 6 to 10
Sigma trending downwards from 10 to 6

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Table 1: Summary Statistics

	1870-1913			1921-1939			1950-2000		
	N	Mean	Std. Dev.	N	Mean	Std. Dev.	N	Mean	Std. Dev.
Bilateral trade	11429	18.06	2.23	4940	18.81	1.59	13256	20.45	1.80
GDP	11429	20.85	1.74	4940	22.38	1.61	13256	25.13	1.93
Distance	11429	8.04	1.19	4940	8.04	1.19	13256	8.04	1.19
Exchange rate volatility	11429	0.50	0.50	4940	0.22	0.41	13256	0.08	0.28
Common language	11429	0.16	0.37	4940	0.16	0.37	13256	0.16	0.37
Imperial membership	11429	0.10	0.30	4940	0.09	0.29	13256	0.09	0.29
Shared border	11429	0.12	0.32	4940	0.12	0.32	13256	0.12	0.32

Table 2: Gravity in Three Eras of Globalization

Dependent variable: log of bilateral exports from i to j

Panel A: With country fixed effects

	1870-1913			1921-1939			1950-2000		
	Coefficient	Std .Err.		Coefficient	Std .Err.		Coefficient	Std .Err.	
GDP	0.70	0.02	***	0.82	0.02	***	0.80	0.01	***
Distance	-0.31	0.02	***	-0.15	0.02	***	-0.65	0.01	***
Fixed exchange rate regime	0.45	0.04	***	0.17	0.03	***	0.33	0.03	***
Common language	0.48	0.04	***	0.32	0.05	***	0.19	0.03	***
Imperial membership	1.66	0.07	***	0.65	0.08	***	0.59	0.05	***
Shared border	1.01	0.04	***	1.00	0.04	***	0.65	0.02	***
Observations	11429			4940			13256		
R-squared	0.6418			0.6806			0.8380		

Panel B: With country-specific annual fixed effects

	1870-1913			1921-1939			1950-2000		
	Coefficient	Std .Err.		Coefficient	Std .Err.		Coefficient	Std .Err.	
GDP	-	-		-	-		-	-	
Distance	-0.38	0.02	***	-0.20	0.03	***	-0.69	0.01	***
Fixed exchange rate regime	0.79	0.06	***	0.36	0.07	***	0.64	0.04	***
Common language	0.38	0.05	***	0.21	0.06	***	0.19	0.04	***
Imperial membership	1.46	0.08	***	0.35	0.10	***	0.33	0.05	***
Shared border	1.09	0.05	***	1.09	0.06	***	0.72	0.03	***
Observations	11429			4940			13256		
R-squared	0.6445			0.6243			0.7939		

NB: Country and year fixed effects not reported; robust standard errors; *** significant at the 1% level.

Table 3: Determinants of Trade Costs in Three Eras of Globalization

Dependent variable: log of bilateral trade costs separating i and j

	Pooled			1870-1913			1921-1939			1950-2000		
	Coefficient	Std .Err.		Coefficient	Std .Err.		Coefficient	Std .Err.		Coefficient	Std .Err.	
Distance	0.13	0.00	***	0.11	0.01	***	0.06	0.01	***	0.17	0.00	***
Fixed exchange rate regime	-0.03	0.01	***	-0.08	0.01	***	-0.04	0.01	***	-0.09	0.01	***
Common language	-0.11	0.01	***	-0.14	0.01	***	-0.08	0.01	***	-0.08	0.01	***
Imperial membership	-0.28	0.01	***	-0.46	0.02	***	-0.20	0.02	***	-0.15	0.01	***
Shared border	-0.26	0.01	***	-0.29	0.01	***	-0.26	0.01	***	-0.22	0.01	***
Observations	14807			5709			2470			6628		
R-squared	0.6502			0.7251			0.6989			0.8242		

NB: Country and year fixed effects not reported; robust standard errors; *** significant at the 1% level.

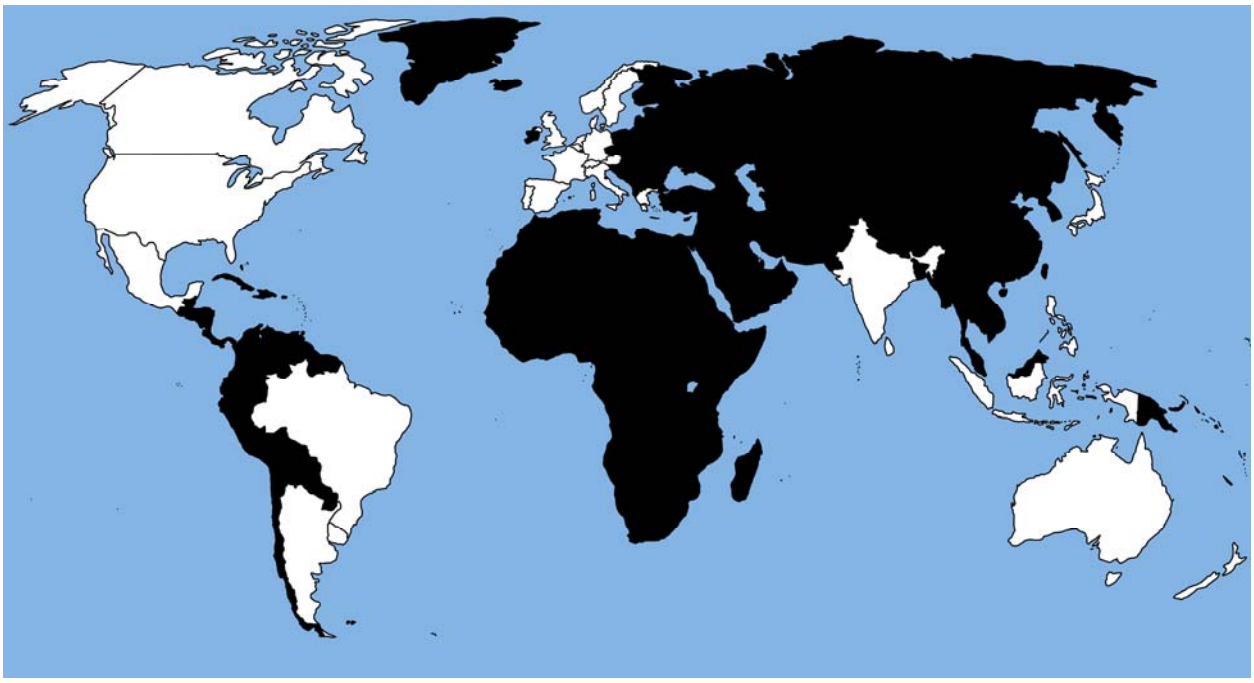
Table 4: Upper and Lower Bound Estimates of Percentage of Explained Variation in Trade Costs

	1870-1913		1921-1939		1950-2000	
	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound
Distance	0.1362	0.0191	0.1238	0.0143	0.4513	0.0668
Fixed exchange rate regime	0.0968	0.0033	0.0619	0.0012	0.0028	0.0024
Common language	0.0411	0.0044	0.0581	0.0026	0.0230	0.0017
Imperial membership	0.0366	0.0276	0.0118	0.0063	0.0103	0.0043
Shared border	0.1139	0.0224	0.0984	0.0367	0.2213	0.0178

Table 5: Decomposition of Trade Booms and Busts, 1870-2000

			Contribution of growth in output (GDP weighted)		Contribution of growth in income similarity (GDP weighted)		Contribution of change in trade costs (GDP weighted)		Contribution of change in multilateral factors (GDP weighted)		Average growth of international trade (GDP weighted)
1870-2000	**Full sample**	**(n = 130)**	**744%**	**+**	**-16%**	**+**	**326%**	**+**	**-25%**	**=**	**1029%**
	Americas	(n = 6)	886	+	14	+	162	+	-1	=	1061
	Asia/Oceania	(n = 7)	610	+	51	+	436	+	-24	=	1074
	Europe	(n = 56)	590	+	23	+	330	+	-38	=	904
	Americas-Asia/Oceania	(n = 6)	832	+	-47	+	511	+	-28	=	1268
	Americas-Europe	(n = 35)	808	+	-56	+	281	+	-22	=	1011
	Asia/Oceania-Europe	(n = 20)	601	+	28	+	386	+	-30	=	985
1870-1913	**Full sample**	**(n = 130)**	**225%**	**+**	**-11%**	**+**	**290%**	**+**	**-18%**	**=**	**486%**
	Americas	(n = 6)	331	+	0	+	151	+	-19	=	463
	Asia/Oceania	(n = 7)	105	+	29	+	434	+	-11	=	557
	Europe	(n = 56)	177	+	-6	+	176	+	-23	=	324
	Americas-Asia/Oceania	(n = 6)	281	+	-48	+	339	+	-9	=	564
	Americas-Europe	(n = 35)	273	+	-26	+	297	+	-18	=	524
	Asia/Oceania-Europe	(n = 20)	146	+	20	+	497	+	-16	=	647
1921-1939	**Full sample**	**(n = 130)**	**88%**	**+**	**4%**	**+**	**-87%**	**+**	**-6%**	**=**	**0%**
	Americas	(n = 6)	82	+	14	+	-115	+	9	=	-10
	Asia/Oceania	(n = 7)	58	+	12	+	-36	+	0	=	34
	Europe	(n = 56)	103	+	-2	+	-65	+	-16	=	20
	Americas-Asia/Oceania	(n = 6)	78	+	6	+	-37	+	2	=	48
	Americas-Europe	(n = 35)	86	+	7	+	-132	+	-6	=	-45
	Asia/Oceania-Europe	(n = 20)	85	+	1	+	-50	+	-6	=	30
1950-2000	**Full sample**	**(n = 130)**	**353%**	**+**	**8%**	**+**	**148%**	**+**	**-25%**	**=**	**484%**
	Americas	(n = 6)	347	+	7	+	16	+	-7	=	363
	Asia	(n = 7)	448	+	-14	+	-27	+	-15	=	391
	Europe	(n = 56)	332	+	7	+	331	+	-38	=	633
	Americas-Asia	(n = 6)	356	+	29	+	84	+	-25	=	444
	Americas-Europe	(n = 35)	343	+	5	+	125	+	-23	=	450
	Asia-Europe	(n = 20)	386	+	2	+	185	+	-28	=	544

Figure 1: Sample Countries (in white)



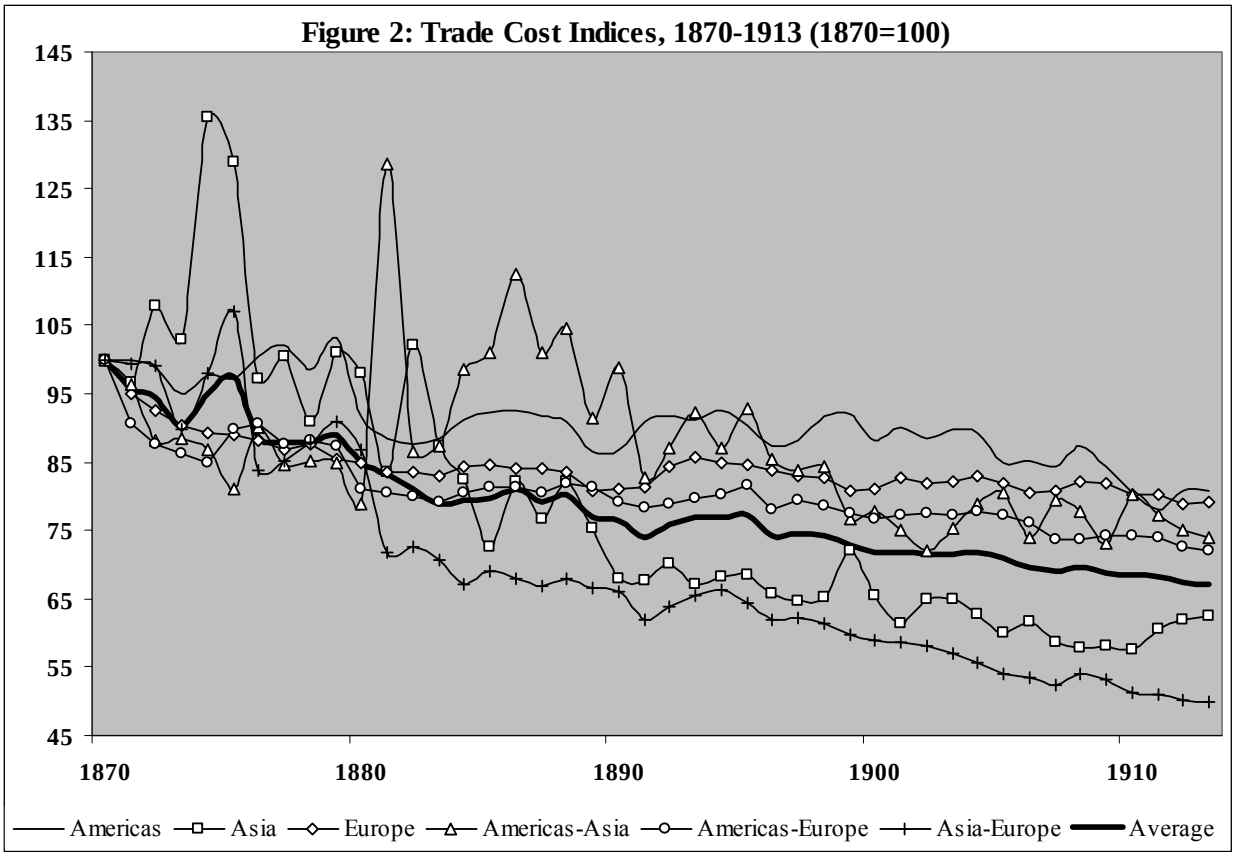


Figure 2: Trade Cost Indices, 1870-1913 (1870=100)
145
135
125
115
105
95
85
75
65
55
45
1870
1880
1890
1900
1910
Americas
Asia
Europe
Americas-Asia
Americas-Europe
Asia-Europe
Average

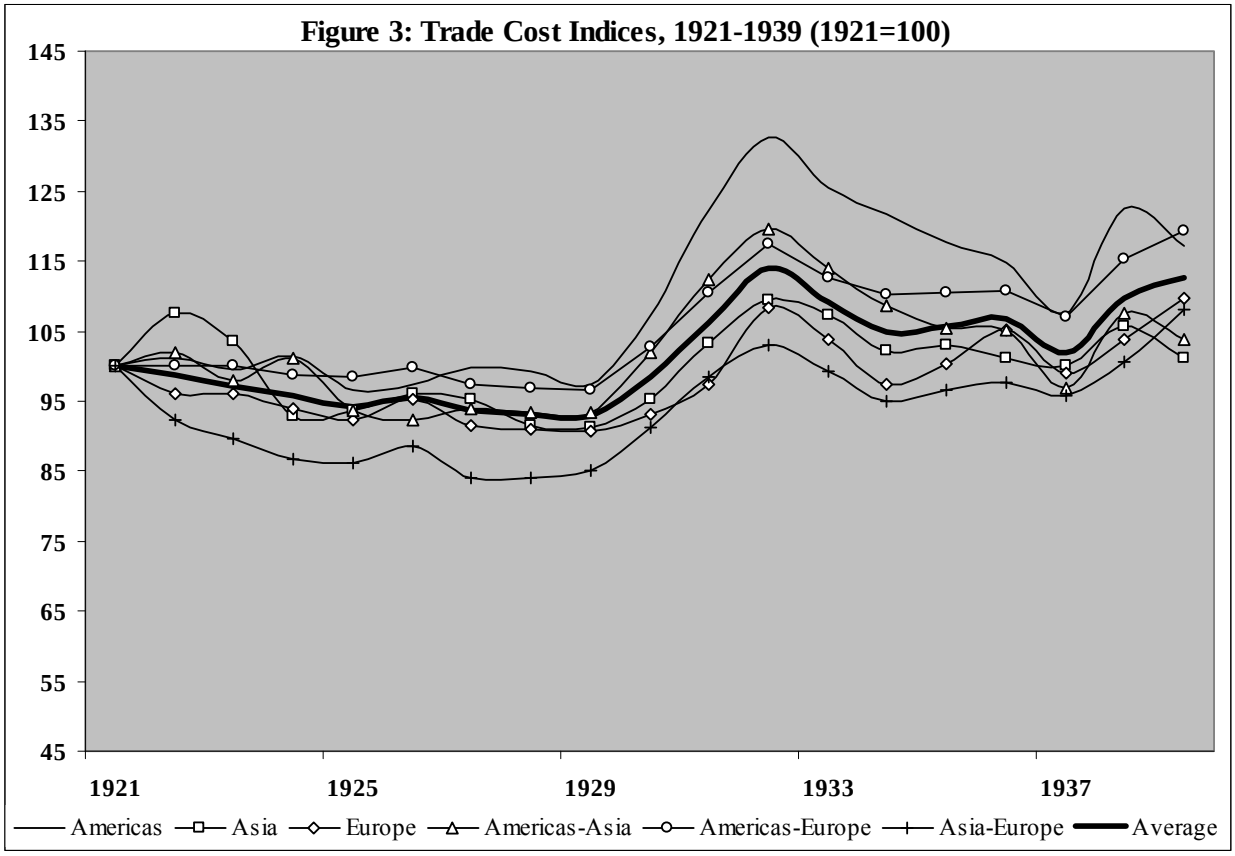


Figure 3: Trade Cost Indices, 1921-1939 (1921=100)
145
135
125
115
105
95
85
75
65
55
45
1921
1925
1929
1933
1937
Americas
Asia
Europe
Americas-Asia
Americas-Europe
Asia-Europe
Average

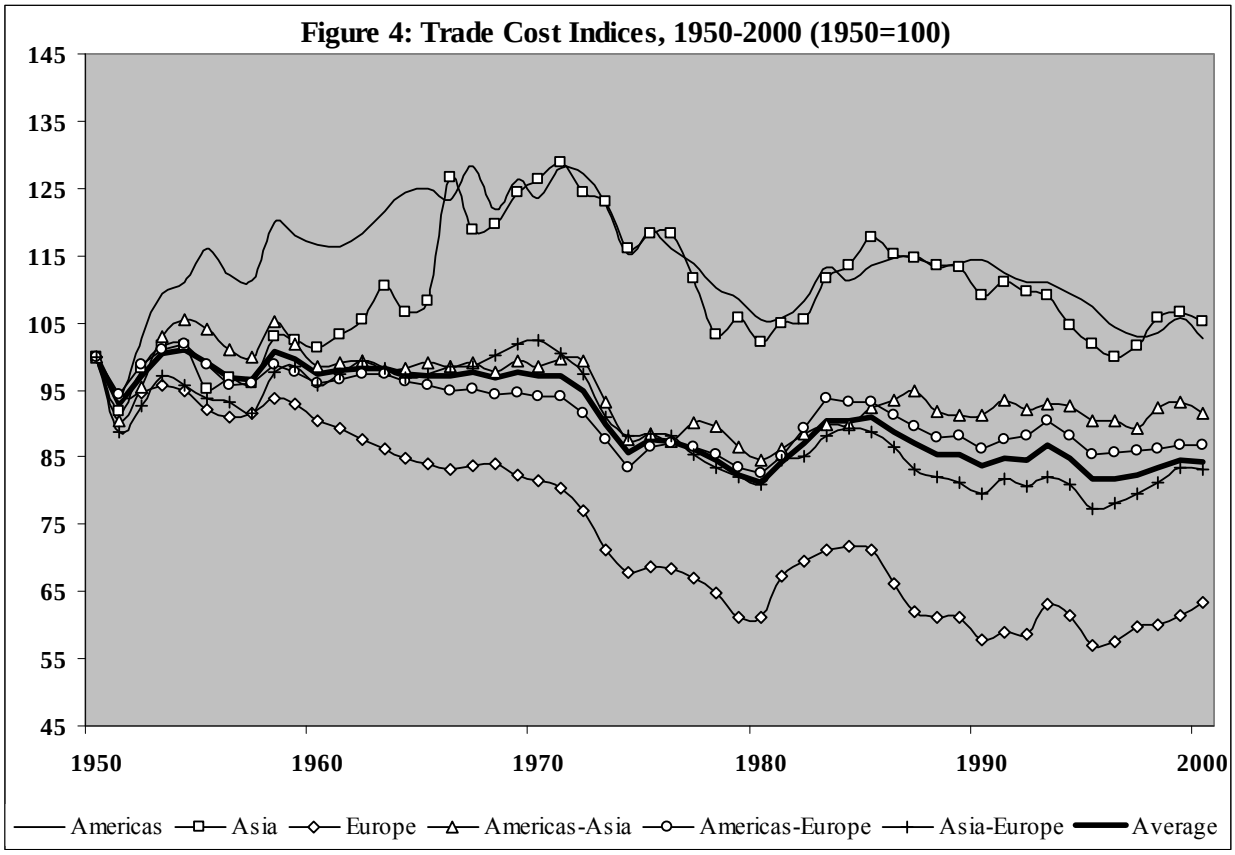


Figure 4: Trade Cost Indices, 1950-2000 (1950=100)
145
135
125
115
105
95
85
75
65
55
45
1950
1960
1970
1980
1990
2000
Americas
Asia
Europe
Americas-Asia
Americas-Europe
Asia-Europe
Average

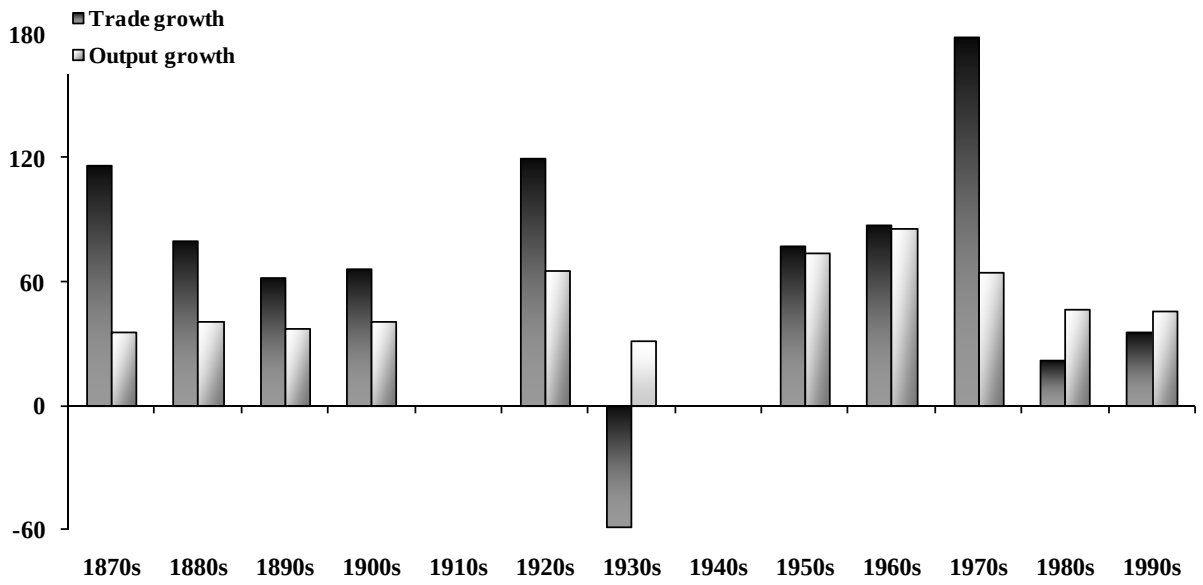



Figure 5: Trade Growth versus Output Growth (in %)