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Back to the Future: International Trade Costs and the Two Globalizations

Michel Fouquin & Jules Hugot

Highlights

- We provide the most comprehensive historical trade dataset for 1827-2014.
- We demonstrate that the First globalization had already begun c.1840.
- We show that both the First and the Second Globalization have been associated with an increasing regionalization of trade.

Abstract

This article provides an assessment of the nineteenth century trade globalization based on a systematic collection of bilateral trade statistics. Drawing on a new data set of more than 1.9 million bilateral trade observations for the 1827-2014 period, we show that international trade costs fell more rapidly than intra-national trade costs from the 1840s until the eve of World War I. This finding questions the role played by late nineteenth century improvements in transportation and liberal trade policies in sparking this First Globalization. We use a theory-grounded measure to assess bilateral relative trade costs. Those trade costs are then aggregated to obtain world indices as well as indices along various trade routes, which show that the fall of trade costs began in Europe before extending to the rest of the world. We further explore the geographical heterogeneity of trade cost dynamics by estimating a border effect and a distance effect. We find a dramatic rise in the distance effect for both the nineteenth century and the post-World War II era. This result shows that both modern waves of globalization have been primarily fueled by a regionalization of world trade.

Keywords

Globalization, Trade Costs, Border Effect, Distance Effect.

JEL

F14, F15, N70.

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RESEARCH AND EXPERTISE ON THE WORLD ECONOMY

Back to the Future: International Trade Costs and the Two Globalizations[1]

Michel Fouquin* and Jules Hugot†

Abstract

This article provides an assessment of the nineteenth century trade globalization based on a systematic collection of bilateral trade statistics. Drawing on a new data set of more than 1.9 million bilateral trade observations for the 1827-2014 period, we show that international trade costs fell more rapidly than intra-national trade costs from the 1840s until the eve of World War I. This finding questions the role played by late nineteenth century improvements in transportation and liberal trade policies in sparking this First Globalization. We use a theory-grounded measure to assess bilateral relative trade costs. Those trade costs are then aggregated to obtain world indices as well as indices along various trade routes, which show that the fall of trade costs began in Europe before extending to the rest of the world. We further explore the geographical heterogeneity of trade cost dynamics by estimating a border effect and a distance effect. We find a dramatic rise in the distance effect for both the nineteenth century and the post-World War II era. This result shows that both modern waves of globalization have been primarily fueled by a regionalization of world trade.

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1. Introduction

The existence of two distinct periods of international market integration in the modern era – the First Globalization of the nineteenth century and the post-World War II Second Globalization – has been extensively documented. However, the precise chronology of the First Globalization remains unclear. Understanding this timing is a necessary prerequisite to a proper analysis of the causes behind globalization. Some argue that the First Globalization is a late nineteenth century phenomenon, emphasizing the role of transportation technologies such as the steamship (Harley, 1988, Pascali, 2014), communication technologies such as the telegraph (Steinwender, 2014), and pro-trade policies such as the gold standard (Estevadeordal et al., 2003, López-Córdova and Meissner, 2003). Others argue that the First Globalization took off in the early nineteenth century, emphasizing the end of various trade monopolies as a trigger (O'Rourke and Williamson, 2002) or the role played by improvements in transportation already achieved in the late eighteenth century (Jacks, 2005).

We adopt a systematic approach to collecting trade statistics in order to explore the chronology and geographical pattern of both globalizations. Specifically, we compile a data set that gathers more than 1.9 million bilateral trade observations for the 188 years from 1827 to 2014. We also provide data on aggregate trade, aggregate and bilateral tariffs, GDP, exchange rates and various bilateral variables commonly used in the gravity literature.

We show that the obstacles specific to international trade fell steadily from the 1840s until World War I This result creates a new temporal perspective for the factors that are claimed to be the leading causes of nineteenth century globalization. Disentangling these factors, however, remains beyond the scope of this paper. The early onset of trade globalization is consistent with evidence on freight costs[2] and on the European movement of unilateral trade liberalization,[3] but also with those studies demonstrating that the trade treaties of the 1860s were of limited impact.[4] However, this paper challenges the studies that argue that late nineteenth century technological improvements were the key driver behind the First Globalization.[5]

We also explore the geographical dynamics of globalization by disentangling between a border effect and a distance effect. We show that both waves of globalization have been associated with an increasing response of trade to distance. In other words, both globalizations have been driven by an increased regionalization of world trade patterns.

[2]Harley (1988) finds that before the 1840s, freight rates fluctuated dependent on the recurring wars that affected Europe. He documents a continuous reduction of freight rates from c. 1840 to 1913.

[3]The British repeal of the Corn laws is well documented (Sharp, 2010) but it was in fact a broader phenomenon. Between 1827 and 1855, customs duties-to-imports ratios fell from 24% to 12% in France, from 33% to 15% in the U.K. and from 3.5% to 2.3% in the Netherlands (Detailed sources in Fouquin and Hugot (2016)).

[4]Accominotti and Flandreau (2006) and Lampe (2009) find that the Cobden-Chevalier network of treaties did not contribute to expanding trade but merely substituted previous unilateral liberalizations. Lampe (2009), however, finds some evidence of a trade-enhancing effect for particular commodities.

[5]Pascali (2014) claims that "*the adoption of the steamship* [c. 1870] *was the major reason for the first wave of trade globalization*" (p.23.).

Trade globalization is the process by which international goods markets integrate. A simple increase of world trade relative to output – the trade openness ratio – is therefore not sufficient to diagnose globalization. In particular, trade openness is sensitive to the world distribution of economic activity. Indeed, for a constant level of market integration, world trade openness increases as the world economy becomes more scattered.[6] In the long run, controlling for the dispersion of the world economy is therefore necessary to properly grasp the evolution of trade globalization.

The economic history literature has adopted two distinct approaches to assess the extent of trade globalization. The indirect approach looks at price-convergence. The direct approach relies on trade statistics. The indirect approach builds on the intuition that, in the absence of international trade costs, arbitrage should eliminate price gaps across countries. Empirically, this prediction has been tested by measuring price gaps across different markets for the same commodity. This approach is particularly helpful to investigate pre-modern globalization.[7] Indeed, the first comprehensive customs reports were only drafted in the early eighteenth century, and only for a handful of countries.[8]

Using data on colonial commodities such as cloves and pepper, O'Rourke and Williamson (2002) observe price convergence across continents in the early nineteenth century. These commodities, however, exhibit a high value-to-weight ratio, which makes them particularly worth trading. More generally, the conclusions of such studies are product-dependent. For instance, using the same approach, O'Rourke and Williamson (1994) show that the transatlantic convergence of meat prices did not occur before c. 1900. Another caveat is that price gaps only reveal information on trade costs when bilateral trade actually occurs and trade with third countries is negligible (Coleman, 2007). Finally, the price gap literature has focused on long-distance trade, while our data reveals that by 1840 more than 50% of European trade was conducted within Europe.[9]

Our results bring support to the more recent strand of the price gap literature that claims that the conditions for the First Globalization were in fact already met in the late eighteenth century. Those conditions could not translate into a surge of trade due to the recurring disruptive shocks that plagued international relations until 1815. O'Rourke (2006) shows that international price gaps widened during the Napoleonic Wars. He takes this as a sign that world markets were already well connected in the late eighteenth century. Moreover, several authors find direct

[6]Helpman (1987) shows that a rise of trade relative to income can result from a more even distribution of world GDP. One simple illustration emerges from the comparison of two hypothetical situations. Imagine that consumers allocate their expenditure to countries, including their own, in proportion to their GDP, i.e. that markets are perfectly integrated. In the first situation, the world GDP is shared between two identical countries: world openness is therefore 50%. In the second situation, there are 5 identical countries. Consumers therefore allocate 4/5 of their expenditure to foreign countries. World trade openness is therefore 80%.

[7]Sources of pre-modern price data include the records of the Dutch East India Company (Bulbeck et al., 1998), the accounts of hospitals (Hamilton, 1934) and even Babylonian tablets (Földvári and van Leeuwen, 2000).

[8]We collected trade statistics from 1697, 1703 and 1720, respectively for the thirteen colonies, Britain and France.

[9]This figure relies on a sample of five European countries: Belgium, France, the Netherlands, Spain and the U.K.

evidence of price convergence in the eighteenth century.[10] The causes behind this nascent market integration, however, remain unclear.[11] What is certain is that the Congress of Vienna, in 1815, marked the beginning of a century-long period of peace in Europe,[12] associated with a rise of trade of an unprecedented magnitude.

The direct approach to assessing the timing of globalization relies on observed bilateral trade. The vast majority of these studies, however, focus on the 1870-1913 period[13] (Estevadeordal et al., 2003, Jacks et al., 2008, López-Córdova and Meissner, 2003). This may give the false impression that the First Globalization began later than it actually did. Jacks et al. (2008) use trade statistics to infer aggregate international relative trade costs. Their measure of trade costs builds upon the Head and Ries index (2001), which is itself derived from the gravity equation. They find substantial trade cost reductions between 1870 and 1913. Beyond the limitation in terms of temporal coverage, their study concentrates on three countries: France, Britain, and the USA. As opposed to previous studies, our work relies on a systematic collection of trade statistics before 1870 and back to 1827.[14]

We use aggregate international relative trade costs as a tool for evaluating the timing of globalization. These trade costs are consistent with our definition of globalization as they are an inverse measure of changes in trade that controls for the world distribution of production and expenditure. While we rely on an aggregate measure, some authors have tried to measure individual components of trade costs.[15] This bottom-up approach has several drawbacks when it comes to tracking overall trade costs over time. Indeed, trade costs range from observable barriers – such as tariffs or freight costs – to a variety of unobservable features, such as language barriers and taste preferences. Using the gravity model, Anderson and van Wincoop (2004) estimate that observable trade barriers only account for a 20% tariff equivalent cost, out of a 74% typical international trade costs for rich countries.[16] Head and Mayer (2013) refer to these unobservable components as "dark trade costs". They find that these hidden costs account for 72 to 96% of distance-related trade costs. These results cast a long shadow on the possibility of recovering aggregate trade costs based on a bottom-up approach.

[10] Sharp and Weisdorf (2013) and Dobado-González et al. (2012) focus on British-American wheat trade, Rönnbäck (2009) uses data on eleven colonial commodities, Jacks (2004) focuses on trade in the North and Baltic Seas.
[11] One exception is Solar (2013), who documents a steep reduction of shipping costs between c. 1770 and c. 1820.
[12] The Crimean War and the wars related to the German and Italian unification are the only exceptions.
[13] Lampe (2009) is an exception as he collected product-level bilateral trade data for seven countries from 1857 to 1875. His focus, however, is not on the timing of globalization, but on the heterogeneous effect of the Cobden-Chevalier network of trade treaties across commodities.
[14] Jacks et al. (2011) extend the sample to 130 country pairs, of which 61 do not involve France, Britain or the USA. By comparison, our sample covers more than 42,000 country pairs, including about 1,500 country pairs for the 1827-1870 period. We provide a comparison of our data set with three others in Table 2.
[15] Anderson and van Wincoop (2004) provide a survey of this literature.
[16] We define observable trade barriers as freight costs plus protectionist policies. Anderson and van Wincoop (2004) find that they respectively result in an 11% and a 8% tariff equivalent cost: $1.11 \times 1.08 = 1.20$.

We choose a top-down approach and use observed trade to infer aggregate international relative trade costs. This method has the advantage of capturing all the possible components of trade costs without having to assume an *ad-hoc* specification for each of them. On the flip side, the top-down approach prevents us from identifying the individual components of trade costs.

The measure of trade costs we use takes its roots in the gravity literature. Specifically, we use the Head and Ries index to relate observed trade to the frictionless counterfactual that emerges from the structural gravity theory. Aggregate trade costs are inferred from this comparison. Economists have derived gravity equations from a variety of general equilibrium trade models (Anderson and van Wincoop, 2003, Krugman, 1980, Eaton and Kortum, 2002, Chaney, 2008, Melitz and Ottaviano, 2008). Head and Mayer (2014) review these micro-foundations and coin "structural gravity" the models that involve multilateral resistance terms.[17] These multilateral factors reflect the fact that bilateral trade does not only depend on bilateral factors but also on the costs associated with the outside option of trading with third countries. Head and Mayer (2014) show that all structural gravity models yield the same macro-level gravity equation.

The generality of the gravity equation allows the skeptical reader to remain agnostic as to which model best describes the fundamental reasons to trade. This becomes crucial when dealing with a period of almost two centuries as it can be argued that the reasons to trade have changed dramatically.[18] Beyond its generality, the Head and Ries trade cost index presents several advantages. First, it perfectly controls for the country-specific determinants of trade emphasized by the structural gravity literature, including supply and demand but also multilateral resistance terms. Second, the Head and Ries index is bilateral-specific, which allows us to explore the dynamics of globalization across trade routes. Third, the Head and Ries index can be converted into a tariff equivalent measure (Jacks et al., 2008), on the condition of imposing a value for the elasticity of trade with respect to trade costs (hereafter: trade elasticity).

We also contribute to the literature by providing the first estimates of the trade elasticity for the nineteenth century. The trade elasticity reflects the response of trade to trade costs in any structural gravity model. A small trade elasticity reveals large incentives to trade, as agents are ready to pay high costs to trade across borders. In the end, the larger the theoretical gains from trade, the higher will be the measure of trade costs inferred from any given observed trade flows. The reasons why the trade elasticity may have changed depend on the micro-level factors that push countries to trade.[19] In a monopolistic competition framework, product varieties may become closer substitutes as more countries industrialize. In a Ricardian framework, productivity

[17]Equation (2), p.8. Arkolakis et al. (2012) also emphasize the generality of the gravity equation. Similarly, Allen et al. (2014) provide a unifying theory they call "universal gravity".
[18]e.g. economies of scale have been claimed to become key drivers of trade after World War II (Krugman, 1980).
[19]We have no reason to believe that the trade elasticity is volatile in the short run: Broda and Weinstein (2006) estimate the elasticity of substitution for two recent periods: 1972-1988 and 1990-2001, at the product level. They find a small and insignificant reduction in the median elasticity: from 2.5 to 2.2 (Table IV, p.568).

across sectors may become more homogeneous due to technology convergence. Both these claims imply a reduction of the theoretical gains from trade. As the potential gains peter out, consumers become more reluctant to pay higher costs to obtain foreign goods. Trade therefore becomes more sensitive to trade costs and the trade elasticity increases.

We use bilateral tariffs to identify the trade elasticity in both the cross section and the time dimension. None of our estimates is statistically different from an interval between -5.24 and -5.39, which is surprisingly close to the median value of -5.03 found by Head and Mayer (2014) in their meta-analysis of trade elasticities estimated on World War II data. We conclude that the trade elasticity did not substantially change over the last two centuries [20] and therefore use -5.03 as our benchmark value.

We elicit differences in the dynamics of trade costs across trade routes. In particular, we show that trade costs fell faster within Europe that across long distance routes during the nineteenth century. We then make further use of the gravity equation to investigate the geographical pattern of trade cost dynamics. Specifically, we decompose overall trade costs into a component that is independent of the distance between the trading partners – the border effect – and a distance effect. The border effect is the average trade reducing effect of international borders, once distance is taken into account. The distance effect reflects the negative impact of distance on trade. This decomposition, however, requires imposing an *ad-hoc* – although standard – functional form for trade costs. In the end, we show that both waves of globalization have been disproportionately fueled by an increase in short-haul trade. This feature has been documented for the Second Globalization by Combes et al. (2008) and Disdier and Head (2008), but this article is the first to find a similar pattern for the nineteenth century.

As a last step, we provide a distance equivalent measure of the border effect, which shows that both waves of globalization have been associated with borders becoming "thinner", i.e. that distance-induced trade costs rose relative to border-related costs. This provides another way to illustrate the increased regionalization of trade patterns over the course of both globalizations.

Section 2 discusses the Head and Ries index of trade costs. Section 3 introduces the data. In Section 4, we estimate the trade elasticity for the nineteenth century. In Section 5, we estimate our index of world trade costs. Section 6 explores the heterogeneity of trade cost dynamics across trade routes. In Section 7, we decompose trade costs into a border and a distance effect, and compute a measure of border thickness. Section 8 provides concluding remarks.

[20] A stable aggregate trade elasticity could very well hide substantial changes at the commodity level.

2. The Head and Ries measure of trade costs

The empirical literature has isolated particular components of international trade costs, such as language barriers or transportation costs. This approach often comes at the cost of imposing somewhat arbitrary functional forms for these barriers. Moreover omitted variable bias becomes a source of concern as only a subset of the potential barriers are included in these regressions. Head and Ries (2001) tackle this issue and derive a comprehensive index that infers trade costs from observed trade flows. The Head and Ries index therefore captures both the observable and the unnobservable components of trade costs.[21] This feature is particularly appealing since data on the components of trade costs is hardly available for the nineteenth century.

The Head and Ries index controls perfectly for the country-specific determinants of trade, including supply and demand as well as multilateral resistance terms. In turn, the Head and Ries index precisely reveals international trade costs relative to domestic ones, for each pair of country. On the other hand, atheoretical measures, such as the trade openness ratio, do not allow to disentangle between trade costs and internal factors.[22] An example is given by Eaton et al. (2011) who document a steep reduction of trade openness during the trade collapse of 2008-2009 while trade costs remained rather stable.

Head and Ries derive their trade cost index from both the monopolistic competition model of Krugman (1980) and a perfect competition model of national product differentiation, similar to Anderson and van Wincoop (2003) (hereafter: AvW). The Head and Ries index relates observed trade to the frictionless prediction that emerges from both models. The comparison of actual trade to the frictionless counterfactual yields a measure of the aggregate trade barriers associated with each country pair. Novy (2013) shows that the Head and Ries index can be derived from a broader range of models, including the Ricardian (Eaton and Kortum, 2002) and heterogeneous firms models (Chaney, 2008, Melitz and Ottaviano, 2008).[23] More generally, the Head and Ries index can be derived from any structural gravity equation of the form:

$$X_{ij} = \frac{Y_i \, X_j}{P_i \, \Pi_j} \, \tau_{ij}^{\epsilon}, \tag{1}$$

where $P_i = \sum_l \frac{\tau_{i\ell}^{\epsilon} X_\ell}{\Pi_\ell}$ and $\Pi_j = \sum_\ell \frac{\tau_{\ell j}^{\epsilon} Y_\ell}{P_\ell}$. ℓ indexes third countries.

Bilateral trade (X_{ij}) is positively related to production in the origin country (Y_i), expenditure in the destination country (X_j); and negatively related to the exporter's outward multilateral

[21] The Head and Ries index not only captures trade costs *per se*, but also home and third country-biased preferences (e.g. if French consumers particularly dislike British products, the Franco-British trade cost will be high). The trade cost measure that we eventually compute converts these preferences into a tariff equivalent.

[22] Figure A.1 reports aggregate export openness ratios for six balanced samples.

[23] The AvW model builds upon an Armington demand structure to yield a gravity equation: trade occurs because of consumers' taste for variety. In the Ricardian model, trade occurs because of countries' comparative advantages in production. In heterogeneous firms models, trade is related to firms' advantages in productivity.

resistance term (P_i), the importer's inward multilateral resistance term (Π_j) and bilateral trade costs (τ_{ij}). The trade elasticity ($\epsilon < 0$) gives the response of trade to trade costs.

The multilateral resistance terms capture the fact that bilateral trade does not only depend on bilateral factors but also on trade costs with third source and outlet countries.[24] These terms provide a challenge as they cannot be solved for analytically. Head and Ries (2001) provide an elegant solution to cancel them out; as a result, they are able to obtain a ratio of bilateral relative to internal trade costs. Multiplying equation (1) by its counterpart for the symmetric flow and assuming balanced trade at the country level ($Y_i = X_i$) yields:[25]

$$X_{ij}\, X_{ji} = (Y_i\, Y_j)^2 \left(\frac{\tau_{ij}^{\epsilon}\, \tau_{ji}^{\epsilon}}{P_i\, P_j\, \Pi_i\, \Pi_j} \right). \tag{2}$$

The gravity equation for internal trade writes:

$$X_{ii} = \frac{Y_i^2}{P_i\, \Pi_i} \tau_{ii}^{\epsilon}. \tag{3}$$

Rearranging equation (3) yields an expression for $P_i\, \Pi_i$ ($P_j\, \Pi_j$):

$$P_i\, \Pi_i = \frac{Y_i^2\, \tau_{ii}^{\epsilon}}{X_{ii}}. \tag{4}$$

Plugging the previous equation for $P_i\, \Pi_i$ and $P_j\, \Pi_j$ back into equation (2) yields:

$$X_{ij}\, X_{ji} = X_{ii}\, X_{jj} \left(\frac{\tau_{ij}\, \tau_{ji}}{\tau_{ii}\, \tau_{jj}} \right)^{\epsilon}. \tag{5}$$

Rearranging and taking the geometric average of both directional relative trade costs yields the Head and Ries index of trade cost:

$$\left(\frac{\tau_{ij}\, \tau_{ji}}{\tau_{ii}\, \tau_{jj}} \right)^{\frac{\epsilon}{2}} = \sqrt{\frac{X_{ij}\, X_{ji}}{X_{ii}\, X_{jj}}}. \tag{6}$$

The Head and Ries index is a top-down measure: it makes use of theory to infer trade costs from the observable variables in the right hand side of the equation. The Head and Ries index is also a relative measure of trade costs: it evaluates the barriers to trading with a foreign partner,

[24] In atheoretical estimations of the gravity equation, multilateral resistance terms were often approximated by a weighted average of distance to third countries. See a discussion in AvW (2003), pp.173-174. Baldwin and Taglioni (2006) refer to the omission of multilateral resistance terms as the "*gold medal mistake*" of the gravity literature.
[25] Novy (2007) shows that the trade cost measure remains valid under imbalanced trade (Appendix A.3., p.32).

relative to internal trade barriers. Any variation of the index can therefore reveal changes in international or intra-national trade costs. The intuition is that the more countries trade internally[26] as opposed to with foreign partners, the larger international trade barriers must be relative to internal barriers. Trade costs should *a priori* not be assumed to be symmetric. In this setting, however, only the geometric average of both directional trade costs can be identified, which renders impossible to properly relate trade costs to direction-specific explanatory factors.

Jacks et al. (2008) propose a tariff equivalent interpretation of the Head and Ries index. In the general framework of structural gravity, their measure of trade costs writes:

$$TC_{ij} \equiv \sqrt{\frac{\tau_{ij}\ \tau_{ji}}{\tau_{ii}\ \tau_{jj}}} - 1 = \left(\frac{X_{ii}\ X_{jj}}{X_{ij}\ X_{ji}}\right)^{-\frac{1}{2\epsilon}} - 1. \tag{7}$$

To illustrate equation (7), let us consider two perfectly integrated markets. For this pair of countries, the international trade barriers are nil. The tariff-equivalent trade cost must therefore equal zero. In turn, the ratio in the right hand side of equation (7) must be equal to one. In other words, in a frictionless world, the product of two countries' internal trade should be equal to the product of the bilateral flows that link them.

Computing the Jacks et al. (2008) measure of trade costs requires to set a value for the trade elasticity. In the benchmark results, we set ϵ to -5.03, which is the preferred estimate from the meta-analysis of Head and Mayer (2014).[27] In Section 4, we provide our own estimates for the nineteenth century and show that they are not significantly different from our benchmark value.

3. Data

One distinctive feature of this research has been to systematically collect bilateral and aggregate trade data as well as GDP and exchange rates between 1827 and 2014. Fouquin and Hugot (2016) provide a detailed description of the data. Here we simply emphasize some key features.

Table 1 provides a summary of the main variables. Table 2 compares our data with three bilateral trade data sets of reference. In order for these comparisons to be meaningful, we compare each of these data sets with the sub-sample of our own data that covers the same period.[28] At constant time coverage and in terms of the number of observed trade flows, our data set is therefore more than twice as large as (Pascali, 2014), about 11 times larger than (Jacks et al., 2011) and more than 6 times the size of (Barbieri and Keshk, 2012).

[26] We discuss the measure of internal trade we use in Section 3.
[27] Specifically, we use the median coefficient from their meta-analysis, restricted to the structural gravity estimates identified through tariff variation (see Table 5, p.33).
[28] We restrict the samples to the years before 1948 because all the data sets rely on the same data from the IMF after that point.

	Bilateral trade	Total exports	Total imports	GDP	Exchange rates	Bilateral tariffs
Dimension	country-pair direction-year[1]	country year	country year	country year	country year	country-pair direction-year
Number of observations	1,904,574	21,085	20,869	14,084	14,381	8,720
Number of country pairs	42,447					410
Number of countries[2]	319	247	245	218	145	172

[1] Each year, in theory, two trade flows pertain to each country pair: the exports from country A to country B and the exports from country B to country A.

[2] We use the word "country" to designate any administrative entity for which bilateral data is reported.

Table 1 – Summary of the main variables

	Coverage	Our data	Pascali (2014)	Jacks et al. (2011)[1]	Barbieri and Keshk (2012)
Bilateral trade flows		**51,710**	23,000[2]		
Country pairs	1850-1900	**2,476**	1,000[2]		
Countries		**191**	129		
Bilateral trade flows		**238,850**		21,806	38,646
Country pairs	1870-1947	**14,497**		298	2,036
Countries		**295**		27	68

[1] We use the data from which the balanced sample used in Jacks et al. (2011) has been extracted.

[2] Approximated figures extracted from Pascali (2014), p.2.

Table 2 – Comparison of the bilateral trade data with three data sets of reference, at constant time coverage

The use of bilateral trade data to compute international relative trade costs is straightforward, but the results also depend on the measure of internal trade. Unfortunately, data on aggregate domestic shipments does not exist for as large a spatial and time coverage. Instead, we use a measure of gross output, from which we subtract aggregate exports. Most gravity-oriented articles on nineteenth century trade use constant price GDP data from Maddison (2001) (Jacks et al., 2008, 2011, Pascali, 2014, Estevadeordal et al., 2003, López-Córdova and Meissner, 2003) sometimes reflated using the U.S. price index.[29] On the other hand, the structural gravity theory demands that both trade flows and GDP are entered in nominal terms. Indeed,

[29]Baldwin and Taglioni (2006) coined this adjustment of GDP series the "bronze medal mistake" in the gravity literature: "*Since there are global trends in inflation rates, inclusion of* [the U.S. price index] *probably creates biases via spurious correlations*", p.7.

the gravity equation is a function that allocates nominal expenditures across countries, i.e. that allocates nominal GDP into nominal imports. We therefore rely exclusively on nominal series.

Internal trade, as any measure of trade, is a gross concept in the sense that it includes intermediate goods. It should thus be measured as gross domestic tradable output, minus total exports.[30] Unfortunately, reconstructions of national accounts have concentrated on GDP series that are by definition net of intermediary consumption. Our approach is to use the average ratio of gross output to value added taken from de Sousa et al. (2012) to scale up current price GDP data and obtain an approximation of gross output.[31] We finally subtract total exports and use the resulting series as our benchmark measure of internal trade.[32]

4. Estimation of the trade elasticity

The trade elasticity is a necessary parameter to infer trade costs from trade data. Indeed, a strong response of trade to trade costs translates in lower trade costs being inferred from the same data. In the extreme case, if consumers are infinitely sensitive to trade costs, then the absence of trade does not reveal prohibitive trade costs, but simply a total lack of interest for foreign goods. In our case, any observed reduction of trade costs can therefore be genuine, or an artifact due to a fall in the (absolute) trade elasticity over time. Checking for long run trends in the trade elasticity is therefore crucial to establishing the robustness of our results. Beyond our direct interest, the trade elasticity is also a key parameter in the recent literature which aims at recovering the welfare gains from trade. In particular, Arkolakis et al. (2012) show that in a broad class of trade models two statistics are sufficient to calculate countries' welfare gains from trade: the import openness ratio and the trade elasticity. Historical estimations of the trade elasticity are therefore a necessary prerequisite to any structural investigation of the welfare gains associated with nineteenth century trade.

Head and Mayer (2014) show that in any trade model that yields structural gravity, the trade elasticity is related to the parameter that governs the scope for trade gains. More precisely, the response of trade to trade costs decreases with the potential trade gains. It is thus necessary to look into the models to understand the micro-level reasons for changes in the trade elasticity.

[30] Gross output = GDP + Intermediary consumption. Measuring internal trade as Gross output − exports is especially relevant for countries that are very open to trade, as for some years, failing to adjust GDP for intermediate consumption would result in negative internal trade. For further discussion, see Head and Mayer (2014), p.169.

[31] Specifically, we aggregate their figures across industrial sectors to obtain an average ratio of 3.16. We then take the product of this ratio and GDP as a measure of gross output.

[32] We provide alternative results with internal trade measured as: Tradable GDP − exports. To do so, we decompose GDP into a tradable (agriculture and industry) and a non-tradable component (services). We scale-up this data using ratios of value added to gross production. For the industrial sector, we use the ratio from de Sousa et al. (2012). For agriculture, we use a ratio of 2.4 (INSEE, Compte provisoire de l'agriculture, May 2013). This comes at the cost of restricting the sample to 58% of its full potential. In Figure A.15, we estimate our world trade cost index using this alternative method.

In the demand-side models of AvW (2003) (perfect competition) and Krugman (1980) (monopolistic competition), the trade elasticity is linked to the elasticity of substitution across varieties ($\epsilon = 1 - \sigma$). Countries trade to satisfy consumers' love of variety. In turn, when varieties are close substitutes (large σ), the incentives for trading narrow and the (absolute) trade elasticity increases. An increasing similarity of the goods produced across countries would therefore lead to a rise of the trade elasticity. In supply-side models such as the Ricardian model (Eaton and Kortum, 2002) and heterogeneous firms models (Chaney, 2008, Melitz and Ottaviano, 2008), θ (γ) is the parameter that governs the degree of heterogeneity of industries' (Ricardo) or firms' productivity (heterogeneous firms). The less heterogeneity on the production side (large θ or γ), the smaller the scope for trade gains and the larger the trade elasticity. An homogenization of industries' or firms' productivity would therefore lead to a rise of the trade elasticity.

We follow Romalis (2007) and use bilateral tariffs to identify the trade elasticity in both the cross section and the time dimension using French data for 1829-1913. The identifying assumption is that tariffs are pure cost shifters, i.e. that trade costs react one for one to changes in tariffs. We begin with the structural gravity equation:

$$X_{ijt} = \frac{Y_{it}\, X_{jt}}{P_{it}\, \Pi_{jt}}\, \tau_{ijt}^{\epsilon}. \tag{8}$$

We specify trade costs as follows:

$$\begin{aligned} \tau_{ijt} = {} & (1 + t_{ijt}) \times Dist_{ij}^{\alpha_1} \times \exp(\alpha_2\, Colo_{ijt}) \times \exp(\alpha_3\, Comlang_{ij}) \\ & \times \exp(\alpha_4\, Conti_{ij}) \times \eta_{ijt}, \end{aligned} \tag{9}$$

where t_{ijt} is a measure of bilateral tariffs. $Dist_{ij}$ is the population-weighted great-circle distance. $Colo_{ijt}$, $Comlang_{ij}$ and $Conti_{ij}$ are three dummies that account for colonial relationship, common language and a shared border. η_{ijt} reflects the unobserved components of trade costs.

We estimate the trade elasticity using the ratio of bilateral customs duties to imports as a proxy for bilateral tariffs. A caveat should be noted: tariffs have an ambiguous link to these ratios. First, higher tariffs increase the value of the customs duties that are collected. At the same time, tariffs reduce imports by making imported goods more expensive[33]. The resulting duties-to-imports ratios may therefore underestimate the actual level of protection. In turn, the trade elasticities we estimate should be considered as lower bounds (in absolute terms).

[33] In particular, the prohibitive tariffs that were imposed on some products until the late nineteenth century result in an underestimation of the actual level of protection. See the Irwin-Nye controversy (Nye, 1991, Irwin, 1993).

We obtain the cross-section equation by plugging equation (9) into (8), taking logs and removing time subscripts. We estimate the resulting equation separately for each year using OLS. The notation explicitly specifies that France is always the destination country:

$$\begin{aligned}\ln X_{iFR} = \epsilon \ln(1 + t_{iFR}) + \gamma \ln Y_i + \beta_1 \ln Dist_{iFR} + \beta_2\, Colo_{iFR} \\ + \beta_3\, Comlang_{iFR} + \beta_4\, Conti_{iFR} + \ln \eta_{iFR}.\end{aligned} \tag{10}$$

We use the notation $\beta_x = \alpha_x \times \epsilon$, $\forall\, x \in \{1, 2, 3, 4\}$. Y_i is the GDP of country i. The error term (η_{iFR}) captures the bilateral components of trade costs that are not explicitly controlled for, as well as origin countries' outward multilateral resistance terms. As a result, the trade elasticities obtained from equation (10) cannot be considered as structural estimates.[34]

We also identify the trade elasticity in the time dimension, using decade-long intervals. This time, we keep the time subscripts and impose a set of origin-country fixed effects. The identification therefore entirely comes from the time dimension:

$$\begin{aligned}\ln X_{iFRt} = \epsilon \ln(1 + t_{iFRt}) + FE_{iFR} + \gamma_1 \ln Y_{it} + \gamma_2 \ln Y_{FRt} \\ + \beta_2\, Colo_{iFRt} + \ln \eta_{iFRt}.\end{aligned} \tag{11}$$

The error term (η_{iFRt}) captures the time-varying unobserved components of trade costs, as well as the time-varying components of both inward and outward multilateral resistance terms. The coefficients estimated using equation (11) thus do not qualify as structural gravity estimates.

Figure 1 shows that the estimated trade elasticities are never different from each other at the 95% confidence level, which suggests that the trade elasticity has not changed significantly over the nineteenth century. We find a median elasticity of -4.84 [2.40] and −5.07 [.70], respectively in the cross section and the time dimension. None of these estimates is statistically different at the 95% level of confidence from −5.03, the median value found in the meta-study of Head and Mayer (2014). We take this as a sign that the trade elasticity did not substantially change between the early nineteenth and the late twentieth century.[35] The results of the following sections rely on a constant trade elasticity of −5.03.

[34]Obtaining structural estimates would require controlling for both origin and destination country multilateral resistance terms, for example through two sets of fixed effects. This would require bilateral tariff data for more than one country, which we were unfortunately unable to find.

[35]However the standard errors are too large to claim that nineteenth century trade elasticities lied closer to the lower or the upper bound of the post World War II estimates, which typically range from −1 to −7.

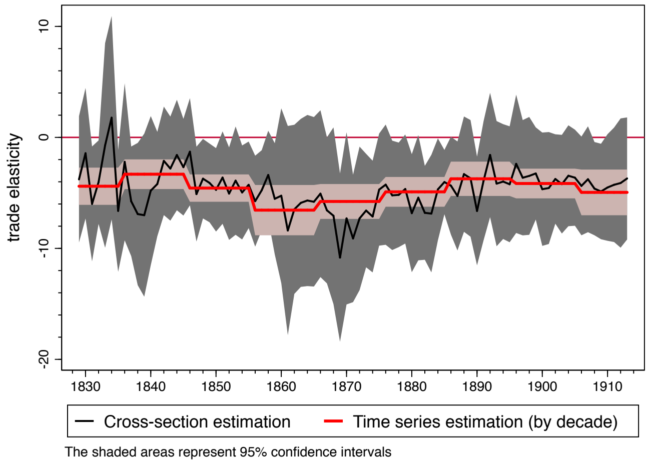


Figure 1 – Cross-sectional and longitudinal estimations of the trade elasticity: 1829-1913

5. World trade cost indices

Once equipped with a value for the trade elasticity, we can use equation (7) to compute trade costs. We obtain more than 370,000 measures of trade costs for about 14,000 country pairs. Reporting all of the results would be impossible; instead, we report selected aggregates.

We begin by restricting the sample to the country pairs for which we obtain trade costs on a continuous basis throughout the period.[36] Figure 2 reports weighted-mean trade costs for four balanced samples (Figure A.2 reports the simple mean).[37] Specifically, we weight trade costs by the sum of the two countries' internal trade. We use the same aggregation method to compare transatlantic and intra-European trade costs (Figure A.3).

Aggregating trade costs over all available country pairs is not trivial since the sample changes over time (Figure 3). In particular, the composition of the sample may be endogenously determined as most data for early years comes from the most developed countries. In turn, exchanges among these countries are associated with structurally low trade costs. Ignoring this sampling bias would thus result in an underestimation of any trade cost reduction. On the other hand, limiting the analysis to balanced panels considerably reduces the information available. In particular, many countries are simply formed or dismantled during our two centuries of interest, which

[36] In order to increase the number of country pairs included in the samples, we interpolate missing trade costs if the following criteria are all satisfied: i) trade costs are observed for the initial and the last year of the sample, ii) observed trade costs account for at least 90% of potential observations, iii) gaps are inferior or equal to 5 years.
[37] The 1827 sample covers: CHL-FRA, CHL-USA, DNK-FRA, ESP-FRA, ESP-GBR, ESP-PRT, ESP-USA, FRA-GBR, FRA-PRT, FRA-USA, GBR-USA. The 1835 sample adds: BEL-DNK, BEL-ESP, BEL-FRA, BEL-GBR, BEL-NLD, BEL-USA, COL-FRA, COL-USA, DNK-NLD, DNK-SWE, ESP-SWE, FRA-NLD, FRA-NOR, FRA-SWE, GBR-NLD, GBR-SWE, NLD-USA, NOR-SWE, SWE-USA, while ESP-PRT and FRA-PRT leave the sample.

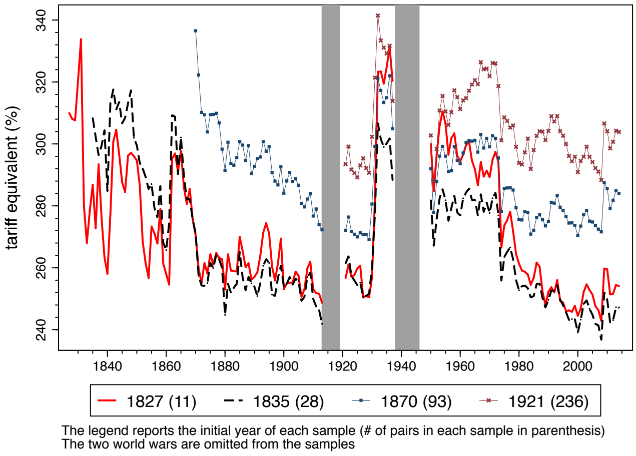


Figure 2 – Internal trade-weighted mean trade costs, balanced samples

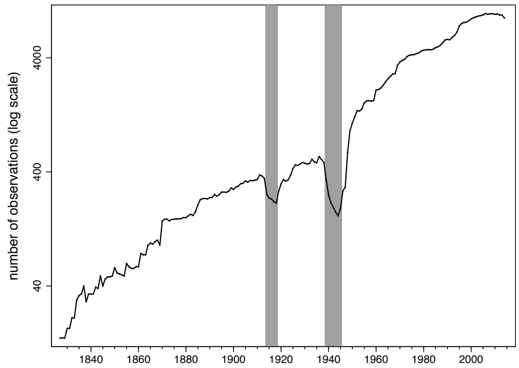


Figure 3 – Number of computed bilateral trade costs

automatically rules them out from any balanced sample.[38] We therefore propose an index of trade costs that makes use of all of the information available while also partially controlling for the sampling bias. Specifically, we decompose trade costs into a bilateral and a time effect:[39]

$$\ln TC_{ijt} = \alpha_{ij}\, FE_{ij} + \beta_t\, FE_t + \eta_{ijt}. \tag{12}$$

The bilateral effects capture the factors that are both country-pair-specific and time-invariant (e.g. distance, long-run cultural ties, etc.); but the pairs included in the sample vary over time. In turn, $exp(\beta_t)$ is the expectation of trade costs in year t relative to the benchmark year, conditional on the country pairs available in year t. Figure 4 plots $exp(\beta_t)$, which is our index of world trade costs. Figure A.4 plots the former against a trade cost index that is obtained by weighting each observation by the total value of both partner's internal trade. Figure A.4 shows that the long-run trends of the trade cost index are not driven by small countries.

Despite our correction, the trade cost index remains subject to a composition bias, as we estimate the conditional expectation of the log of trade costs on a sample that varies over time. The only way to eliminate this bias is to estimate equation (12) using balanced samples. Figure 5 shows the resulting indices estimated on five samples.[40] Figure 6 replicates the exercise but this time using five sub-periods that do not extend until 2014.[41] Finally, Figure 7 plots the

[38]We compute 14 bilateral trade costs for 1827 and about 9,000 for 2014. Over time, the number of computed trade costs tends to increase, to the exception of the two world wars, which temporarily reduce data availability.
[39]We estimate equation (12) using the *reghdfe* command from Stata, which is itself a generalization of the *xtreg,fe* command that allows for unbalanced panels.
[40]see footnote 36.
[41]These sub-periods are: 1835-1870, 1871-1912, 1921-1937, 1950-1980 and 1981-2014.

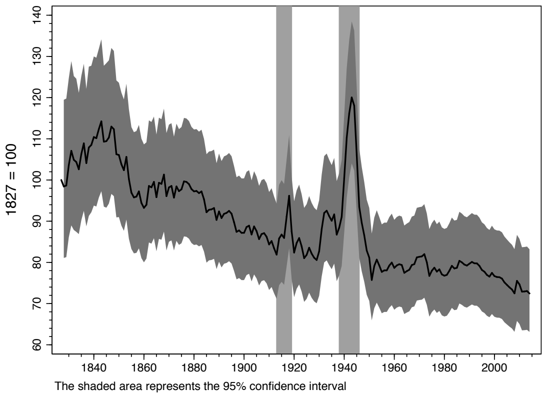


Figure 4 – World trade cost index

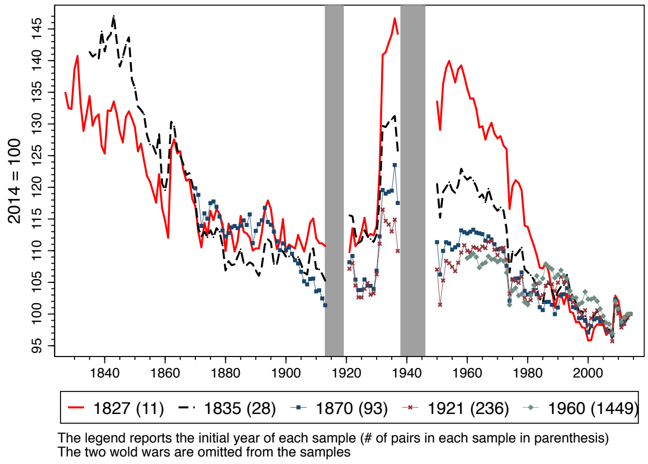


Figure 5 – World trade cost indices, balanced samples

world trade cost index estimated on balanced two-year samples. The resulting estimates are then chained to obtain a global picture of the evolution of trade costs.

Figures 4 to 7 both show a steady fall of trade costs that begins in the late 1840s and lasts until World War I. Trade cost indices return to their 1913 levels soon after the war. Not surprisingly, the Great Depression is associated with a rise of trade costs that extends into World War II. Trade costs then quickly recover their pre-war level in the 1950s.[42] Trade costs remain rather stable in the three decades after World War II before resuming to fall in the late 1970s.

The level of trade costs is sensitive to the value of the trade elasticity. Figure A.5 reports the Franco-British trade cost obtained using alternative trade elasticities. As a thought experiment, Figure A.6 also imposes an increasing and a decreasing linear trend for the trade elasticity, using -3 and -7 as extreme values. A reduction of the (absolute) value of the trade elasticity reveals larger scope for trade gains. In the end, any observed trade cost reduction could in fact be due to a reduction of the (absolute) trade elasticity. However, Section 4 has established the stability of the trade elasticity for our period of interest.

6. Route-specific trade cost indices

We now explore the heterogeneity of trade costs across trade routes. Specifically, we estimate trade cost indices based on various sub-samples. Figure 8 plots indices obtained by aggregating

[42]Figure 5 provides a somewhat different picture as trade costs take more than 20 years to recover their prewar level for the the most restricted samples. This divergence is due to an over-representation in these samples of the countries that suffered the most from the war.

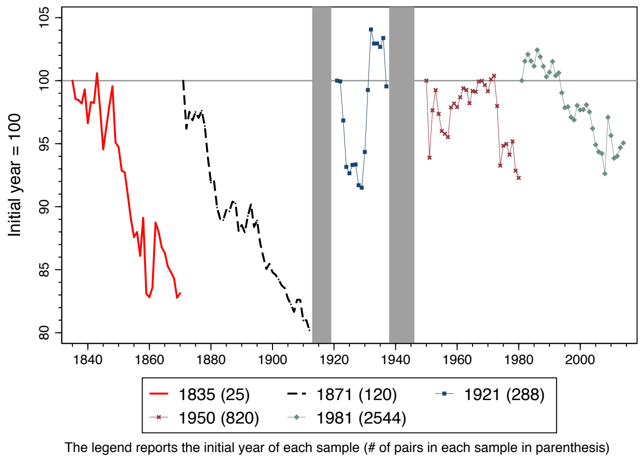


Figure 6 – World trade cost indices, balanced samples

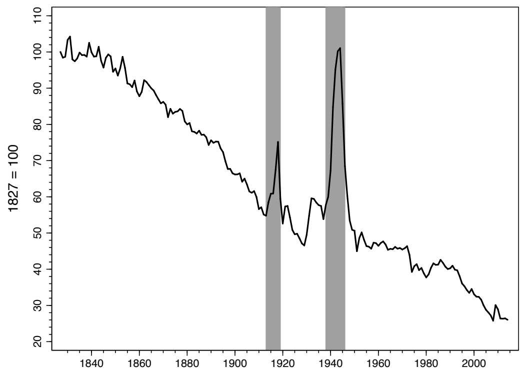


Figure 7 – World trade cost index, chained estimates from two-year balanced samples

bilateral trade costs across all partners for three countries.[43] For the nineteenth century, the patterns for France and the U.K. are similar as the largest reduction of trade costs happens between the early 1850s and the 1870. Trade costs then remain almost stable until the Great Depression. The patterns diverge after World War II. While trade costs trend downwards for France until the 1980s, they start rising after 1980 for the U.K.. This means that trade costs within the U.K. have been falling faster than international trade costs for the recent period. The dynamics of trade costs affecting the United States is very different as the steady fall of trade costs only begins around 1870. Trade costs only recover to their antebellum low point around 1890, which illustrates the long-lasting effect of the Civil War on U.S. foreign trade, through the protectionist policies imposed by the victorious North. Figure A.7 reports additional trade cost indices for Belgium, the Netherlands, Spain and Sweden.

Figure 9 plots trade cost indices for three regions.[44] Specifically, we aggregate trade costs across all the country pairs that include a country of the region of interest. Figure 9 shows that trade costs start falling for core European countries in the late 1840s. For the European periphery and the rest of the world, the high volatility prior to 1880 is followed by a dramatic reduction of trade costs around the turn of the century. All three regions are affected by comparable rises of trade costs during the Great Depression and World War II. After the war, trade costs remain rather stable for Core Europe, while they fall for the European periphery. Trade costs for the rest of the world are stable until they resume falling in the early 1990s.

[43] Note that for country-specific aggregations, equation (12) writes: $\ln TC_{it} = \alpha_i FE_i + \beta_t FE_t + \eta_{it}$, where i indexes the trading partners of the country of interest. Figure A.8 reports the corresponding chained trade cost indices, estimated on balanced two-year samples.

[44] Core Europe corresponds to Northwestern Europe. The European periphery includes Central, Eastern and Southern Europe, together with Scandinavia. See region coding in Fouquin and Hugot (2016). Figure A.9 reports the corresponding chained trade cost indices, estimated on balanced two-year samples.

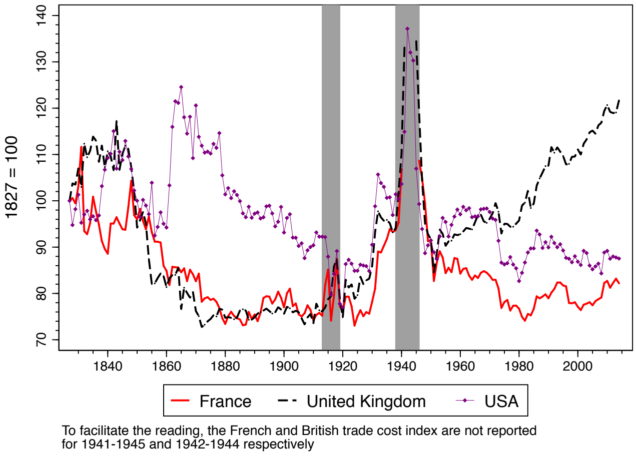


Figure 8 – Trade cost indices: France, U.K., USA

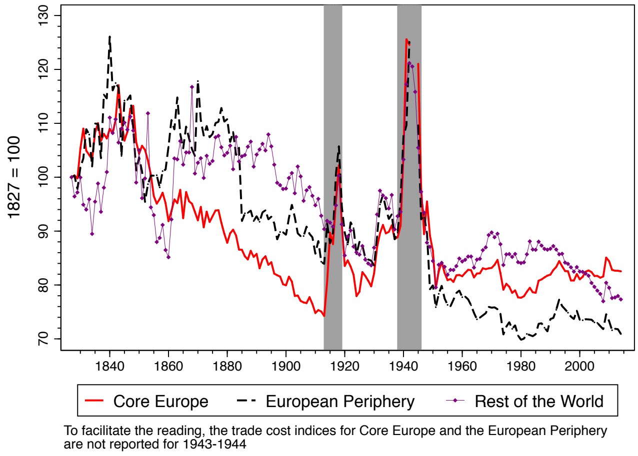


Figure 9 – Trade cost indices: Core Europe, European Periphery, Rest of the world

Figure 10 takes a closer look at the dynamics of trade costs across Europe. The patterns are relatively similar during the nineteenth century, except that trade costs affecting Northwestern Europe fall more steadily. After World War II, trade costs remain stable for Northwestern Europe and Scandinavia, but they resume falling for Southern European countries.

Figure 11 shows that trade costs also follow different patterns across trade routes. Transatlantic trade costs are very volatile until the reduction that occurs between 1890 and World War I. The U.S. Civil War is accompanied by a spike of trade costs, followed by a quick recovery, despite the persistent high level of tariffs imposed by Northern states.[45] It therefore seems that the high level of protection was more than compensated by improvements in transportation and communication technologies (Pascali, 2014, Steinwender, 2014).

After the initial spike that affects intra-European trade (Scandinavia in particular), trade costs fall faster within Europe than across the Atlantic. The most dramatic fall of trade costs across the Atlantic occurs in the decade before World War I. Intra-European trade costs are also more affected by the Great Depression and the two world wars. After World War II, intra-European trade costs fall while transatlantic trade costs increase, which points to the success of the European integration and the consecutive relative dis-integration of transatlantic trade.

[45]In 1868, the U.S. aggregate tariff reaches 45% (see Figure A.10). Tariffs remain consistently high until World War I, fluctuating between 20% and 30%, roughly twice as high as in France and the U.K..

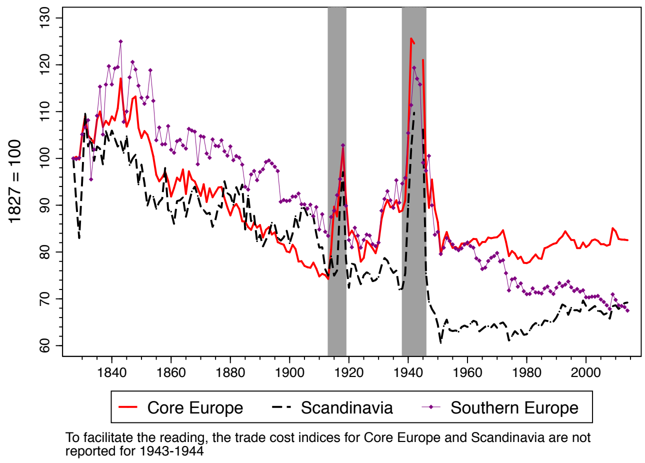


Figure 10 – Trade cost indices: Northwestern Europe, Scandinavia, Southern Europe

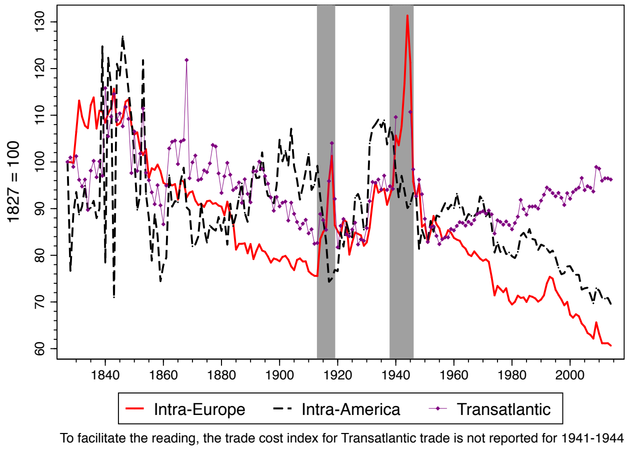


Figure 11 – Trade cost indices: intra-European trade, intra-American trade, transatlantic trade

7. Regionalized globalizations

The previous section emphasizes the heterogeneity of trade costs dynamics across trade routes. Here, we further explore the geographical dynamics of trade globalization. Once more, we begin with the structural gravity equation:

$$X_{ij} = \frac{Y_i \, X_j}{P_i \, \Pi_j} \, \tau_{ij}^{\epsilon}. \tag{13}$$

We impose the following functional form for bilateral trade costs:

$$\tau_{ij} = \exp(a \, For_{ij}) \times Dist_{ij}^{b} \times \eta_{ij}, \tag{14}$$

where For_{ij} is a dummy variable set to unity if $i \neq j$. $Dist_{ij|i \neq j}$ is the population-weighted great-circle bilateral distance and $Dist_{ij|i=j}$ is internal distance.[46] a and b are the elasticities of trade costs to international borders and distance respectively. η_{ij} reflects the unobserved components of trade costs, including for example bilateral tariffs.

[46] For details on these variables, see Fouquin and Hugot (2016)

Plugging (14) into (13), taking logs and imposing origin and destination fixed effects to control for the monadic determinants of trade, we estimate equation (15), separately for each year, using the OLS estimator. The identification comes entirely from the cross-sectional variation:[47]

$$\ln X_{ij} = FE_i + FE_j + \beta_1 \; For_{ij} + \beta_2 \; \ln Dist_{ij} + \ln \eta_{ij}, \tag{15}$$

where $X_{ij|i \neq j}$ is bilateral trade and $X_{ij|i=j}$ is internal trade. FE_i and FE_j are vectors of origin and destination fixed effects. $\beta_1 = a \times \epsilon$ is the border effect and $\beta_2 = b \times \epsilon$ is the trade elasticity of distance. Note that the fixed effects perfectly control for the monadic determinants of trade, including multilateral resistance terms. Because the errors are likely correlated within country pairs, we cluster the standard errors at the bilateral level.

7.1. Border effect

β_1 can be interpreted as a border effect as it reflects the average trade reducing effect of international borders, all monadic determinants of trade and distance being equal. We convert the border effect into a tariff equivalent using the pure cost-shifter property of tariffs.[48]. Indeed, *ad-valorem* tariffs have a one for one relationship to trade costs. In turn, the error term of equation (15) can be decomposed as follows:

$$\eta_{ij} = (1 + t_{ij})^1 \times Z_{ij}, \tag{16}$$

where t_{ij} is the (unobserved) *ad-valorem* tariff imposed by j on imports from i. Z_{ij} is a vector of the other bilateral components of trade costs, together with their elasticities to trade costs.

The border effect we propose is equal to the tariff that would have the same trade reducing effect as the average border. We therefore use the β_1 estimated for each year via equation (15) to solve for the border effect (BE) in the following equation:

$$(1 + BE)^{\epsilon} = \exp(\beta_1). \tag{17}$$

The resulting tariff-equivalent border effect, converted to a percentage, writes:

$$BE = \left[\exp\left(\frac{\beta_1}{\epsilon}\right) - 1 \right] \times 100. \tag{18}$$

[47] The identification of the border effect relies on a comparison of internal trade with bilateral trade as in Wei (1996), who extended the methodology introduced by McCallum (1995) for cases in which bilateral intra-national trade flows are not available.

[48] Figure A.11 reports the border effect as the exponential of β_1. These values read as the number of times countries trade more, on average, with themselves than with foreign partners, all monadic terms and distance being equal.

Figure 12 reports the border effect with the trade elasticity (ϵ) set to our benchmark value of -5.03.[49] Overall, the border effect falls from approximately 300% c. 1830 to about 150% for most recent years. More precisely, the border effect falls until World War I, with two episodes of stagnation: in the 1840s and the two decades between 1860 and 1880. Not surprisingly, the border effect rises during the Great Depression and until after World War II, before resuming a steady fall from the late 1960s. In 2014, which is the last year of the sample, the border effect has still not reached its low point of 1920.

Our estimates are higher than those typically found in the literature. The pioneering study by McCallum (1995) found that the U.S.-Canada border reduced trade by a factor 22 in 1988. AvW (2003) provided the first structural estimation of the border effect (i.e. controlling for the multilateral resistance terms) and found that the U.S.-Canada border reduced trade by a factor 5. For the corresponding years and based on our entire sample, we find a border effect about 15 times larger than McCallum's and 37 times larger than AvW's.[50] These results can be reconciled by acknowledging that both McCallum (1995) and AvW (2003) consider the border between two advanced economies. On the contrary, our sample is much broader. In fact, reducing the sample to developed countries dramatically reduces the discrepancy. For example, estimating the border effect on E.U. internal trade yields estimates that are only 4.5 times as large as those of AvW (2003)[51] (Figure 13). In contrast, our estimates are perfectly in line with the border effects estimated on samples similar to ours for the recent period (de Sousa et al., 2012).[52]

The reduction of the border effect since the 1970s is a well-established result. Helliwell (1998) was the first to document that phenomenon, for 1991-1996. Head and Mayer (2000) provide structural estimates for the E.U., based on data for 1975-1995. Finally, de Sousa et al. (2012) extend the sample to the entire world, for 1980-2006 and still reach the same conclusion. In contrast, we bring a new perspective on border-related trade barriers for the century and a half before 1970. In particular, Figure 12 shows that the border effect fell by about one third between 1850 and World War I. Then they doubled between 1920 and 1955 before falling again. Consequently, the border effect is close in 2014 to its level during the run-up to World War I. In order to find a border effect as high as in 1955, one has to go back in time to 1831. The border effect thus appears to have followed similar trajectories during both period of globalization.

7.2. Distance elasticity

Figure 14 illustrates the rise of the distance elasticity with an example. From 1850 to 1914 the GDP of Chile grew three times faster than the Dutch GDP. Between World War I and

[49] Both the level and the variability of the border effect are sensitive to the value of the trade elasticity. Figure A.16 reports tariff-equivalent border effects obtained using different trade elasticites.

[50] For 1988, we find a border effect equal to -5.77, which implies that *ceteris paribus*, countries traded on average 314 times more within their borders than with foreign partners (exp(5.77 = 321)). For 1993, we find a coefficient of -5.22 (i.e. a factor of 185).

[51] For E.U. member countries as of 1995, we find a coefficient equal to -3.11, which corresponds to a factor 22.

[52] They find a border effect of -5.97 for the 1980-2006 period (p.1043), while we find -5.51.

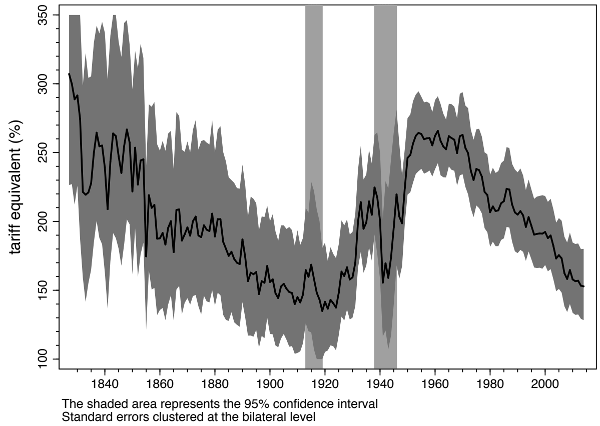


Figure 12 – Tariff-equivalent border effect

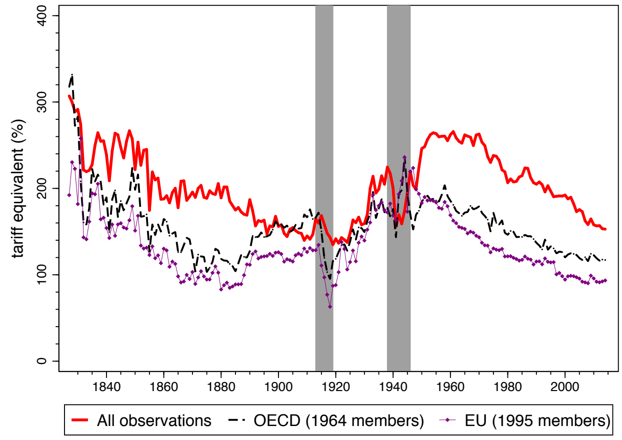


Figure 13 – Tariff-equivalent border effect: Full sample, OECD, E.U.

2014 the GDP of both countries rose by similar magnitudes.[53] Following the logic behind the gravity model, one would expect that trade between Chile and, say, the U.K. would have at least increased as fast as between the Netherlands and the U.K.. Figure 14 shows that in fact, trade increased much faster with the proximate country (the Netherlands) than with the distant country (Chile) during both waves of globalization.[54] Another way to grasp the intuition behind the changes in the distance elasticity is to look at the distribution of trade by distance for a given country. Figure A.17 presents evidence from the Netherlands. These graphs suggest that distance was an increasingly important factor in determining trade patterns during the nineteenth century. The effect of distance then fell in the interwar, before rising again after World War II.

We now estimate the distance elasticity using the entire sample. Figure 15 shows that the distance elasticity has been increasing since World War II, which is congruent with both Combes et al. (2008) and Disdier and Head (2008).[55] Yet, the present study is the first to document a comparable rise of the distance elasticity for the nineteenth century. This increase in the distance effect primarily affected the trade of Europe with third countries (Figure A.12). The rise of the distance elasticity also materialized by a reallocation of European countries' trade towards European partners. In absolute terms, distance is an even greater binding force within Europe than across continents. Within Europe, however, the rise of the distance elasticity was limited until the 1870s and stable, if not declining around the turn of the twentieth century.

[53] Between 1850 and 1913, the Dutch GDP grew by 300%, while the Chilean GDP grew by 900%. Between 1948 and 2014, the GDP of both Chile and the Netherlands grew by 11,000% (in nominal terms).
[54] British exports to the Netherlands grew by 3.52% per year during the First Globalization and by 10.41% per year after World War II. Over the same periods, British exports to Chile only grew by 1.97% and 7.87% per year.
[55] Disdier and Head (2008) show in their meta-analysis that the rise of the distance effect cannot be explained by sampling error. They argue that the actual distance elasticity rose from about -0.7 in 1960 to -1.1 in 2000. They coin this phenomenon the "distance puzzle".

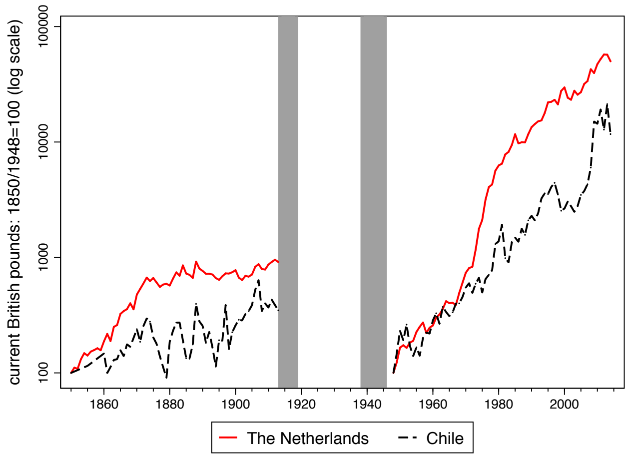


Figure 14 – British exports to the Netherlands and Chile

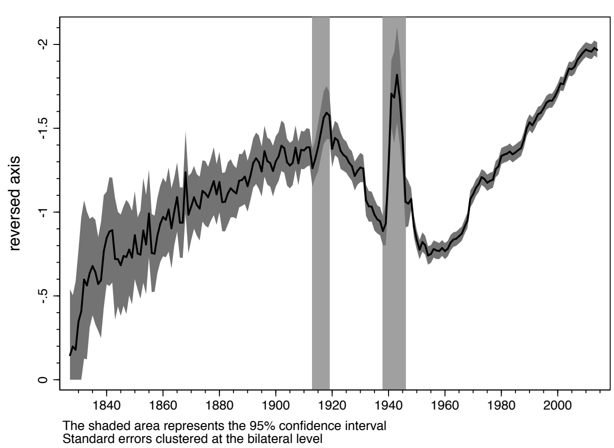


Figure 15 – Distance elasticity

Decolonization could explain the post-World War II rise of the distance effect. Because colonial links stimulate trade (Head et al., 2010) and colonies were relatively distant from their metropolis, decolonization disproportionately reduced long-distance trade, mechanically causing the distance elasticity to rise. Similarly, the interwar fall of the distance effect would be consistent with the reallocation of European countries' trade towards their colonies. Figure 16 shows that colonial trade was indeed relatively less sensitive to distance. Figure 17, however, shows that controlling for colonial links does not significantly affect the trend of the distance elasticity. Neither colonization, nor de-colonization can therefore explain changes in the distance elasticity.

We explore the robustness of the rise of the distance elasticity to an estimation through the Poisson Pseudo-Maximum Likelihood estimator (hereafter: PPML). Santos Silva and Tenreyro (2006) show that the OLS only yields unbiased distance elasticities conditional on the error term being lognormal. In the presence of heteroskedasticity, they argue that the gravity equation should be estimated in its multiplicative form, using a non-linear estimator. They suggest to use the PPML. In fact, Figure A.13 shows that the error terms of our OLS estimations consistently deviate from lognormality.[56] Heteroskedasticity is therefore a source of concern for our OLS estimates. Moreover, estimating a gravity equation specified in logarithm implies to drop all the zeros in the trade matrix. The resulting distance elasticity is thus estimated using variation in the intensive margin. In the presence of zero-trade observations, which account for 23% of the observations in the data, the OLS estimator therefore creates a selection bias. In contrast, the distance elasticity can be estimated with the PPML on both the extensive and the intensive margin. We therefore estimate the following equation using the PPML for each year:

$$X_{ij} = \exp(FE_i + FE_j + \beta_1\, For_{ij} + \beta_2\, \ln Dist_{ij}) \times \eta_{ij}. \tag{19}$$

[56] The p-values of the standard Breusch-Pagan test lie consistently below the 0.05 threshold.

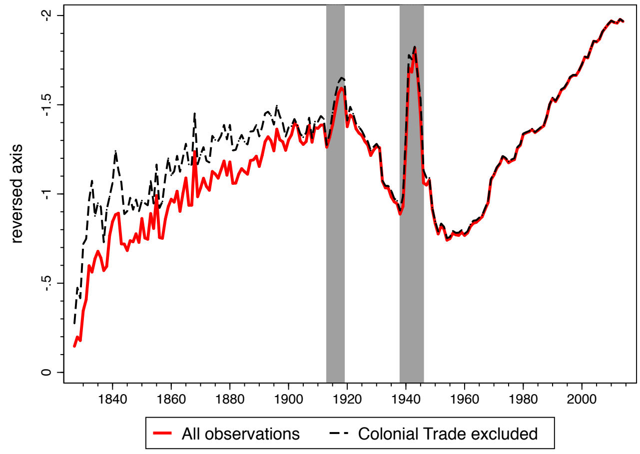


Figure 16 – Distance elasticity: Colonial trade included and excluded

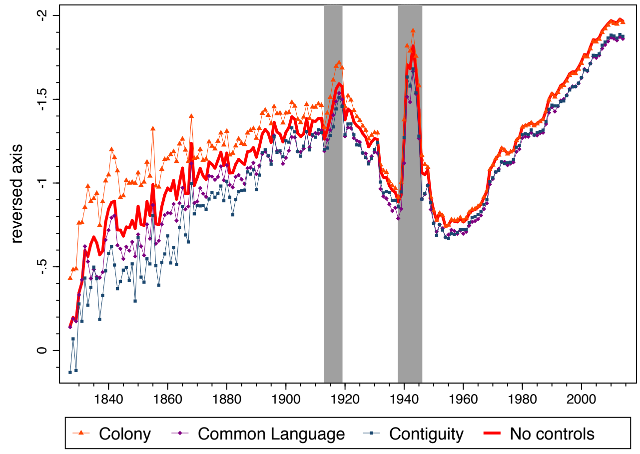


Figure 17 – Distance elasticity estimated with colonial links, common language and contiguity controls

Figure 18 compares OLS and PPML estimates.[57] Consistently with Bosquet and Boulhol (2015) the rise of the distance elasticity appears to be slower using PPML. For the nineteenth century, the rise of the distance elasticity is also slower – though still significant. In the end, the rise of the distance elasticity during both waves of globalization is robust to PPML estimation.

Intuitively, trade patterns are the results of an equilibrium between a force that reflects the extent to which countries want to trade (ϵ)[58] and a force that reflects how costly it is to overcome trade barriers (b). Any change in the distance elasticity may thus arise from either of the two factors. Equation (20) expresses the distance effect as the product of the trade elasticity and an elasticity of trade costs to distance:

$$\beta_2 = \epsilon \times b = \frac{\partial \ln \text{Trade}}{\partial \ln \text{Trade costs}} \times \frac{\partial \ln \text{Trade costs}}{\partial \ln \text{Distance}}. \tag{20}$$

There are two reasons not to believe that the rise in the distance elasticity is due to an increase in the absolute value of the trade elasticity. First, our own estimates from Section 4 show no significant change between 1829 and 1913. Moreover, our estimates for the nineteenth century lie close to the estimates for the contemporary period. Another clue lies in the fact that the trade elasticity not only affects the distance elasticity, but also the border effect. Indeed, the border effect is the product of the trade elasticity and the elasticity of trade costs to international borders (equation 15). Comparing Figure 12 to Figure 15 shows opposite patterns for the border and the distance effect, despite the fact that both of them include the very same trade elasticity.

[57] Similarly, Figure A.14 compares the border effect obtained using the two techniques.
[58] $\epsilon = 0$ means that trade does not react at all to trade barriers.

We are thus left with the elasticity of trade costs to distance to explain the rise of the overall distance elasticity. One explanation may be that trade liberalization has primarily targeted neighboring countries.[59] On the contrary, the interwar fall of the distance elasticity can be linked to European countries raising tariffs *vis-à-vis* their neighbors and reallocating trade towards their distant colonies. The nineteenth century rise of the distance effect could also be due to a disproportionate impact of railways or the steamship on short international routes. As both these innovations spread in the 1840s, this would be consistent with both the early fall of trade costs and rise of the distance elasticity. Finally, a composition effect could explain the rise of the distance elasticity: as transportation costs fall, more bulky products become worth trading. In turn, these products are more sensitive to distance-related costs, in particular fuel costs.

7.3. Border thickness

We now relate the border effect to the distance effect to illustrate their relative economic significance. To do so, we propose a measure of border thickness that reflects the distance equivalent of the average border. The approach we take is to ask how much should bilateral distance increase to have the same negative impact on trade as crossing the average border.[60] Using equation (15), the variation of trade associated with crossing a border writes:

$$\frac{\Delta X_{ij}}{X_{ij}} = \exp(\beta_1) - 1. \tag{21}$$

Solving for the border equivalent rate of change of distance, we obtain:

$$\frac{\Delta Dist_{ij}}{Dist_{ij}} = \frac{\exp(\beta_1) - 1}{\beta_2}. \tag{22}$$

Taking the product of the border equivalent rate of change of distance and the mean distance between country pairs in the sample yields the measure of border thickness:

$$THICK = \frac{\exp(\beta_1) - 1}{\beta_2} \times \overline{Dist_{ij}}. \tag{23}$$

Figure 19 plots our measure of border thickness, which is the distance equivalent of the average border, in terms of its trade reducing effect. Hence, the thinner the border, the more important distance is relative to borders. In other words, thin borders (lower part of the graph) reveal regionalized trade patterns. Figure 19 thus shows that both waves of globalization have been associated with an increasing regionalization of trade.

[59] The European Cobden-Chevalier network of trade treaties and the E.U. are probably the most striking examples.

[60] Using a regression similar to equation (15), Engel and Rogers (1996) propose a measure of border thickness equal to $\exp(\beta_1/\beta_2)$. Parsley and Wei (2001) point out that this measure is sensitive to the unit of measurement.

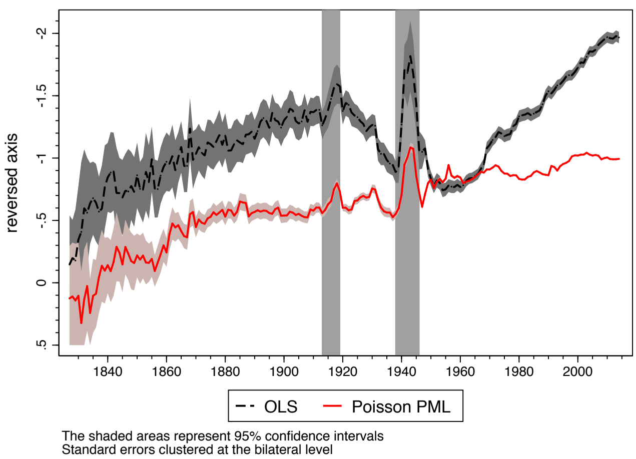


Figure 18 – Distance elasticity: OLS vs. PPML estimation

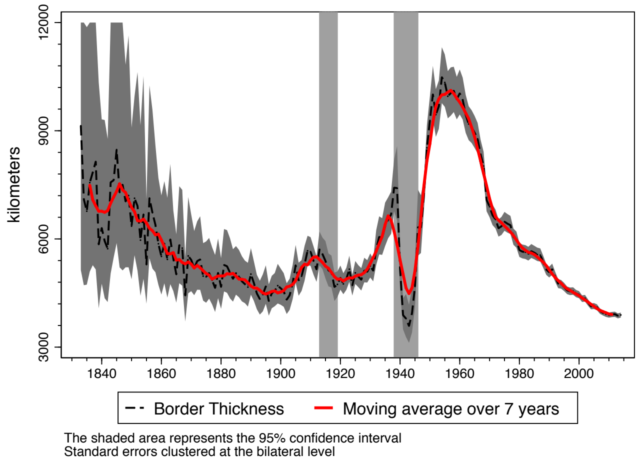


Figure 19 – Border thickness (Distance equivalent of the average border)

8. Conclusion

Using systematically-collected trade and GDP data for the 188 years from 1827 to 2014, we have shown that international relative trade costs had already begun to fall in the 1840s. This early start contradicts the studies that claim that late nineteenth century technological improvements in shipping and communication were responsible for sparking nineteenth century globalization. This result also contradicts the theories that attribute the leading cause of the First Globalization to the Gold Standard and to the trade treaties that bloomed after 1860.

The early trade cost reduction points to the role played by the unilateral trade liberalization policies that were implemented in the late 1840s. These liberal trade policies should be associated with the *Pax Britannica* that begins with the Congress of Vienna in 1815 and only comes to an end with the First World War.[61] Another potential reason for the early onset of the First Globalization may be found in the early nineteenth century improvements in shipping technology. This brings some perspective on the role played by the major innovations of the late nineteenth century – the steamship, the telegraph and the diffusion of the Gold Standard – in the expansion of world trade. At most, these factors took over from other pre-existing ones.

We have also shown that both globalizations were fueled by a relative intensification of short-haul trade: globalizations turn out to be not so global after all. In other words, what has been referred to as periods of "globalization" were indeed periods of internationalization, but they were also periods of regionalization of trade patterns. This result implies that the scope for economic integration across distant markets remains wide and largely unexploited.

[61] The Opium Wars, the Russo-Japanese War, and the wars related to the German and Italian unification are some exceptions. But none of these conflicts was comparable to either the Napoleonic Wars or World War I.

References

Accominotti, Olivier and Marc Flandreau, "Does Bilateralism Promote Trade? Nineteenth Century Liberalization Revisited," Working paper 5423, CEPR Jan. 2006.

Allen, Treb, Costas Arkolakis, and Yuta Takahashi, "Universal Gravity," Working paper 20787, NBER Dec. 2014.

Anderson, James E. and Eric van Wincoop, "Gravity with Gravitas: A Solution to the Border Puzzle," *American Economic Review*, Mar. 2003, *93* (1), 170–192.

Anderson, James E. and Eric van Wincoop, "Trade costs," *Journal of Economic Literature*, Sep. 2004, *42* (3), 691–751.

Arkolakis, Costas, Arnaud Costinot, and Andrés Rodríguez Clare, "New Trade Models, Same Old Gains?," *American Economic Review*, Aug. 2012, *102* (1), 94–130.

Baldwin, Richard and Daria Taglioni, "Gravity for Dummies and Dummies for Gravity Equations," Working paper 5850, CEPR Sep. 2006.

Barbieri, Katherine and Omar Keshk, "Correlates of War Project Trade Data set," 2012, *version 3.0.* Available online: http://correlatesofwar.org.

Bosquet, Clément and Hervé Boulhol, "What is Really Puzzling about the "Distance Puzzle"," *Review of World Economics*, 2015, *151* (1), 1–21.

Broda, Christian and David E. Weinstein, "Globalization and the Gains from Variety," *Quarterly Journal of Economics*, May 2006, *121* (2), 541–585.

Bulbeck, David, Anthony Reid, Lay Cheng Tan, and Yiqu Wu, *Southeast Asian Exports since the 14th Century: Cloves, Pepper, Coffee, and Sugar*, Leiden, The Netherlands: KITLV Press, 1998.

Chaney, Thomas, "Distorted Gravity: The Intensive and Extensive Margins of International Trade," *American Economic Review*, Sep. 2008, *98* (4), 1707–1721.

Coleman, Andrew, "The Pitfalls of Estimating Transactions Costs from Price data: Evidence from Trans-Atlantic Gold-point Arbitrage, 1886-1905," *Explorations in Economic History*, 2007, *44*, 387–410.

Combes, Pierre-Philippe, Thierry Mayer, and Jacques-François Thisse, *Economic Geography: The Integration of Regions and Nations*, Princeton, N.J., USA: Princeton University Press, 2008.

de Sousa, José, Thierry Mayer, and Soledad Zignago, "Market Access in Global and Regional Trade," *Regional Science and Urban Economics*, Nov. 2012, *42* (6), 1037–1052.

Disdier, Anne-Célia and Keith Head, "The Puzzling Persistence of the Distance Effect on Bilateral Trade," *Review of Economics and Statistics*, Feb. 2008, *90* (1), 37–48.

Dobado-González, Rafael, Alfredo García-Hiernaux, and David E. Guerrero, "The Integration of Grain Markets in the Eighteenth Century: Early Rise of Globalization in the West," *Journal of Economic History*, Sep. 2012, *72* (3), 671–707.

Eaton, Jonathan and Samuel Kortum, "Technology, Geograpy and Trade," *Econometrica*, Sep. 2002, *70* (5), 1741–1779.

Eaton, Jonhatan, Samuel Kortum, Brent Neiman, and John Romalis, "Trade and the Global Recession," Working paper 16666, NBER Jan. 2011.

Engel, Charles and John H. Rogers, "How Wide is the Border?," *American Economic Review*, 1996, *86* (5), 1112–1125.

Estevadeordal, Antoni, Brian Frantz, and Alan M. Taylor, "The Rise and Fall of World Trade: 1870-1939," *Quarterly Journal of Economics*, May 2003, *118* (2), 359–407.

Földvári, Péter and Bas van Leeuwen, "Markets in Ancient Societies? The Structural Analysis of Babylonian Price Data," Working paper 2000.

Fouquin, Michel and Jules Hugot, "Two Centuries of Bilateral Trade and Gravity data: 1827-2012," Working paper 2016-14, CEPII May 2016.

Hamilton, Earl J., *American Treasure and the Price Revolution in Spain, 1501-1650*, Cambridge, M.A., USA: Harvard University Press, 1934.

Harley, C. Knick, "Ocean Freight Rates and Productivity, 1740-1913: The Primacy of Mechanical Invention Reaffirmed," *Journal of Economic History*, Dec. 1988, *48* (4), 851–876.

Head, Keith and John Ries, "Increasing Returns versus National Product Differentiation as an Explanation for the Pattern of U.S.-Canada Trade," *American Economic Review*, Sep. 2001, *91* (4), 858–876.

Head, Keith and Thierry Mayer, "Non-Europe: The Magnitude and Causes of Market Fragmentation in the E.U.," *Review of World Economics*, 2000, *136* (2), 284–314.

Head, Keith and Thierry Mayer, "What Separates Us? Sources of Resistance to Globalization," *Canadian Journal of Economics*, Nov. 2013, *46* (4), 1196–1231.

Head, Keith and Thierry Mayer, "Gravity Equations: Workhorse, Toolkit, and Cookbook," in Gita Gopinath, Elhanan Helpman, and Kenneth Rogoff, eds., *vol. 4 of the Handbook of International Economics*, Amsterdam, The Netherlands: Elsevier, 2014, pp. 131–195.

Head, Keith, Thierry Mayer, and John Ries, "The Erosion of Colonial Trade Linkages After Independence," *Journal of International Economics*, 2010, *81* (1), 1–14.

Helliwell, John F., *How Much Do National Borders Matter?*, Washington, D.C., USA.: Brookings Institution, 1998.

Helpman, Elhanan, "Imperfect Competition and International Trade: Evicence from Fourteen Industrial Countries," *Journal of the Japanese and International Economies*, 1987, *1*, 62–81.

Irwin, Douglas A., "Free Trade and Protection in Nineteenth-Century Britain and France Revisited: A Comment on Nye," *Journal of Economic History*, Mar. 1993, *53* (1), 146–152.

Jacks, David S., "Market Integration in the North and Baltic Seas, 1500-1800," *Journal of European Economic History*, 2004, *33* (3), 285–329.

Jacks, David S., "Intra- and International Commodity Market Integration in the Atlantic Economy, 1800-1913," *Explorations in Economic History*, 2005, *42*, 381–413.

Jacks, David S., Christopher M. Meissner, and Dennis Novy, "Trade Costs: 1870-2000," *American Economic Review: Papers and Proceedings*, 2008, *98* (2), 529–534.

Jacks, David S., Christopher M. Meissner, and Dennis Novy, "Trade Booms, Trade Busts, and Trade Costs," *Journal of International Economics*, 2011, *83* (2), 185–201.

Krugman, Paul, "Scale Economies, Product Differentiation, and the Pattern of Trade," *American Economic Review*, Dec. 1980, *70* (5), 950–959.

Lampe, Markus, "Effects of Bilateralism and the MFN Clause on International Trade: Evidence for the Cobden-Chevalier Network, 1860-1875," *Journal of Economic History*, 2009, *69* (4), 1012–1040.

López-Córdova, J. Ernersto and Christopher Meissner, "Exchange-Rate Regimes and International Trade: Evidence from the Classical Gold Standard Era," *American Economic Review*, Mar. 2003, *93* (1), 344–353.

Maddison, Angus, *The World Economy: A Millenial Perspective*, Paris, France: Development Centre Studies - OECD, 2001.

McCallum, John, "National Borders Matter: Canada-U.S. Regional Trade Patterns," *American Economic Review*, Jun. 1995, *85* (3), 615–623.

Melitz, Marc J. and Gianmarco I. P. Ottaviano, "Market Size, Trade, and Productivity," *Review of Economic Studies*, 2008, *75* (1), 295–316.

Novy, Dennis, "Is the Iceberg Melting Less Quickly? International Trade Costs after World War II," Warwick Economic Research Papers 764, Warwick University 2007.

Novy, Dennis, "Gravity Redux: Measuring International Trade Costs with Panel Data," *Economic Inquiry*, Jan. 2013, *51* (1), 101–121.

Nye, John Vincent, "The Myth of Free-trade Britain and Fortress France: Tariffs and Trade in the Nineteenth Century," *Journal of Economic History*, Mar. 1991, *51* (1), 23–46.

O'Rourke, Kevin H., "The Worldwide Economic Impact of the French Revolutionary and Napoleonic Wars: 1793-1815," *Journal of Global History*, Mar. 2006, *1* (1), 123–149.

O'Rourke, Kevin H. and Jeffrey G. Williamson, "Late Nineteenth-Century Anglo-American Factor-Price Convergence: Were Heckscher and Ohlin Right?," *Journal of Economic History*, Dec. 1994, *54* (4), 892–916.

O'Rourke, Kevin H. and Jeffrey G. Williamson, "When did Globalisation Begin?," *European Review of Economic History*, Feb. 2002, *6*, 23–50.

Parsley, David C. and Shang-Jin Wei, "Explaining the Border Effect: The Role of Exchange Rate Variability, Shipping Costs and Geography," *Journal of International Economics*, 2001, *55* (1), 87–105.

Pascali, Luigi, "The Wind of Change: Maritime Technology, Trade and Economic Development," Working paper 1049, Warwick economic research papers Jun. 2014.

Romalis, John, "NAFTA's and CUFTA's Impact on International Trade," *The Review of Economics and Statistics*, Aug. 2007, *89* (3), 416–435.

Rönnbäck, Klas, "Integration of Global Commodity Markets in the Early Modern Era," *European Review of Economic History*, 2009, *13*, 95–120.

Santos Silva, João M. C. and Silvana Tenreyro, "The Log of Gravity," *The Review of Economics and Statistics*, Nov. 2006, *88* (4), 641–658.

Sharp, Paul, "'1846 and All That': The Rise and Fall of British Wheat Protection in the Nineteenth Century," *Agricultural History Review*, 2010, *58* (1), 76–94.

Sharp, Paul and Jacob Weisdorf, "Globalization Revisited: Market Integration and the Wheat Trade between North America and Britain from the Eighteenth Century," *Explorations in Economic History*, Jan. 2013, *50* (1), 88–98.

Solar, Peter M., "Opening to the East: Shipping between Europe and Asia,1770-1830," *Journal of Economic History*, Sep. 2013, *73* (3), 625–661.

Steinwender, Claudia, "Information Frictions and the Law of One Price: "When the States and the Kingdom Became United"," Working paper, London School of Economics Apr. 2014.

Wei, Shang-Jin, "Intra-national versus International Trade: How Stubborn are Nations in Global Integration?," Working paper 5531, NBER Apr. 1996.

Appendix

A. Additional figures

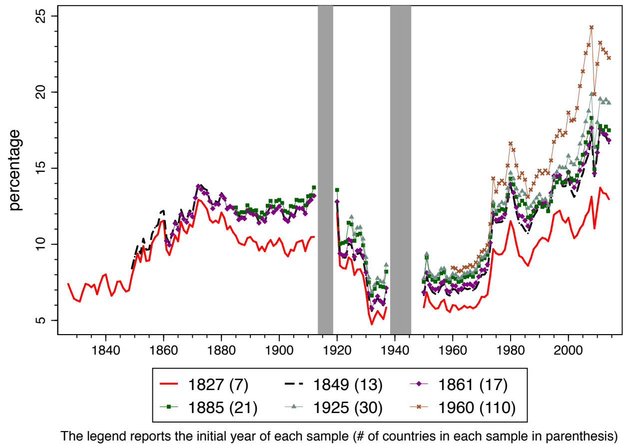


Figure A.1 – Aggregate export openness, balanced samples

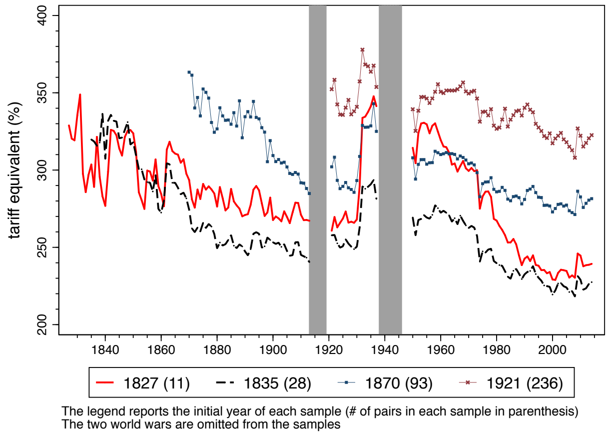


Figure A.2 – Mean trade costs, balanced samples

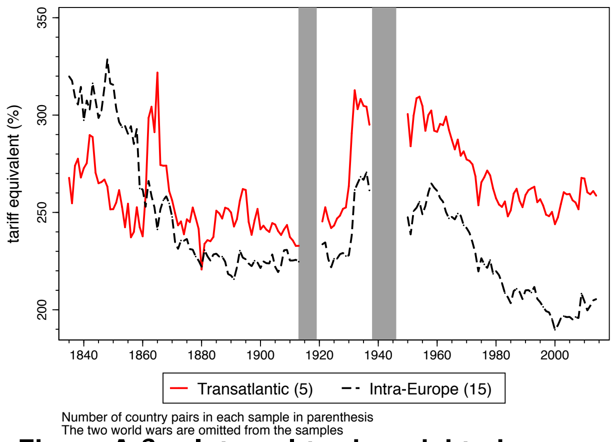


Figure A.3 – Internal trade-weighted mean trade costs, balanced samples

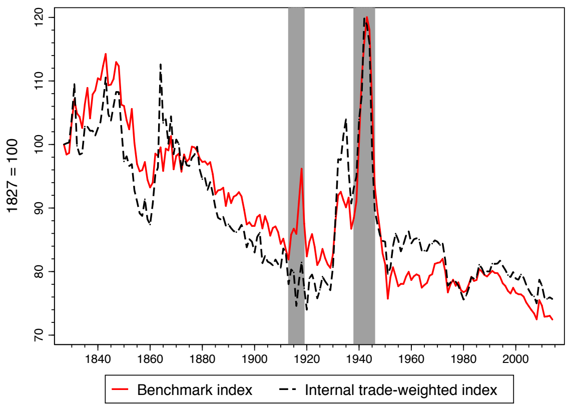
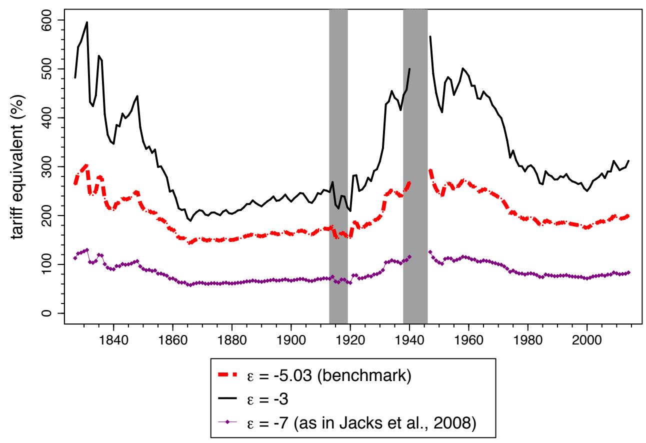


Figure A.4 – Benchmark vs. internal trade-weighted world trade cost indices



To facilitate the reading, trade costs for are not reported for 1941-1946

Figure A.5 – Franco-British trade costs for various values of the trade elasticity

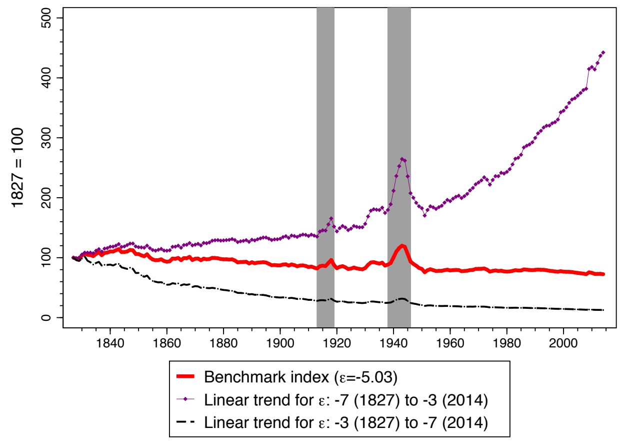
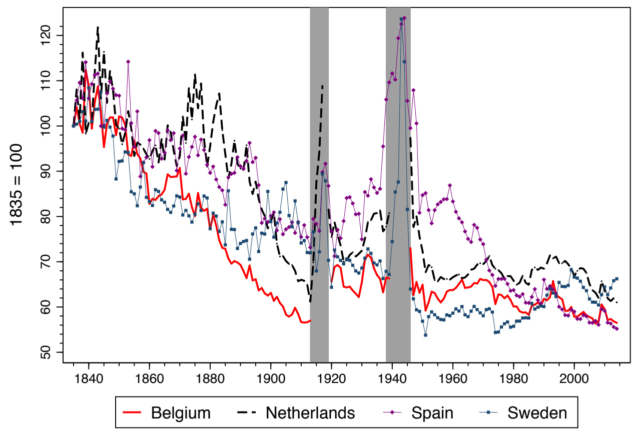
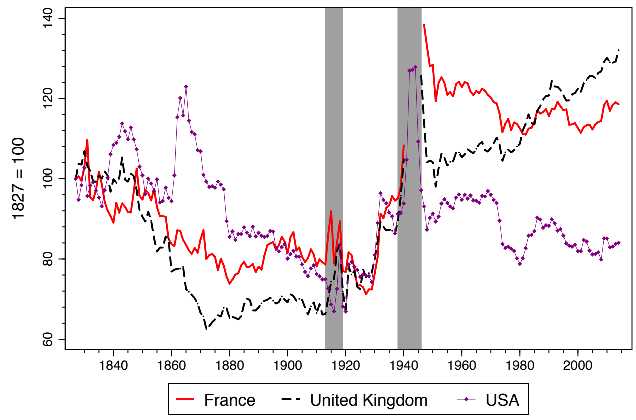


Figure A.6 – World trade cost indices with linear trends for the trade elasticity



To facilitate the reading, the Dutch trade cost index is not reported for 1918

Figure A.7 – Trade cost indices: Belgium, the Netherlands, Spain, Sweden



To facilitate the reading, the French and British trade cost index are not reported for 1941-1946 and 1941-1945 respectively

Figure A.8 – Chained trade cost indices from two-year balanced samples

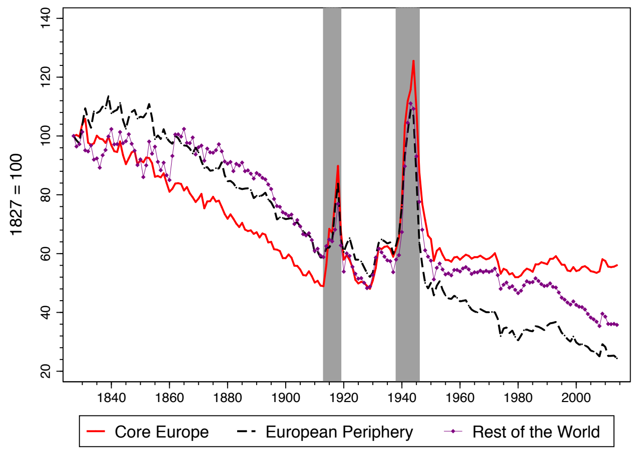


Figure A.9 – Chained trade cost indices from two-year balanced samples

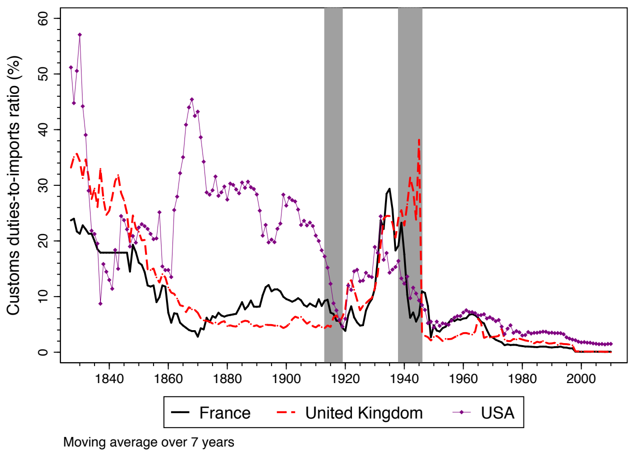


Figure A.10 – Aggregate tariffs: France, U.K., USA

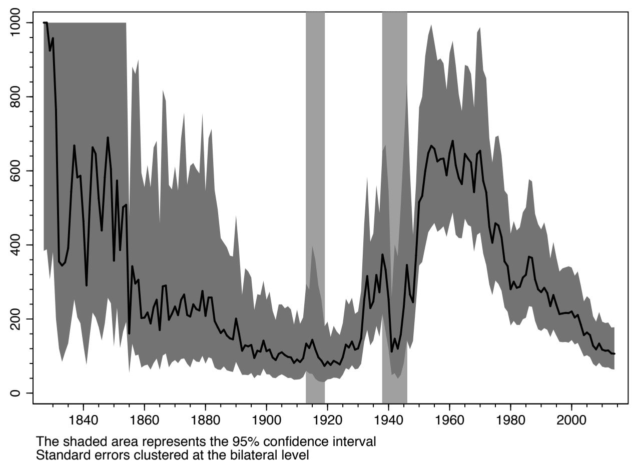


Figure A.11 – Border effect (Exponentiated β_1 coefficient, from equation (15))

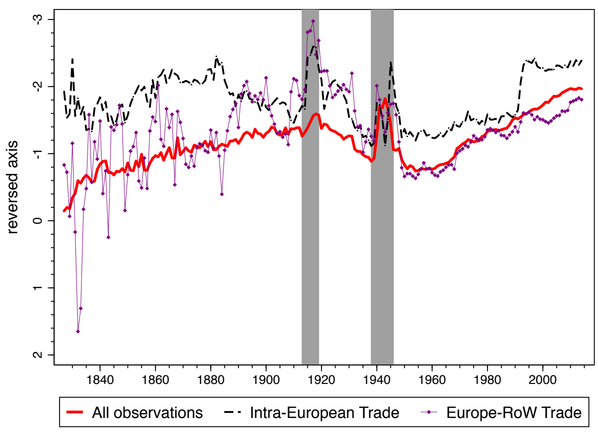


Figure A.12 – Distance elasticity: All trade flows, intra-European trade, European trade with the rest of the world

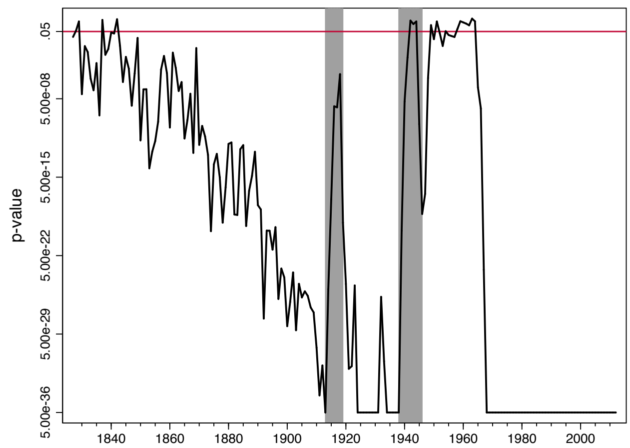


Figure A.13 – P-values of the Breusch-Pagan test for the OLS estimation of equation (15)

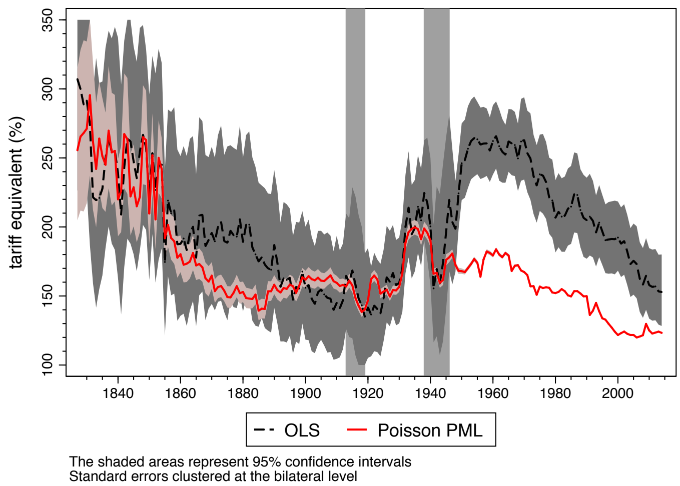


Figure A.14 – Tariff-equivalent border effect: OLS vs. PPML estimation

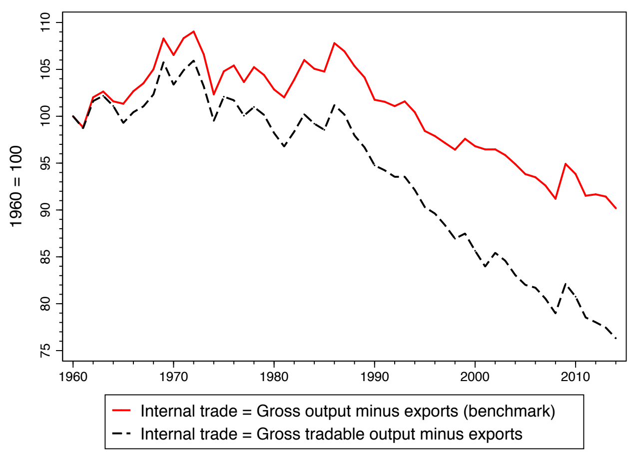


Figure A.15 – World trade cost indices with alternative measures of internal trade, restricted samples

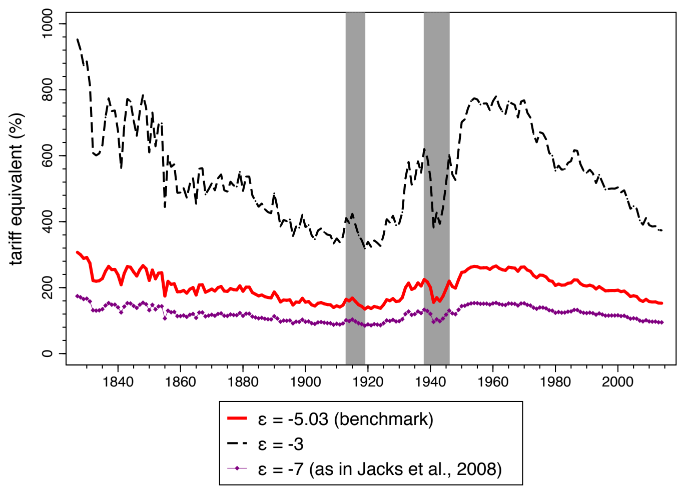
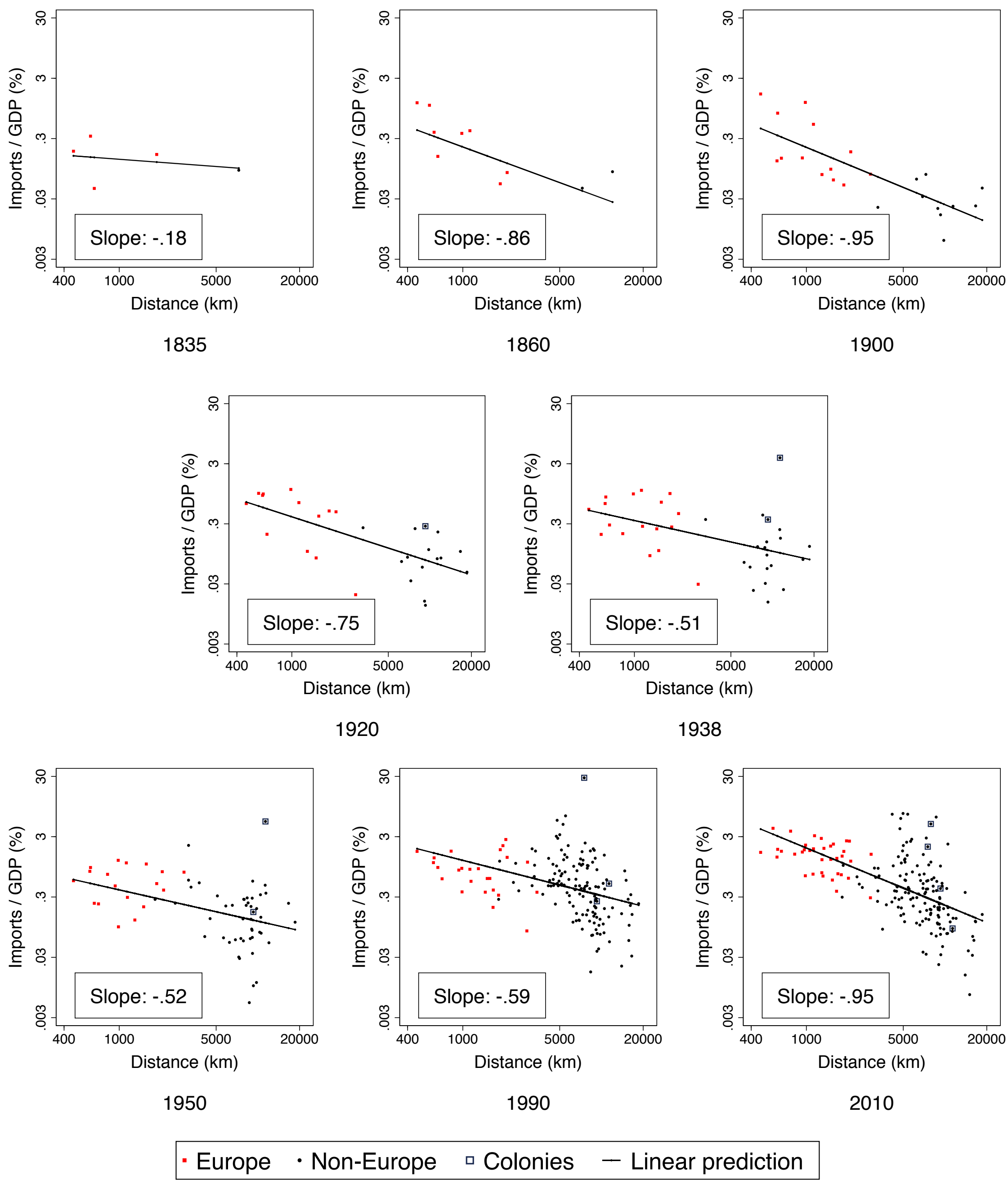


Figure A.16 – Tariff-equivalent border effect: Alternative trade elasticities



Both axis in log scale

Figure A.17 – Import shares from the Netherlands, by distance