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Revisiting the ‘Cobden-Chevalier network’ trade and welfare effects[☆]

Jacopo Timini

Bank of Spain: Banco de Espana, Spain

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ABSTRACT

This study revisits the trade and welfare effects of 19th century bilateralism exploiting the latest developments in structural gravity models, including the consideration of domestic trade. Using bilateral trade data between 1855 and 1875, I show that the Cobden-Chevalier network, i.e. a system of bilateral trade agreements including the Most Favored Nation clause, has large, positive and significant effects on members’ trade. These, however, are heterogeneous at the treaty-level. I then calculate its general equilibrium effects on total trade and welfare. They are considerable, while trade diversion effects are negligible. These results reshape the understanding of the Cobden-Chevalier network, helping in further rationalizing the “free trade epidemic” of the 1860s and 1870s.

1. Introduction

The two decades between 1860 and 1880 are often referred to as the “golden age” of trade liberalization: the proliferation of bilateral trade agreements led to substantial reduction in tariffs, which constituted a relevant part of the impediments weighing on international trade (Stringher, 1889). Indeed, in 1860, Great Britain and France signed a landmark trade treaty, substantially reducing – even if not entirely eliminating – bilateral tariffs between the two countries. This agreement, named after the two negotiators Richard Cobden and Michel Chevalier, incorporated the Most Favored Nation (MFN) clause. This clause granted that tariff concessions agreed in the treaty would be automatically applied to all other trade partners with whom the countries had also stipulated a trade agreement incorporating a MFN clause. Since then, bilateral trade agreements became popular among European countries as well as beyond the continent’s borders (Tena-Junguito et al., 2012), creating a genuine trade network.[1]

While accounts of 19th century trade policy praise the Cobden-Chevalier network as a useful instrument for economic integration (Bairoch, 1989; Nye, 1991a, 1991b; Irwin, 1993a, 1993b; O’Rourke and Williamson, 1999), a series of quantitative assessments based on gravity models question its real effectiveness in promoting trade. Accominotti and Flandreau (2008) and Lampe (2009) argue that

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[☆] The views expressed in this paper are those of the authors and do not necessarily represent the views of Banco de España or the Eurosystem. I am extremely grateful to the editor, Carola Frydman, and two anonymous referees for their comments and suggestions. I would like to thank Robert Pahre for sharing his “Trade Agreements Database” and for his suggestions, and Rui Esteves, Rodolfo Campos, Monica Correa Lopez, and other participants at the Joint CEPR and Seventh Banco de España Economic History Seminar, and at Banco de España Research Seminar for their comments. All remaining errors are mine.

E-mail address: jacopo.timini@bde.es

[1] An in-depth discussion of the causes behind the spread of trade agreements during the 1860s and 1870s are beyond the scope of this paper. Interested readers may refer to Pahre (2007) and Lampe (2011).

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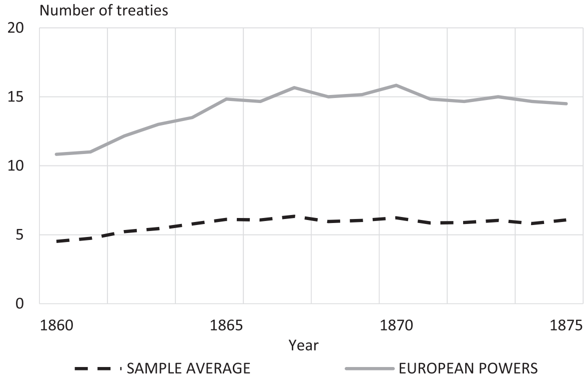

Fig. 1. Post-Cobden-Chevalier trade agreements, 1860–1875.
Note: "Sample average" is measured by the average number of trade agreements in force per country. "European powers" is estimated as the average number of trade agreements in force in Great Britain, France, Germany, Belgium, Austria-Hungary, Italy.
Source : Author's elaboration on Trade Agreements Database (Pahre, 2007).
Source : Author's elaboration on Trade Agreements Database (Pahre, 2007).

the Cobden-Chevalier network has insignificant effects on aggregate bilateral trade. Lampe (2009), however, exploits sector-level data and finds positive trade effects for some sectors.

These findings are surprising, as these trade treaties tend to consider "a large set of important products" (Becuwe et al., 2021), corresponding to substantial shares of pre-agreement bilateral trade. Importantly, these studies only consider international trade. However, recent contributions (e.g. Yotov et al. 2016, Yotov 2022) show the importance of including not only international but also domestic trade in gravity models. Indeed, countries (and firms) can trade both domestically and internationally, i.e. sell their products in the domestic market or to other countries. Trade agreements affect the relative costs of selling products to members not only with respect to non-members, but also with respect to the domestic market. Making use of a structural gravity model with both international and domestic trade, this paper revisits the effects of the Cobden-Chevalier network on trade. Additionally, I further expand the analysis to explore the heterogeneity of treaty-level effects, and to quantify country-level total trade and welfare effects.

I find that, on average, the Cobden-Chevalier network has large, positive, and significant effects on bilateral trade among members, mostly driven by the change in relative costs between trading domestically and with network members. Additionally, I also document a substantial degree of heterogeneity of trade effects across treaties, and show, using a general equilibrium framework, that the Cobden-Chevalier network had, on average, a positive impact on the welfare of nations. The general equilibrium calculations also indicate that the Cobden-Chevalier network had only very limited negative effects on non-members trade. By providing evidence in support of important trade and welfare effects, these results help reconciling the Cobden-Chevalier network historical accounts with its empirical analysis.

2. Historical context and literature review

In the two decades between 1860 and 1880, bilateral trade agreements became a widely used trade policy tool both in Europe and in the rest of the world (see Fig. 1).

The 1860 trade treaty between Great Britain and France – the so-called Cobden-Chevalier treaty – is often regarded as the inception of the bilateral agreement-based network that developed thereafter, with more than 50 agreements signed (Lampe, 2009),[2] coinciding with a period of sustained increase in world trade (see Fig. 2, and Federico and Tena-Junguito, 2019).

Traditional accounts of the first wave of globalization (Bairoch, 1989; Nye, 1991a, 1991b; Irwin, 1993a, 1993b; O'Rourke and Williamson, 1999) regard the Cobden-Chevalier treaty, and the subsequent network of bilateral trade agreements incorporating MFN clauses, as a catalyst for trade liberalization.[3] Jacks et al. (2010, 2011) also point towards a decisive role of trade costs decline in promoting trade integration during the first wave of globalization.

However, other cliometric efforts quantifying the trade effects of the Cobden-Chevalier trade network cast doubts on its effectiveness. Using a gravity model, Accominotti and Flandreau (2008) find that the Cobden-Chevalier network, measured by an indicator for

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[2] In this paper, the information on trade agreements has been retrieved from the Trade Agreements Database (Pahre, 2007). Pahre (2007) coded "any treaty, exchange of letters, or other understanding as a trade agreement as long as the states made mutual tariff concessions *or* granted each other mutual MFN status". This implies a broader approach than Accominotti and Flandreau (2008) and Lampe (2009): they considered the Cobden-Chevalier network as composed only by those bilateral trade treaties that included a MFN clause, with tariff reductions codified in the treaty or transmitted. To make sure that my results are not driven by differences in the list of treaties considered, I use Accominotti and Flandreau (2008) and Lampe (2009) lists of treaties for robustness (see Appendix). Main results are not sensitive to these changes.

[3] Tena-Junguito et al. (2012) provide an in-depth analysis of the evolution of tariff rates in Europe and the rest of the world before and after the Cobden-Chevalier treaty of 1860.

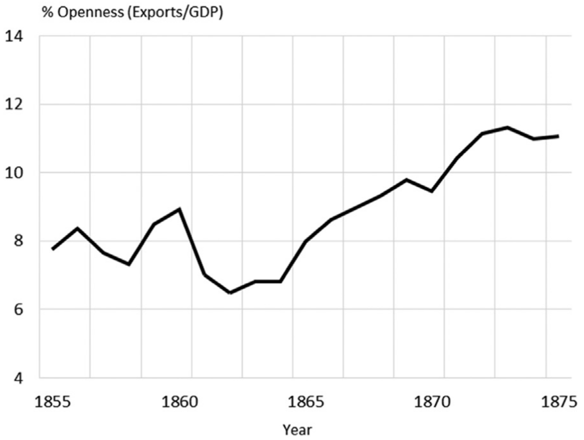

Fig. 2. World openness, 1855–1875.
Note: Openness is calculated as exports/GDP (world sample, current prices).
Source : World Trade Historical Database (Federico and Tena-Junguito, 2019).
Source : World Trade Historical Database (Federico and Tena-Junguito, 2019).

the existence of a MFN treaty between exporter and importer countries, has no discernible effects on trade.[4] Lampe (2009) suggests that the Cobden-Chevalier trade network do not affect aggregate bilateral trade, but indicates sector-level bilateral trade effects instead, mostly for manufacturing. These results would reflect the negotiators interest in reducing specific, product-level, tariffs rather than overall protection.

Trade negotiations are often a matter of product-specific negotiations concerning the corresponding changes to tariff barriers to be included in the agreement. Two considerations are relevant here. First, product-level negotiations are also a characteristic of 20th and 21st century trade agreements, which have been found to have positive effects on aggregate bilateral trade (Dai et al., 2014; Baier et al., 2019). Second, and perhaps more importantly, at least in some cases, 19th century trade agreements include tariff cuts for a long list of important products, corresponding to substantial shares of pre-agreement bilateral trade.[5] For example, tariff exemptions, tariff cuts, MFN or other preferential treatments agreed in the treaties between Italy and France (1863), and Italy and Austria-Hungary (1867) cover more than two thirds (≈70%) of Italian bilateral export value (to France and to Austria-Hungary, respectively). The preferential treatments conceded in the 1860 Anglo-French Treaty of Commerce itself comprise “a large set of important products” (Becuwe et al., 2021). Were these number to be true on a wider scale, one would expect the Cobden-Chevalier network to have effects on aggregate bilateral trade.

Reframing these considerations from a trade theory perspective, the null effect of trade agreements on trade suggested by earlier cliometric efforts is surprising: the entry into force of a trade agreement is expected to reduce bilateral trade costs between partners, for example by cutting tariffs. In turn, this reduction in bilateral trade costs implies a decline in trade-impeding frictions: bilateral trade is therefore expected to increase. However, using modern trade data, Head and Mayer (2014) show the sensitivity of trade policy variables to modeling choices. Their findings are confirmed by Dai et al. (2014) and Bergstrand et al. (2015), whose results highlight the importance of considering both domestic and international trade (see next Section for more details). This paper takes these results into account by considering both domestic and international trade in gravity models to revisit the Cobden-Chevalier network trade and welfare effects.

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[4] While focusing on the gold standard during the 1870-1913 period, Lopez-Cordova and Meissner (2003) found similar results for the control variable chosen to identify the trade network in the 1870s.

[5] To the best of my knowledge, there is no structured database including information on product-level trade flows and tariff changes. Therefore, I report (anecdotal) evidence based on certain bilateral product-level trade and tariff (cuts) data, that are publicly available. On one side, bilateral trade flow data has been digitized for a number of countries in recent years (for an exhaustive list, see Timini 2020), but Federico et al. (2012) is, to the best of my knowledge, the only publicly available database including bilateral product-level trade information (Italy and its trade partners). On the other side, bilateral tariff data are even more difficult to gather. Non-exhaustive lists of products that received tariff preferences (either exemptions, cuts, MFN or other preferential treatments) are available (Camera dei Deputati, 1867; Corbino, 1929) for the following treaties: Italy-France (1863), and Italy-Austria-Hungary (1867). I match this information with Federico et al. (2012) trade data using the product name reported in the tariff and trade lines. I use 1862 and 1865 trade data for Italy-France and Italy-Austria-Hungary calculations, respectively.

3. Theory, empirical strategy and data

3.1. Theory

I utilize a partial equilibrium empirical framework based on a structural gravity model,[6] as formulated by Anderson and van Wincoop (2003), Head and Mayer (2014) and Yotov et al. (2016). As shown by Arkolakis et al. (2012), this well-known general theoretical framework embodies a wide set of distinct models, and can be summarized by the following set of equations:

$$X_{ij} = \frac{Y_i}{\Omega_i}\frac{E_j}{\Pi_j}\tau_{ij} \tag{1}$$

$$\Omega_i = \sum_j \frac{E_j}{\Pi_j}\tau_{ij}, \tag{2}$$

$$\Pi_j = \sum_i \frac{Y_i}{\Omega_i}\tau_{ij}. \tag{3}$$

Here, X_{ij} identifies bilateral trade flows from exporter *i* to importer *j*. When $i = j$, X_{ij} denotes domestic trade flows, and when $i \neq j$, X_{ij} denotes international trade flows. Exporter's *i* production value is Y_i, and importer's *j* expenditure is E_j. The element τ_{ij} captures bilateral trade costs. The terms Ω_i and Π_j are the outward and inward multilateral resistances (Anderson and van Wincoop, 2003): they correspond to measures of exporter's *i* access to export markets, and competition in the importer's *j* domestic market (Fally, 2015), i.e. measures of the trade barriers that each exporter or importer faces with all its trading partners. The subscript *t*, time, can be easily incorporated in this system of equations.

The explicit consideration of domestic trade is one of the latest advances in structural gravity models (Yotov, 2012; Dai et al., 2014; Bergstrand et al., 2015; Anderson and Yotov, 2016; Yotov et al., 2016; Baier et al., 2019; Felbermayr and Yotov, 2021). In this context, the inclusion of domestic trade is very important for two main reasons.[7] First, it improves consistency of the empirical approach with gravity theory, where consumers differentiate goods by the country where they are produced (i.e. the country of origin). In this way, consumers have access not only to foreign but also to domestically produced goods. Second, of particular concern for the identification of the effect of trade agreements on trade, the inclusion of domestic trade allows capturing all changes in relative costs generated by the entry into force of a trade agreement. Indeed, a trade agreement changes both the relative costs of exporting goods to member compared to non-member destinations, and the relative costs of exporting goods to member destinations compared to selling goods in the domestic market. In other words, with international flows only, it is not possible to capture eventual domestic-to-international "diversion" effects, likely resulting in downward biased estimates.

3.2. Empirical strategy

To implement empirically the theoretical approach, I use the Poisson pseudo-maximum likelihood (PPML) estimation technique (Santos Silva and Tenreyro, 2006), and compute standard errors by clustering on exporter, importer, and time (Egger and Tarlea, 2015). This methodology allows to properly account for the presence of "zeros" and heteroscedasticity, two relevant features of bilateral trade data.

For comparison, in the first specification I follow the existing literature, and use international trade only:

$$X_{ijt} = \exp\left(\beta_0 + \beta_1 TA_{ijt} + \delta_{it} + \gamma_{jt} + \omega_{ij}\right) + \varepsilon_{ijt} \tag{4}$$

In this case, X_{ijt} are exports from country *i* (the exporter) to country *j* (the importer) at time t. The variable TA_{ijt} identifies trade agreements, and corresponds to a dummy variable that is equal to one when the exporter *i* and the importer *j* have a trade agreement in force at time t, and zero otherwise. The variables δ_{it} and γ_{jt} are exporter-time and importer-time dummies, and represent the theory-consistent way to incorporate the multilateral resistance terms described in Eqs. (2) and (3). The variable ω_{ij} identifies exporter-importer dummies. In this way, in line with the literature, I control for asymmetric trade costs and trade imbalances (Waugh, 2010), and address possible trade policy endogeneity – i.e. the concern that two countries that trade more are more likely to sign a trade agreement – as in the approach of Baier and Bergstrand (2007).[8] The error term is ε_{ijt}.

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[6] The general equilibrium framework is summarized in Section 4.2 and explained in detail in Appendix B.

[7] Yotov et al. (2016) and Yotov (2022) describe in details all the advantages of considering domestic trade in structural gravity models. Only few papers explicitly take domestic trade flows into account. For the first globalization period, prominent examples are Jacks et al. (2010) and Jacks et al. (2011), studying the evolution and determinants of trade and trade costs. Karlsson and Hedberg (2021) focus on the effect of wars on trade instead, and estimate domestic trade by using different sources.

[8] These batteries of dummy variables also absorb standard gravity variables with exporter-time, importer-time and country-pair variation, such as GDP, GDP per capita, population, distance, contiguity, common language, colonial relationship, etc.., preventing their estimation. Baier and Bergstrand (2007) solution to trade policy endogeneity is to include pair fixed effects because their inclusion absorbs any country-pair variation, therefore levelling out initial differences in the level of bilateral trade across country-pairs. Possibly, these sets of fixed effects also contribute to mitigate eventual issues with heterogeneity in national trade statistics, e.g. different practices in measuring of trade aggregates or trade origins (Lampe, 2008).

As an intermediate step, in the second specification, I consider both international and domestic trade:

$$X_{ijt} = \exp\left(\beta_0 + \beta_1 TA_{ijt} + \delta_{it} + \gamma_{jt} + \omega_{ij}\right) + \varepsilon_{ijt} \tag{5}$$

Here, X_{ijt} includes both domestic (X_{iit}) and international trade flows (X_{ijt}, $\forall$ $i \neq j$). The inclusion of domestic trade is important for having theory-consistent estimates and to capture trade diversion from domestic to international.

In the preferred specification, I implement Bergstrand et al. (2015) approach to disentangle broader economic integration processes from the bilateral trade agreement effects:

$$X_{ijt} = \exp\left(\beta_0 + \beta_1 TA_{ijt} + \rho_t INTL\_BRDR_{ijt} + \delta_{it} + \gamma_{jt} + \omega_{ij}\right) + \varepsilon_{ijt} \tag{6}$$

The new variable in Eq. (6), $INTL\_BRDR_{ijt}$, is the result of the interaction of a dummy ($INTL\_BRDR_{ij}$) that identifies whether the goods exported are crossing an international border (i.e. $INTL\_BRDR_{ij}$=1 if $i \neq j$), with year dummies. Therefore, $INTL\_BRDR_{ijt}$ is identifying international trade flows, as opposed to domestic trade flows. Given the structure of my specification, the coefficients ρ_t correspond to the semi-elasticities of bilateral trade flows to international borders. In other words, the evolution of the coefficients ρ_t over time shows the ease of trading internationally with respect to trading domestically. Hence, as suggested by Bergstrand et al. (2015) and Baier et al. (2019), it can be used as an indicator of globalization – intended as the ability of trading internationally. This strategy controls for the widespread reduction in transport costs, dictated by the expansion of railroads and steamships that took place during the period of analysis (Jacks et al., 2010; Pascali, 2017).[9] Eq. (6) is my preferred specification, as it allows disentangling the "trade agreement" effect from any other factor affecting differently international and domestic trade.

Finally, I exploit the advances in econometrics and in data availability to estimate treaty-level trade effects, i.e. the effect of each trade agreements included in the database. Similar to Kohl (2014) and Baier et al. (2019) methodological approaches, I estimate the following equation:

$$X_{ijt} = \exp\left(\beta_0 + \sum_{n=1}^{N} \beta_n TA^n_{ijt} + \rho_t INTL\_BRDR_{ijt} + \delta_{it} + \gamma_{jt} + \omega_{ij}\right) + \varepsilon_{ijt} \tag{7}$$

Here, the new element is $\sum_{n=1}^{N} \beta_n TA^n_{ijt}$, where $n = 1,\ldots,$N, and N indicates the number of agreements in the sample.

3.3. Data

International bilateral trade data, measured in British pound sterling, are from the TRADHIST Database (Fouquin and Hugot, 2017), which gathers together bilateral nominal trade flows both directly from primary sources and from other well-known historical trade databases such as RICardo (Dedinger and Gerard, 2017).[10]

Data on domestic trade flows are not readily available. Given the limited information available for the first globalization period, I follow Yotov (2012), and calculate domestic trade flows (X_{ijt}, $\forall$ $i = j$) as the difference between nominal GDP and total nominal exports, both directly available from the same source used for bilateral trade flows, i.e. the TRADHIST database. The theoretical limitations of this approach are thoroughly described in Head and Mayer (2014), and includes the fact that GDP is a value-added measure of output while exports are reported in gross terms. More theoretically consistent methods include the use of gross production data or input-output tables.[11]

There are two main reasons why, despite these concerns, I use GDP-based calculation of domestic trade. First, GDP-based calculations are the only alternative for having comparable data for a large number of countries during the period of interest. Second, Campos et al. (2021) compare the most common ways of estimating domestic trade, including GDP-based calculation used in this paper. Despite theoretical concerns, they show that the empirical estimates of the impact of trade agreements do not depend on how domestic trade is measured, suggesting that "the collection of exporter-year, importer-year and country pair dummy variables common in gravity equations is effective in eliminating differences across methods". These results imply that the GDP-based domestic trade measure is an "acceptable alternative to estimate the effect of trade agreements on trade flows".

Information on trade agreements has been retrieved from the Trade Agreements Database (Pahre, 2007). In line with other studies on the Cobden-Chevalier network, the period of analysis is 1855–1875.[12] Bilateral distance, which is used in robustness checks, is

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[9] Additionally, this approach is in line with a number of previous economic history contributions arguing that international borders matter for trade and market integration during the first globalization (see, e.g., Jacks 2005, Wolf 2009, Schulze and Wolf 2009, Wolf et al. 2011, Schulze and Wolf 2012, Liu and Meissner 2015).

[10] TRADHIST provides information on the original source of each trade flow reported in the database.

[11] Input-output tables allow to construct domestic trade by exploiting information on intermediate and final consumption (see Timmer 2015, for more information, and Larch et al. 2018, for an application). Gross output data allows to estimate domestic trade by subtracting gross exports from gross production (see Dai et al. 2014, or Borchert and Yotov 2017, for an application).

[12] This choice is motivated by three intertwined reasons. The first reason is historical: the economic conditions surrounding the Cobden-Chevalier trade network drastically changed by the end of the 1870s – beginning of the 1880s, with the return of protectionist policies, that drastically changed the existing trade treaties and the MFN clauses contained therein. In some cases, bilateral trade treaties were repealed, in some others they were modified (including less favorable preferential treatments). The second reason is empirical: the substantial and frequent bilateral trade policy changes (i.e. repeal, or change in preferential treatments contained in the trade agreements) complicates the empirical settings for estimating the "trade agreement effect". The third reason is comparability: previous Cobden-Chevalier studies focus on this period.

Table 1
Effects of the Cobden-Chevalier network – structural gravity estimates.

	w/o domestic trade (1)	with domestic trade (2)	with domestic trade and border*year (3)
TA	0.0125	0.270***	0.241***
	(0.054)	(0.060)	(0.041)
Observations	5232	5638	5638
Domestic trade	NO	YES	YES
Border*year	NO	NO	YES
δ_{it}	YES	YES	YES
γ_{jt}	YES	YES	YES
ω_{ij}	YES	YES	YES

Note: PPML regressions. Fixed effects, control variables and constants not reported for the sake of simplicity. Standard errors (in parentheses) are clustered at the exporter, importer and time level.
$^{**}p < 0.05$.
$^{*}\ p < 0.1$.
$^{***}\ p < 0.01$.

taken from CEPII (Mayer and Zignago, 2011). The sample includes 24 countries (depending on the availability of domestic trade data, see Table A.2 in the Appendix).[13] Summary statistics are reported in Table A.3 in the Appendix.

4. Results and discussion

4.1. Main results

The main results, based on the structural gravity model described in the previous sections, are presented in Table 1.

In Column 1, I replicate the approach of Accominotti and Flandreau (2008) and Lampe (2009) by using international trade data only. In line with their contributions, I find that the effect of the Cobden-Chevalier trade agreements on total bilateral trade are small and insignificant.[14] These results may be driven by different factors. The exclusion of domestic trade from gravity models is not granted by theory, and results obtained from these regressions may be biased. Additionally, if signing a trade agreement increases trade with both members and non-members – for example, as suggested by Molina (2010), due to the existence of entry costs in export markets or of learning by exporting effects – the identification of its trade effects in a gravity model with international trade only will be difficult.

Once I consider both domestic and international trade (Column 2 and 3)[15] the coefficient becomes positive, large, and significant. In my preferred specification (Column 3), I follow Bergstrand et al. (2015) and disentangle econometrically broader globalization effects from the "pure" trade agreement effects, by including a set of dummies capturing the interaction of a dummy that identifies international trade flows ($INTL\_BRDR_{ij}$), with year dummies. In this case, the results indicate that the Cobden-Chevalier network lead to a 27% increase in bilateral trade flows (i.e. $100^{*}[e^{\beta^{TA}} - 1]$). The Cobden-Chevalier network effect on trade is very close to the value for 20th and 21st century trade agreements indicated by Head and Mayer (2014).

These findings suggest that including domestic trade in the regressions is of crucial importance for the understanding of the Cobden-Chevalier network effects: the inclusion of domestic trade captures the substitution of domestic sales with international sales (Dai et al., 2014). These results are consistent with the existence of capacity constrained producers, forced to choose between selling at home or abroad. The results are also consistent with insights provided by the analysis of firm-level micro data, suggesting a negative correlation between domestic sales and exports (e.g. Vannoorenberghe 2012; Ahn and McQuoid 2017) after trade liberalization episodes. Bustos (2011) confirms these findings for the specific case of signing a trade agreement.

Fig. 3 complements the information reported in Table 1, by plotting ρ_t, the coefficients of the variable $INTL\_BRDR_{ijt}$, i.e. the interaction between the international border dummy and year dummies. $INTL\_BRDR_{ij1875}$ is omitted given the inclusion of

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[13] Data and replication files are available at the following link: https://doi.org/10.3886/E182762V1 (Timini, 2022).

[14] In my main specification the sample is restricted to those countries with domestic trade data (these countries are reported in Table 3, Column "Country"). To make sure that my results are not driven by compositional effects, in the Appendix (Table A.1) I replicate Table 1 results, adapting the sample to the one used in Accominotti and Flandreau (2008), Lampe (2009), and Lopez-Cordova and Meissner (2003). The latter contribution focuses on the gold standard (1870-1913), but include bilateral trade agreements as a control variable. Accominotti and Flandreau (2008) report the list of treaties used in their regressions, based on Lazer (1999). The working paper version of Lampe (2009) also reports the list of treaties used. Therefore, I also adapt the TA definition accordingly. Main results are not sensitive to any of these changes in the data. Table A.2 reports the countries included in Accominotti and Flandreau (2008), Lampe (2009), and Lopez-Cordova and Meissner (2003).

[15] The higher number of observations in Column 2 and 3 (with respect to Column 1) is entirely due to the inclusion of domestic trade observations.

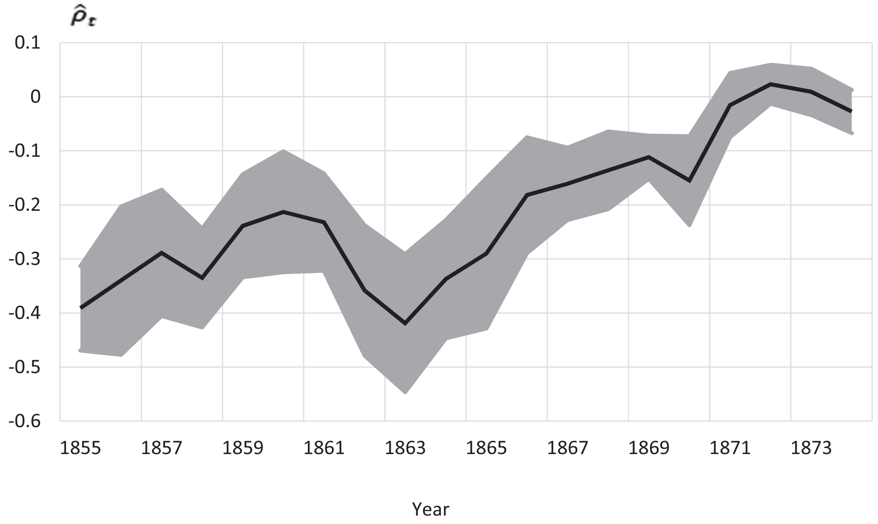

Fig. 3. The declining effect of international borders, 1855–1875.
Note: The figure plots the estimated effect of international borders on trade. The estimation uses the specification in Eq. (6), and corresponds to the results reported in Column 3, Table 1 (coefficients are not shown in Table 1). The black line is constructed from $\hat{\rho}_t$ estimates. The gray area corresponds to the 95% confidence interval.

a constant.[16] The evolution of these coefficients is portrayed in Fig. 3, and shows the declining effect of international borders on trade. The value estimated for ρ_{1855}, −0.391, denotes that at the beginning of the sample, in 1855, it was more difficult to trade internationally relative to the end of the sample. In 1855 international borders were reducing international relative to domestic trade by 32% more than in 1875 (i.e. $100^*[e^{-0.391} - 1]$).

The decline in the estimated effects over time reflects the ongoing process of globalization – intended as the decreasing costs of trading across borders with respect to trading domestically – and matches well with the historical account of a widespread reduction in trade costs due to the expansion of railroads and steamships (Jacks et al., 2010; Pascali, 2017).

The estimations presented in Table 1 are robust to a series of alternative specifications, reported in Table 2, where I consider potential confounding factors to reduce concerns for possible omitted variable bias.

In Column 1, I follow Bergstrand et al. (2015), and add to my main specification (Eq. (6)) time-varying distance effects (the logarithm of bilateral distance interacted with year dummies), a stricter way of controlling for other sources of (bilateral) integration.

In Column 2, I control for fixed exchange rate arrangements, such as the Gold Standard and the Latin Monetary Union (LMU), by inserting a dummy equal to one in case both the exporter and the importer are part of the arrangement. In both cases the coefficient is not statistically different from zero. The LMU results confirm its insignificant “average effect” on trade (Flandreau, 2000; Timini, 2018). The Gold Standard results are to be treated with caution as I only capture its very early years in the sample and the dummy has very limited variation (very few entries and exits). Indeed, Accominotti and Flandreau (2008) and Lampe (2009) do not consider the gold standard in their regressions.

In Column 3, to address the Cheng and Wall (2005) concerns of a possibly sluggish response of trade to trade agreements, I follow Baier and Bergstrand (2007) approach and use 5-year intervals.

Column 4 and Column 5 provide a test for strict exogeneity by including leads of the trade agreement dummy (Baier and Bergstrand, 2007; Kohl, 2014; Yotov et al., 2016): this approach allows identifying existing pre-agreement trends in bilateral trade flows. The small and not statistically significant coefficients of the leads (together with the positive and significant coefficient of the contemporaneous trade agreement dummy) suggest the absence of reverse causality. The higher point estimate of the lead in Column 4 (with respect to Column 5) may be explained by the presence of some anticipation effects in the very short run (Yotov et al., 2016).

In Column 6, I separately consider aggregate tariffs (different from bilateral tariffs, captured by the trade agreement dummy). The TRADHIST database contains a measure of “customs duties-to-imports” ratio, at the country level. Despite being only a crude proxy of tariffs (Tena-Junguito et al., 2012), it has been widely used in the historical literature, particularly in the absence of valid alternatives (e.g. Accominotti and Flandreau 2008). Apart from controlling for the trade effects of multilateral and unilateral tariff reductions, the tariff coefficient can be expressed in terms of trade elasticity of substitution (−(ln(1+tariff)).[17]

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[16] As explained in Bergstrand et al. (2015), given the set of fixed effects included in the structural gravity model, it is not possible to interpret the constant as the estimated of the omitted international border-year variable. The initial level of the international border effect is captured by the pair fixed effects, and therefore can vary across pairs.

[17] Within a structural gravity model, the proper identification of non-discriminatory trade policy variables (i.e. varying along the exporter-time or importer-time dimension, such as the tariff measure defined above) is not possible if only international trade flows are considered. In this case,

Table 2
Effects of the Cobden-Chevalier network – robustness tests.

	ln(dist)*year (1)	GS, LMU (2)	5-year intervals (3)	TA lead (1-year) (4)	TA lead (5-year) (5)	Tariffs (6)
TA	0.196***	0.253***	0.332***	0.180***	0.333***	0.130***
	(0.058)	(0.041)	(0.075)	(0.062)	(0.072)	(0.046)
GS		−0.115				
		(0.092)				
LMU		−0.005				
		(0.072)				
TA_Lead				0.079	−0.006	
				(0.068)	(0.083)	
ln(1+tariff)						−4.625***
						(0.703)
Observations	5638	5638	1391	5638	1391	2186
Domestic trade	YES	YES	YES	YES	YES	YES
Border*year	YES	YES	YES	YES	YES	YES
ln(dist)*year	YES	NO	NO	NO	NO	NO
Year intervals	NO	NO	YES (5-year)	NO	YES (5-year)	NO
δ_{it}	YES	YES	YES	YES	YES	YES
γ_{jt}	YES	YES	YES	YES	YES	YES
ω_{ij}	YES	YES	YES	YES	YES	YES

Note: PPML regressions. Fixed effects, additional control variables and constants not reported for the sake of simplicity. Standard errors (in parentheses) are clustered at the exporter, importer and time level.
** $p < 0.05$.
* $p < 0.1$.
*** $p < 0.01$.

The value of the trade elasticity (4.6) that can be extracted from the regression in Column (6) lies within the "likely range", between 2.5 and 5.1, estimated by Bajzik et al. (2020) as a result of a meta-analysis of the literature, and is very close to Simonovska and Waugh (2014), who – using modern trade data – find a trade elasticity of 4.

4.2. Extensions

I then extend the analysis to study heterogeneity in the effects of trade agreements, and to compute the Cobden-Chevalier network total trade and welfare effects.

4.2.1. Heterogeneous effects of trade agreements

The analysis of heterogeneity relies on the structural gravity model described in Eq. (7), and Fig. 4 reports treaty-level estimates. Given the bilateral trade data available and the inclusion of (pair) fixed effects, it has been possible to estimate agreement level effects for 37 different trade agreements.[18] Out of these 37 estimated coefficients, 13 (35%) are positive and significant, 19 (51%) are not statistically significant, and only 5 (14%) are negative and significant. The distribution of the treaty-level coefficients is very heterogeneous. Such heterogeneity across trade agreements, including negative estimates for a number of trade agreements, is similar to what have already been documented for the second wave of globalization (Kohl et al., 2016; Baier et al., 2018, 2019; Freeman and Pienknagura, 2019).

Treaties including tariff cuts for a long list of important products are expected to generate large and positive trade effects. Indeed, this is the case for those treaties for which was possible to collect such data: point estimates suggest that the 1860 Anglo-French Treaty of Commerce (FRA-GBR in Fig. 4) increased trade by 64%, more than twice the average effect. The treaty between Italy and Austria-Hungary (AUT-ITA) increased trade by 53%, and the treaty between Italy and France (FRA-ITA) by 8%.[19]

Despite limitations in the availability of granular data (e.g. size of tariff cuts), it is however possible to explore the association of the estimated treaty-level effects with relevant trade agreement characteristics: the decade in which the trade agreement has been signed, the geographical location of the countries involved, and the characteristics of the agreement itself (namely, whether it includes a MFN clause or not).

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the coefficient is perfectly collinear with importer-time and exporter-time fixed effects (Head and Mayer, 2014). However, as demonstrated by Heid et al. (2021), the use of both domestic and international trade flows allows identifying the tariff coefficient. In this way, the values contained in the vector of interest changes along the exporter-time and importer-time dimension, being equal to zero for domestic trade flows (as custom duties do not apply to national transactions).

[18] The identification of the agreement level effect depends on the availability of sufficient members' bilateral trade data (before and after the agreement).

[19] The estimation procedure for this treaty relies on very few pre-treatment observations.

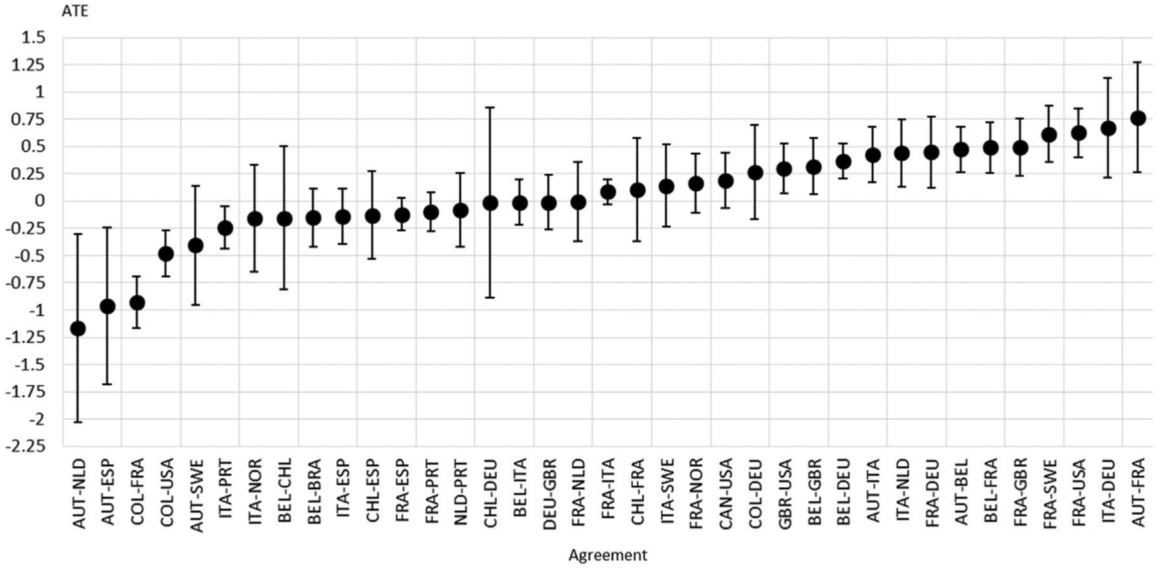

Fig. 4. Cobden-Chevalier network effect, treaty-level estimations
Note: The figure plots the estimated average treatment effect (ATE) of trade agreements (1855–1875). The estimation uses the specification in Eq. (7). The bars display the 95% confidence interval around point estimates (represented as dots).

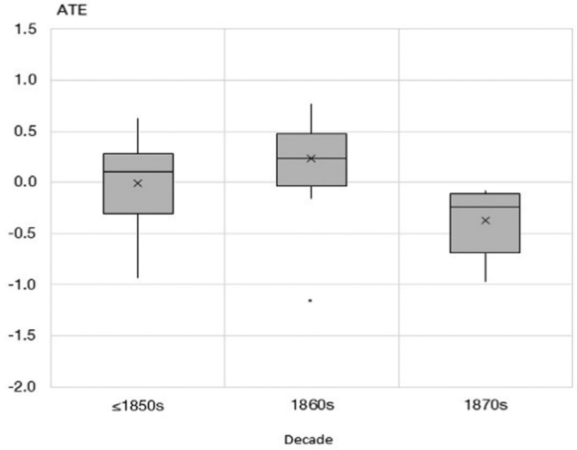

Fig. 5. Treaty-level effects by decade
Note: The figure plots the estimated average treatment effect (ATE) by decade of entry into force. The box plots reported display the median (the line within the box), the 25th and 75th percentile range (the limits of the box), and the maximum and minimum values (lines emerging from the box, above and below, respectively), not classified as outliers. Outliers are reported as dots, and data points are classified as such if they exceed a distance of 1.5 times the interquartile range below the first or above the third quartile. The ‘x’ represents the average value.

First, on average, trade agreements signed during the 1860s have a higher treatment effect than those signed before (1850s) or after (1870s) (see Fig. 5). On the one hand, if compared to the former group (1850s), the larger treatment effect for the treaties signed in the 1860s may reflect a more liberal approach to trade policy during the “free trade epidemics”, possibly capturing larger tariff cuts. On the other hand, the smaller treatment effect in the 1870s can be interpreted as capturing early signs of the return to protectionist trade policy – in the form of less generous concessions included in the treaties.[20] These findings are in line with Accominotti and Flandreau (2008) who argue that liberalization was losing pace after the 1860s. Negative treatment effects may be explained by the simultaneous introduction of new bilateral barriers to trade – such as non-tariff measures – that compensate tariff reductions contained in the trade treaty. Beverelli et al. (2019) and Niu et al. (2020) provide evidence of such mechanism using modern trade

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[20] Such protectionist turn is dated around the end of the 1870s and the beginning of the 1880s see e.g. Lehmann (2010) and Uebele (2011).

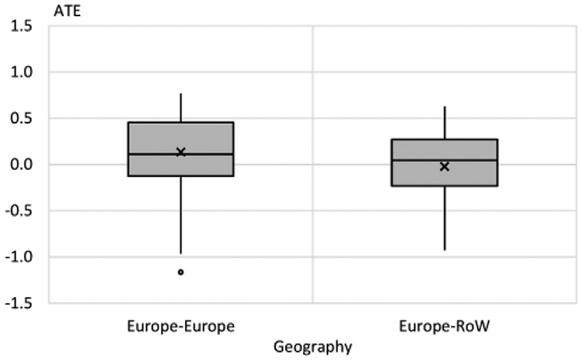

Fig. 6. Treaty-level effects by geography (Europe vs. RoW)
Note: The figure plots the estimated average treatment effect (ATE) by "geography" of the agreement, separating agreements between European countries ("Europe-Europe") and agreements that also include non-European countries ("Europe-RoW"; RoW: Rest of World). The box plots reported display the median (the line within the box), the 25th and 75th percentile range (the limits of the box), and the maximum and minimum values (lines emerging from the box, above and below, respectively), not classified as outliers. Outliers are reported as dots, and data points are classified as such if they exceed a distance of 1.5 times the interquartile range below the first or above the third quartile. The 'x' represents the average value.

data.[21] However, from a methodological standpoint, a word of caution is needed: the smaller treatment effect can be explained by the proximity of the signature of these treaties with the end of the sample. Usually the full trade effect of trade agreements takes several years to emerge (see e.g. Bergstrand et al. 2015), therefore, treatment effects of the treaties signed in the 1870s may be biased downwards.

Second, on average, trade agreements signed between European countries have a higher treatment effect than those signed with non-European countries (see Fig. 6). Intuitively, this difference can be explained by the role of geographic distance as a mediating factor. Indeed, Baier et al. (2018) and Freeman and Pienknagura (2019) show that geographical distance tends to reduce the effect of trade agreements on trade. However, in our sample, most agreements between European countries also share another feature (beyond geography): they include a MFN clause. When splitting the sample along this difference, trade agreements with a MFN clause have, on average, an even larger treatment effect than those without a MFN clause (see Fig. 7). These findings are in line with Lampe (2009) who argues that the MFN clause was an essential feature of the network.

These association exercises may provide insights on the potential causes beyond the heterogeneous distribution of treaty-level effects. However, treaty-level estimations should be interpreted keeping in mind the caveats mentioned in Baier et al. (2019): the more granular the estimates, the fewer data points to rely on, the wider the confidence bands of the coefficient, and the higher the likelihood of incurring in an omitted variable bias or reverse causality. These issues may be exacerbated by the unbalanced nature of the database, i.e. by missing data points or short pre-treatment periods.

4.2.2. *General equilibrium*

The general equilibrium analysis of the Cobden-Chevalier network trade and welfare effects relies on the partial equilibrium estimates reported in Section 4.1.

To obtain general equilibrium estimates, it is necessary to complement and expand the system of gravity equations presented in Section 2 Eqs. (1)–((3)). Indeed, within this theoretical context, by assuming labor as the only factor of production, and imposing a market clearing condition, it is possible to express the gains from trade following the Arkolakis et al. (2012) formula:[22]

$$\hat{G} = \hat{\lambda}_{ii}^{1/\epsilon}$$

This means that to obtain the gains from trade ($\hat{G}$), there are only two necessary inputs, $\hat{\lambda}_{ii}$, the change in the exporter's i domestic trade share measured by the change in bilateral trade costs deriving from the entry into force of a trade agreement); and an estimate

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[21] Baek and Hayakawa (2022) suggest that if trade agreements reduce fixed costs for foreign direct investment more than for exporters, this could incentivize exporters to open new branches in the destination country. This will boost local production and sales in the destination country, rather than exports (from the country of origin). However, this mechanism seems to be less likely to happen in the period 1855-1875.

[22] I implement a one sector constant elasticity of substitution (CES) trade model. This model is very transparent and fits the purpose of performing "benchmark trade and welfare estimates". The model does not consider, however, other factors such as input-output linkages, dynamic effects, trade in intermediates, etc., whose inclusion in the model is usually considered as welfare-augmenting. The model also does not consider changes in tariff revenue as a consequence of tariff reductions. These imply two effects of opposite sign: a tariff revenue loss, corresponding to a transfer from the State to consumers, and a tariff revenue gain, derived from the enlargement of the tax base. The sign of the overall effect is therefore uncertain. The 19th century context poses additional issues, as tariff revenues constituted a sizeable share of total public revenues, but the extent of its transformation to transfers to consumers is arguable, given the public expenditure structure. In line with the extant literature (e.g. Baier et al. 2019), I therefore keep it equal to zero. This model has been applied to estimate general equilibrium trade and welfare effects of trade agreements during the second globalization wave, and of the GATT/WTO (see, e.g., Baier et al. 2019, Felbermayr et al. 2022), and, generally, it is widely accepted as an appropriate benchmark for computing general equilibrium effects of trade policies. A formal description of the model is provided in Appendix B.

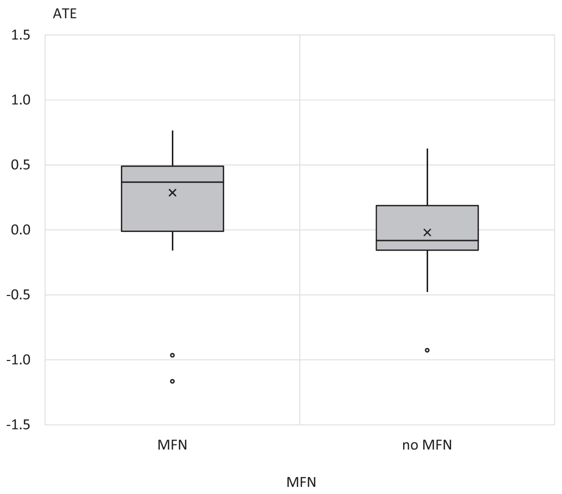

Fig. 7. Treaty-level effects by MFN clause inclusion
Note: The figure plots the estimated average treatment effect (ATE) by the characteristics of the agreement, separating agreements that include a MFN clause ("MFN") from those that do not include such clause "no MFN"). The inclusion of a MFN clause is proxied by the inclusion of the treaty in Accominotti and Flandreau (2008), which use such criteria for identifying a trade agreement. The box plots reported display the median (the line within the box), the 25th and 75th percentile range (the limits of the box), and the maximum and minimum values (lines emerging from the box, above and below, respectively), not classified as outliers. Outliers are reported as dots, and data points are classified as such if they exceed a distance of 1.5 times the interquartile range below the first or above the third quartile. The 'x' represents the average value.

of the trade elasticity $\in$. In this context, the changes in exports, imports and welfare (as reported in Table 3) are the result of the difference between the values those variables take in a "baseline" and in a "counterfactual" scenario, and should be interpreted as medium-to-long-term static effects.[23] In this case, these two situations correspond to a situation without and with the Cobden-Chevalier trade network.

Thus, using this model, I am able to estimate how the Cobden-Chevalier network influenced total exports, total imports, and the welfare of nations during the 1860s-1870s. To do so, I insert in the general equilibrium model a "shock" correspondent to the reduction in bilateral trade costs attributable to the Cobden-Chevalier network. That is to say, the "TA" coefficient (β_1) estimated in Eq. (6) (i.e. $\beta_{TA} \approx 0.241$), my preferred specification.[24] This shock affects bilateral trade flows and the other variables of the model (e.g. production, expenditure, multilateral resistances, wages).[25]

To perform the general equilibrium analysis, I need a balanced dataset, and to assume zero effect of our treatment at the reference year of choice. Therefore, to avoid missing data and to have reasonable levels of bilateral trade, I averaged trade flows for all directional country pairs in the database during the period 1855–1870. For the existence of a trade agreement between the country pair, I took 1870 as the reference year. The trade elasticity parameter is set at 4, as estimated by Simonovska and Waugh (2014), and very close to the median value indicated by Bajzik et al. (2020) in their meta-analysis.

Table 3 displays the results of the general equilibrium analysis. Overall, general equilibrium trade and welfare effects of the Cobden-Chevalier network are large. On average, the Cobden-Chevalier network increased total exports by 9.6%, total imports by 9.9%, and welfare by 0.3%. To understand the extent to which welfare gains stemming from the Cobden-Chevalier network are sizeable, it is possible to look at them through the lens of the welfare gains from trade estimated with modern data and using similar models. Welfare gains deriving from the Cobden-Chevalier network exceed by 50% those estimated by Baier et al. (2019) for the implementation of the Transatlantic Trade and Investment Partnership (TTIP), a trade agreement still under negotiations between the European Union (EU) and the US; and correspond to one-fourth and one-fifth of those generated by two of the most relevant trade policy changes in modern times, the GATT/WTO and the EU, respectively (Felbermayr et al., 2022; Mayer et al., 2019). Compared to these gains, welfare gains of the Cobden-Chevalier network are substantial.

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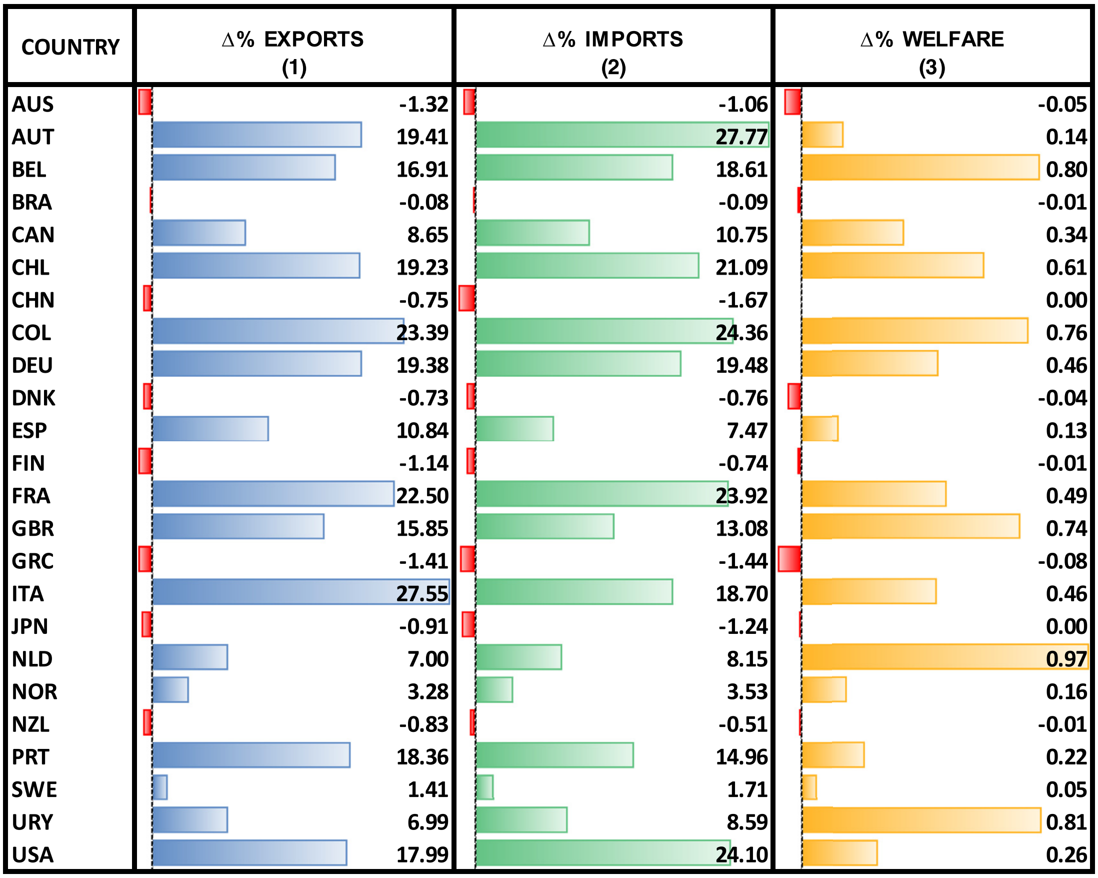
[23] In their handbook chapter, Head and Mayer (2014) report the step-by-step procedure to calculate partial and general equilibrium trade and welfare effects caused by a change in bilateral trade frictions. Yotov et al. (2016) and Campos and Timini (2021) also provide thorough discussions of the specifics of general equilibrium gravity models. For a variety of reasons analyzed in the literature (e.g. phase-in periods, economic adjustments, structural transformations, etc.), trade agreements do not achieve their "full potential" instantaneously. Bergstrand et al. (2015) suggest the full potential is achieved only after 8-12 years since the entry into force of the treaty.

[24] As granular estimates have wider confidence bands for the coefficients (and higher risks of omitted variable bias or endogeneity), I use the "average effect" for calibrating reductions in bilateral trade costs. Using granular estimates will further increase the heterogeneity of general equilibrium effects, already present when using the "average" reduction in bilateral trade costs. The existing heterogeneity is generated by the different exposure of each country to the network (both in terms of agreements signed and share of trade involved).

[25] In this context, the model provides a general equilibrium solution to an endowment economy, and correspond to a "general equilibrium" model (as opposed to "modular") in Head and Mayer (2014) classification, as "wages (and therefore GDPs) also adjust to trade costs" (p.166).

Table 3
Cobden-Chevalier trade network general equilibrium effects.



COUNTRY	Δ% EXPORTS (1)	Δ% IMPORTS (2)	Δ% WELFARE (3)
AUS	-1.32	-1.06	-0.05
AUT	19.41	27.77	0.14
BEL	16.91	18.61	0.80
BRA	-0.08	-0.09	-0.01
CAN	8.65	10.75	0.34
CHL	19.23	21.09	0.61
CHN	-0.75	-1.67	0.00
COL	23.39	24.36	0.76
DEU	19.38	19.48	0.46
DNK	-0.73	-0.76	-0.04
ESP	10.84	7.47	0.13
FIN	-1.14	-0.74	-0.01
FRA	22.50	23.92	0.49
GBR	15.85	13.08	0.74
GRC	-1.41	-1.44	-0.08
ITA	27.55	18.70	0.46
JPN	-0.91	-1.24	0.00
NLD	7.00	8.15	0.97
NOR	3.28	3.53	0.16
NZL	-0.83	-0.51	-0.01
PRT	18.36	14.96	0.22
SWE	1.41	1.71	0.05
URY	6.99	8.59	0.81
USA	17.99	24.10	0.26

Note: The table reports the general equilibrium effects of the Cobden-Chevalier trade network on exports, imports and welfare. In this model, welfare is interpretable as consumption of a representative agent, i.e. per-capita consumption (Arkolakis et al., 2012; Campos and Timini, 2021), as well as real GDP (Yotov et al., 2016). Countries are listed using ISO 3-digit codes.

General equilibrium results contain a substantial degree of heterogeneity. Trade gains of large European countries, having a large number of trade agreements, are well above average. For example, Great Britain increases exports and imports by 16 and 13%, respectively; France by 22 and 24%, Italy by 28 and 19%. Consequently, their welfare gains are also above average. Outside Europe, despite a reduced number of trade agreements, trade gains are also large for Chile, Colombia and the US, given that their treaties cover a large share of their international trade. In terms of welfare gains, small open economies are those that benefit the most, as international trade accounts for a large share of their total trade, i.e. the importance of domestic trade is low. The general equilibrium calculations also indicate that the Cobden-Chevalier network have some trade diversion effects that, despite exceeding trade creation effects in certain cases (mostly for non-members; the negative numbers for exports, imports, and welfare in Table 3),[26] are very limited in size.

5. Conclusions

This paper exploits econometric methods at the frontier of the empirical trade literature to reassess the trade effects of the “free trade epidemic” during the 1860s and 1870s. Additionally, it also provides the corresponding general equilibrium trade and welfare effects.

Using a PPML estimation strategy (Santos-Silva and Tenreyro, 2006) and crucially including domestic trade flows, I find that trade agreements have, on average, a large, positive, and significant effect on members’ bilateral trade. Treaty-level estimates reveal a considerable degree of heterogeneity across trade agreements. For example, the estimated effect on trade of the famous Anglo-

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[26] Changes in exports, imports, and welfare are biased downwards if bilateral trade flows between countries that are part of a trade agreement are missing, trade agreement data are missing, or domestic trade data cannot be estimated.

French treaty of 1860, the Cobden-Chevalier network milestone, doubles the average effect. Quantifying general equilibrium trade and welfare effects provides additional insights: the Cobden-Chevalier network affects total trade and the welfare of nations, by increasing total exports by 9.6%, total imports by 9.9%, and welfare by 0.3% on average. There is a substantial degree of heterogeneity here too. Countries with a considerable number of trade agreements (such as Great Britain, France, or Italy) display larger trade effects. Small open economies tend to report larger welfare gains. The general equilibrium calculations also indicate that the trade diversion effects of the Cobden-Chevalier network are very limited. In line with recent contributions studying the domestic impacts of trade policy and other globalization forces during the 19th century (Becuwe et al., 2021; Jaworski and Keay, 2022), these findings suggest that the Cobden-Chevalier network shapes both international and domestic trade.

However, my results do not shed light on the distributional or structural (e.g. composition of trade, evolution of the economic structure and complexity, etc.) consequences of trade integration during the 1860s and 1870s, issues that could be investigated with more granular data, and offer only limited insights on the causes of the heterogeneity of treaty-level estimates, for which further information on the content of trade agreements would be needed. These questions deserve further research and consideration.

Data Availability

Data and replication files are available at the following link: https://doi.org/10.3886/E182762V1

Appendices

A – Additional tables

B – Theoretical appendix

In a structural gravity model, bilateral trade flows (X_{ij}) from country i (the exporter) to country j (the importer) satisfy the following condition:

$$X_{ij} = \frac{Y_i}{\Omega_i}\frac{E_j}{\Pi_j}\tau_{ij} \geq 0 \tag{A.1}$$

The case $i \neq j$ identifies international trade flows, whereas the case $i = j$ identifies domestic trade flows. In equation (A.1), Y_i corresponds to production in country i – defined as $Y_i \overset{\text{def}}{=} \sum_j X_{ij}$ – and E_j corresponds to expenditure in country j – defined as $E_j \overset{\text{def}}{=} \sum_i X_{ij}$. The term τ_{ij} identifies bilateral trade costs, including (bilateral) trade agreements. Higher values of τ_{ij} correspond to lower bilateral trade costs. Other two conditions proper of structural gravity models are:

$$\Omega_i = \sum_j \frac{E_j}{\Pi_j}\tau_{ij}, \tag{A.2}$$

and

$$\Pi_j = \sum_i \frac{Y_i}{\Omega_i}\tau_{ij}. \tag{A.3}$$

The terms Ω_i and Π_j are called (outward and inward) "multilateral resistances", and are specific to country i and country j, respectively. These terms are interpreted as measures of country i's access to potential export markets, and country j's competition among trade flows from different (any) origin.

In this context, trade shares λ_{ij} are defined as the ratio between bilateral trade flows from country i to country j and expenditure in country j. This corresponds to:

$$\lambda_{ij} \overset{\text{def}}{=} \frac{X_{ij}}{E_j} \tag{A.4}$$

Therefore, by definition, trade shares have non-negative values and $\sum_i \lambda_{ij} = 1$. For $i = j$, λ_{ij} identifies the fraction of goods sold by country i in its domestic market (i.e. domestic trade share).

The entry into force of a new trade agreement changes tariffs between countries, that are an integral part of τ_{ij}, the bilateral trade cost term. Changes in τ_{ij} will affect bilateral trade flows X_{ij}, and all other terms contained in Equation A.1 above. Therefore, recurring to the common "hat algebra" notation (i.e. expressing the change in any variable z, as $\hat{z} = \frac{z'}{z}$), the change in bilateral trade flows generated by the change in bilateral trade costs ($\hat{\tau} = \frac{\tau'}{\tau}$) can be expressed as:

$$\hat{X}_{ij} = \frac{X'_{ij}}{X_{ij}} = \frac{Y'_i}{Y_i}\frac{\Omega_i}{\Omega'_i}\frac{E'_j}{E_j}\frac{\Pi_j}{\Pi'_j}\frac{\tau'_{ij}}{\tau_{ij}} = \frac{\hat{Y}_i}{\hat{\Omega}_i}\frac{\hat{E}_j}{\hat{\Pi}_j}\hat{\tau}_{ij}. \tag{A.5}$$

Given the endogenous responses of $\hat{Y}_i$ and $\hat{\Omega}_i$ (in the case of exporters), as well as $\hat{E}_j$ and $\hat{\Pi}_j$ (in the case of importers), to $\hat{\tau}_{ij}$, the solution for equilibrium trade flows is not straightforward.

Table A.1

Effects of the Cobden-Chevalier network – structural gravity estimates changing countries and trade agreements considered.

a. Accominotti and Flandreau (2008) countries and trade agreements

	Accominotti and Flandreau (2008) countries	Accominotti and Flandreau (2008) countries	Accominotti and Flandreau (2008) countries	Accominotti and Flandreau (2008) countries	Accominotti and Flandreau (2008) countries	Accominotti and Flandreau (2008) countries
TA	0.0130	0.276***	0.244***			
	(0.0566)	(0.0589)	(0.0434)			
TA_Lazer				−0.0641	0.382***	0.249***
				(0.0589)	(0.0187)	(0.0881)
Observations	5078	5408	5408	5078	5408	5408
Domestic trade	NO	YES	YES	NO	YES	YES
Border*year	NO	NO	YES	NO	NO	YES
δ_{it}	YES	YES	YES	YES	YES	YES
γ_{jt}	YES	YES	YES	YES	YES	YES
ω_{ij}	YES	YES	YES	YES	YES	YES
TAs considered	As in main text	As in main text	As in main text	As in A&F (2008)	As in A&F (2008)	As in A&F (2008)

b. Lampe (2009) countries

	Lampe (2009) "core" countries	Lampe (2009) "core" countries	Lampe (2009) "core" countries	Lampe (2009) "extended" countries	Lampe (2009) "extended" countries	Lampe (2009) "extended" countries
TA	−0.0274	0.304***	0.292***	−0.000997	0.288***	0.254***
	(0.0851)	(0.0787)	(0.0558)	(0.0625)	(0.0573)	(0.0425)
Observations	783	915	915	3063	3315	3315
Domestic trade	NO	YES	YES	NO	YES	YES
Border*year	NO	NO	YES	NO	NO	YES
δ_{it}	YES	YES	YES	YES	YES	YES
γ_{jt}	YES	YES	YES	YES	YES	YES
ω_{ij}	YES	YES	YES	YES	YES	YES
TAs considered	As in main text	As in main text	As in main text	As in main text	As in main text	As in main text

c. Lampe (2009) countries and trade agreements

	Lampe (2009) "core" countries	Lampe (2009) "core" countries	Lampe (2009) "core" countries	Lampe (2009) "extended" countries	Lampe (2009) "extended" countries	Lampe (2009) "extended" countries
TA_Lampe	−0.235***	0.439***	0.362**	−0.0925	0.372***	0.245**
	(0.0737)	(0.0310)	(0.154)	(0.0684)	(0.0265)	(0.104)
Observations	783	915	915	3063	3315	3315
Domestic trade	NO	YES	YES	NO	YES	YES
Border*year	NO	NO	YES	NO	NO	YES
δ_{it}	YES	YES	YES	YES	YES	YES
γ_{jt}	YES	YES	YES	YES	YES	YES
ω_{ij}	YES	YES	YES	YES	YES	YES
TAs considered	As in Lampe (2009)	As in Lampe (2009)	As in Lampe (2009)	As in Lampe (2009)	As in Lampe (2009)	As in Lampe (2009)

d. Lopez-Cordova and Meissner (2003) countries

	Lopez-Cordova and Meissner (2003) countries	Lopez-Cordova and Meissner (2003) countries	Lopez-Cordova and Meissner (2003) countries
TA	0.00623	0.274***	0.242***
	(0.0579)	(0.0582)	(0.0442)
Observations	6519	6877	6877
Domestic trade	NO	YES	YES
Border*year	NO	NO	YES
δ_{it}	YES	YES	YES
γ_{jt}	YES	YES	YES
ω_{ij}	YES	YES	YES
TAs considered	As in Lampe (2009)	As in Lampe (2009)	As in Lampe (2009)

Note: PPML regressions. Accominotti and Flandreau (2008), Lampe (2009) and Lopez-Cordova and Meissner (2003) countries are reported in Table A.2. Trade agreements considered are reported in Accominotti and Flandreau (2008) and in Lampe (2009) working paper version. Trade agreements considered in this paper are from Trade Agreements Database (Pahre, 2007). For more details, see main text. Fixed effects, control variables and constants not reported for the sake of simplicity. Standard errors (in parentheses) are clustered at the exporter, importer and time level.

* $p < 0.1$.

** $p < 0.05$,.

*** $p < 0.01$,.

Table A.2
Countries considered.

	Accominotti and Flandreau (2008)	Lampe (2009) "core"	Lampe (2009) "extended"	Lopez-Cordova and Meissner (2003)	Countries with domestic trade observations (at least 1 observation)
Argentina	x			x	
Australia	x			x	x
Austria-Hungary	x	x	x	x	x
Belgium	x	x	x	x	x
Brazil	x			x	x
Canada	x			x	x
Colombia					x
Chile				x	x
China				x	x
Denmark	x		x	x	x
Egypt				x	
France	x	x	x	x	x
Finland				x	x
Germany/Zollverein	x	x	x	x	x
Greece	x				x
India				x	x
Indonesia				x	
Italy	x		x	x	x
Japan	x			x	x
Mexico	x			x	
The Netherlands	x	x	x	x	x
New Zealand	x			x	x
Norway	x		x	x	x
The Philippines				x	
Portugal	x		x	x	x
Russia	x		x	x	
Spain	x		x	x	x
Sweden	x		x	x	x
Switzerland	x		x	x	
Uruguay					x
United Kingdom	x	x	x	x	x
United States	x	x	x	x	x

Table A.3
Summary statistics.

Variable		# of observations	Mean	Std. Dev.	Min	Max
Trade (X_{ijt})		5790	20.5	126	0	2700
	international trade	5384	1.9	5.01	0	74
	domestic trade	406	267	403	3.51	2700
TA		5790	0.176	0.381	0	1

Note: Summary statistics for trade data are reported in millions.

Recalling the definition of trade shares in Eq. (A.4), it is possible to express changes in trade shares as:

$$\hat{\lambda}_{ij} = \frac{\hat{X}_{ij}}{\hat{E}_j} = \frac{\frac{\hat{Y}_i}{\hat{\Omega}_i}\frac{\hat{E}_j}{\hat{\Pi}_j}\hat{\tau}_{ij}}{\hat{E}_j} = \frac{\hat{Y}_i}{\hat{\Omega}_i}\frac{\hat{\tau}_{ij}}{\hat{\Pi}_j}. \tag{A.6}$$

Following the Dekle et al. (2007) derivation, within a structural gravity framework, the change in trade shares $\hat{\lambda}_{ij}$ can be reformulated as:

$$\hat{\lambda}_{ij} = \frac{\frac{\hat{Y}_i}{\hat{\Omega}_i}\hat{\tau}_{ij}}{\sum_i \lambda_{ij}\frac{\hat{Y}_i}{\hat{\Omega}_i}\hat{\tau}_{ij}}\ . \tag{A.7}$$

Given that structural models share the property $\frac{Y_i}{\Omega_i} = A_i w_i^{\in}$ (where $A_i>0$ corresponds to a technological or population constant, and $\in < 0$ corresponds to the trade elasticity), then it follows that $\frac{\hat{Y}_i}{\hat{\Omega}_i} = (\hat{w}_i)^{\in}$. Therefore, changes in shares can be expressed as a function of changes in wages and bilateral trade costs only:

$$\hat{\lambda}_{ij} = \frac{(\hat{w}_i)^{\in}\hat{\tau}_{ij}}{\sum_i \lambda_{ij}(\hat{w}_i)^{\in}\hat{\tau}_{ij}}. \tag{A.8}$$

Assuming an inelastic supply of labor as the only factor of production – i.e. if $\mathrm{Y}_i = w_i L_i$ and L_i is assumed to be constant over time – then $\hat{Y}_i = \hat{w}_i$. Further assuming a market clearing condition implies:

$$\hat{w}_i = \hat{Y}_i = \frac{1}{\mathrm{Y}_i}\sum_j \lambda'_{ij} E'_j = \frac{1}{\mathrm{Y}_i}\sum_j \lambda_{ij}\hat{\lambda}_{ij} E'_j = \frac{1}{\mathrm{Y}_i}\sum_j \frac{\lambda_{ij}\,(\hat{w}_i)^{\in}\hat{\tau}_{ij}}{\sum_i \lambda_{ij}(\hat{w}_i)^{\in}\hat{\tau}_{ij}} E'_j \tag{A.9}$$

However, as trade is usually not balanced in the data (i.e., trade deficits and surpluses exist), expenditure (E_j) is not equal to production (Y_j), the difference between the two being the trade deficit (D_j; if D_j>0 country j runs a trade deficit; if D_j<0 country j runs a trade surplus). Therefore, $E_j = Y_j + D_j$. The evolution of trade deficits may transform in a computational burden. To avoid so, two options are possible (and have been treated as alternative assumptions in the literature). The first option is to assume that deficits evolve in proportion to production. This means $\hat{D}_j = \hat{Y}_j$. Therefore, $E'_j = E_j\hat{Y}_j = E_j\hat{w}_j$. This option is called "multiplicative deficit" in the literature. The second option is to assume that deficits remains constant over time. This means $\hat{D}_j = 1$. Therefore, $E'_j = Y_j\hat{Y}_j + D_j = Y_j\hat{w}_j + D_j$. This option is called "additive deficit". By choosing the latter,[27] it is possible to obtain $\hat{w}_i$ as follows:

$$\hat{w}_i = \frac{1}{\mathrm{Y}_i}\sum_j \frac{\lambda_{ij}\,(\hat{w}_i)^{\in}\hat{\tau}_{ij}}{\sum_i \lambda_{ij}(\hat{w}_i)^{\in}\hat{\tau}_{ij}} E_j\hat{w}_j \tag{A.10}$$

As the initial trade shares (λ_{ij}), output (Y_i) and expenditure (E_j) are known, and a set of changes in bilateral trade costs is given ($\hat{\tau}_{ij}$ or, to apply the same wording of Section 4.2, the "shock" inserted in the model), Equation (A.10) can be solved for wages $\hat{w}_i$. Therefore:

$$\hat{Y}_i = \hat{w}_i \tag{A.11}$$

$$\hat{E}_i = \hat{w}_i \tag{A.12}$$

$$\hat{\Omega}_i = (\hat{w}_i)^{1-\in} \tag{A.13}$$

$$\hat{\Pi}_j = \sum_i \lambda_{ij}(\hat{w}_i)^{\in}\hat{\tau}_{ij} \tag{A.14}$$

$$\hat{\lambda}_{ij} = \frac{(\hat{w}_i)^{\in}}{\hat{\Pi}_j}\hat{\tau}_{ij} \tag{A.15}$$

$$\hat{X}_{ij} = \frac{\hat{Y}_i}{\hat{\Omega}_i}\frac{\hat{E}_j}{\hat{\Pi}_j}\hat{\tau}_{ij} = \hat{\lambda}_{ij}\hat{E}_j = \frac{(\hat{w}_i)^{\in}\hat{w}_j}{\hat{\Pi}_j}\hat{\tau}_{ij} \tag{A.16}$$

A common assumption in structural is to adopt utility functions implying that, for a country i, changes in welfare (also called "gains from trade") correspond to changes in expenditure relative to changes in a price index P_i, where $\hat{P}_i = \hat{\Pi}_i^{1/\in}$. Therefore, the gains from trade following the Arkolakis et al. (2012) formula can be obtained:

$$\widehat{G}_i = \frac{\hat{E}_i}{\hat{P}_i} = \frac{\hat{E}_i}{\hat{\Pi}_i^{1/\in}} = \frac{\hat{w}_i}{\hat{\Pi}_i^{1/\in}} = \left(\frac{(\hat{w}_i)^{\in}}{\hat{\Pi}_i}\right)^{1/\in} = \hat{\lambda}_{ii}^{1/\in} \tag{A.17}$$

The third equality is based on the multiplicative assumption and the last equality is satisfied given $\hat{\tau}_{ii} = 1$.

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[27] Baier et al. (2019) derives the solution adopting the "additive deficit" solution.

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