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The effects of market integration during the first globalization: a multi-market approach

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Abstract

This paper measures the effects of international market integration on world trade and welfare during the first globalization (1815-1913). The analysis is carried out with a multi-market partial equilibrium model, which takes into account the interactions between route-specific changes in trade costs. We consider world trade in the two principal traded commodities, cotton and wheat. The collapse in trade costs accounted for 60% of the increase in trade in cotton and 40% of the increase in trade of wheat. Both producers and consumers gained, but welfare gains were inversely related to the size of the country and positively to the level of openness to trade. We infer that welfare gains from international market integration were equivalent to substantial shares of economic growth in the 'long 19th century'.

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1) Introduction

Economists and economic historians firmly believe that globalization handsomely contributed to economic growth during the 'long 19th century', from Waterloo to World War One. The decline in costs caused trade to grow substantially faster than world GDP (Federico and Tena-Jungito 2017a), and trade fostered growth. Many scholars have tried to measure this contribution, but results so far have not been conclusive. Federico and Tena-Jungito (2017a) compute (a lower bound of) static gains from trade with the sufficient statistic by Arkolakis et al. (2012), but the efforts to measure the dynamic effects of trade-related variables (openness or tariffs) have not reached a consensus (O'Rourke 2000, Clemens and Williamson 2004, Jacks 2006b, Schularick and Solomou 2011, Pascali 2017). As common in the growth regression approach, the results depend on the specification of the regression, with too many potentially relevant variables explaining one single outcome. The literature on the causes of the growth of trade (e.g. Estevadeordal et al. 2003, Jacks and Pendakur 2010, Jacks et al. 2011, Fouquin and Hugot 2016, Pascali 2017) is plagued by imprecise measurements of trade costs. Transportation costs are proxied with bird fly distance, possibly interacted with time, and trade barriers with a set of potential determinants (e.g. border, language and so on). Only few works include among the explicative variables total nominal duties, rather than pair-specific ones. Unfortunately, a precise estimate of historical trade costs needs a lot of data and thus it is in practice unfeasible even for total bilateral trade, let alone for the whole network of world trade.

In theory, the literature on market integration could offer precious additional evidence because its focus on specific products makes it much easier to estimate trade costs. In fact, if the market is efficient, arbitrage keeps price gaps between two trading markets equal or very close to trade costs (Federico 2012). Yet, as our review in Section Two shows, this opportunity has been largely missed. This paper is a first step to address this gap. We estimate the effect of integration on trade and welfare with a multi-market partial equilibrium approach. This model has been developed by agricultural economists and is used by World Bank economists to study the effects of trade liberalization and other poverty-alleviation policies (Minot and Goletti 1998, Arulpragasam and Conway 2003, Robinson et al. 2015), but have never been previously used in economic history. Our multi-market partial equilibrium model estimates the effect of changes in trade costs between all producers and consumers of a single commodity on trade and welfare by comparing actual with counterfactual trade with different (higher) costs and by computing the compensating variation in welfare - i.e. the income that agents are willing to forfeit not to be subject to the increase in trade costs. Thus, multi-market partial equilibrium analysis can be seen an intermediate solution between bilateral partial equilibrium estimates, which are simple to implement but neglect interactions with third markets (Anderson and van Wincoop 2003), and world-level general equilibrium models of international trade, which are extremely data-intensive (de Melo 1988, Alexander and Keay 2018).

This paper deals with wheat and cotton, the two most important traded commodities in the long 19th century (Yates 1959: tab 17). Our empirical contribution is twofold. First and foremost, we estimate the effect of the decline in trade costs on trade and on welfare of the main producers and consumers. We pick 1913 as base-year for our computation, on grounds of data availability and we estimate separately the effects of changes since 1815, 1830 or 1870. These benchmarks capture the market conditions in three different periods – the start of the 'long 19th century', when trade costs were still very high for the consequences of the Napoleonic Wars and of the restrictions to trade with Asia, the beginning of the 'early globalization' (O'Rourke and Williamson 2002, Chilosi and Federico 2015, Federico and Tena-Junguito 2017a) and the start of the 'first globalization' according to the conventional wisdom (Jacks et al. 2010, Klasing and Milionis 2015). The model, as any other in this literature, needs a set of supply and demand elasticities. We get some of them from other historical or contemporary works, but, as our second empirical contribution, we estimate the parameters of British demand for (different qualities of) wheat and cotton, with an AIDS model (Deaton and Mullbauer 1980).

After a short survey of the literature (Section Two), we present the main trends in trade and price convergence in Section Three. We describe our model in Section Four. Section Five presents our estimate of British demand elasticities and the other elasticities used in the model (with more information on the sources in the Appendices A and B). The next two Sections discuss the effects of integration on bilateral and total trade (Section Six) and on welfare (Section Seven). Section Eight concludes.

2) On the effects of market integration: a survey of the literature

The historical literature on market integration is extensive, but the overwhelming majority of articles deal with the measurement of integration and the rest looks at its causes (Federico 2012 and 2018). The effects of integration have been almost entirely neglected. Two papers deal with the beneficial effect of the lay-out of the of telegraph cables between England and the United States in July 1866, arguably the biggest positive shock in market efficiency during the first globalization. The telegraph slashed the time of transmission of information from about ten days to few minutes and the consequent reduction in uncertainty increased American exports. Ejrnæs and Persson (2010) and Steinwender (2018) estimate the corresponding benefits with different specifications and data (respectively monthly prices for wheat and daily prices for cotton), but the results are fairly similar. The telegraph increased exports of cotton by 8% and export of wheat by 2% relative to their pre-telegraph level.

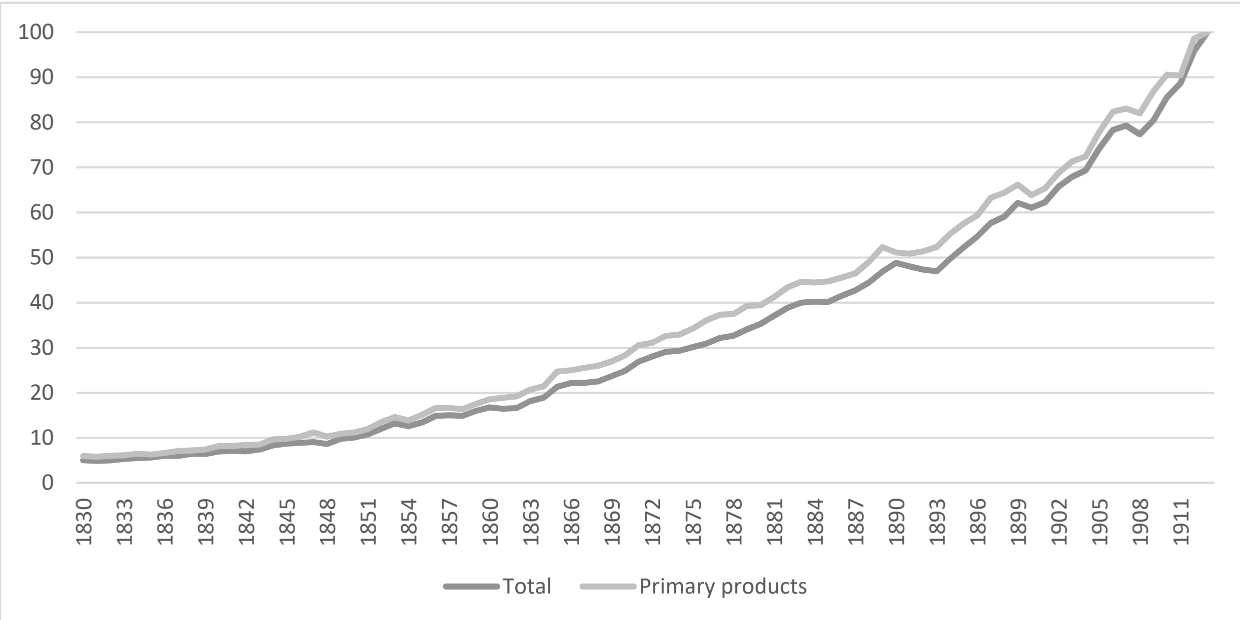
Two papers deal with the long run effects of changes in trade costs with a variant of the standard partial equilibrium analysis of the benefits from trade liberalization (Hufbauer et al. 2002). While the standard approach compares welfare with and without barriers to trade, these papers take into account that trade costs decline rather than disappear altogether. The gains from lower (but still positive) costs are captured by an additional term, which is proportional to the (absolute) difference between shares of the product on consumption and output of the country. Thus, the benefits from integration increase with the relevance of the product in the country's economy and the share of exports on its total output. Federico and Sharp (2013) use this simple framework to estimate the losses from the regulation of American rail fares, which prevented a full transfer of productivity gains to consumers and, above all, the adjustment to collapsing prices for agricultural products during the Great Depression. Chilosi and Federico (2016) deal with the integration of the market between Europe and Asian (British India and Dutch East Indies) and American suppliers for a large number of commodities. They find that consumers gained more than producers. For instance, in the UK, where the commodities account for 20% of the imports, the long-run gains were equivalent to 2% of its GDP.

Last but not least, Donaldson has estimated the (static) general equilibrium effects of domestic market integration with two different strategies, both broadly inspired by new trade theory. Costinot and Donaldson (2016) estimate separately the contributions of technical progress (measured by the differences between maximum potential and actual yields) and market integration (measured by gaps between local and New York prices) to the growth of American agricultural output since 1887. They compare actual output of all counties in a number of benchmark years with a counterfactual one, computed with linear programming by multiplying the actual prices of the benchmark year by the yields of the optimal output in the following benchmark. In another paper, Donaldson (2018) uses a three step regression-based approach to estimate the effects of railways on agricultural output of Indian districts, quite a good proxy for GDP in the case at hand. First, he estimates the costs of transportation with different means by comparing price of a specific type of salt (extracted in a single location) all over India. Then, he shows that transport costs determined trade flows and he estimates the contributions of railway connections to output and trade. Unfortunately, these sophisticated general-equilibrium methods need a lot of detailed data which are simply not available for international analysis.

3) Trade and price convergence

The long 19th century featured a fast growth of world trade and an almost parallel growth of trade in primary products: from 1830 to 1913, the trade in primary products grew by 17.2 times (Figure 1).

Figure 1: The growth of world trade, 1815-1913 (1913=100)



Source: Federico and Tena-Junguito (2019).

There are no comparable series of trade in cotton and wheat, but their trends can be gleaned from the available evidence on their shares on total trade.[2] The share of cotton fluctuated widely around 5% from the 1830 onwards, with a hump around the American Civil war – and thus in the

[2] The shares for cotton (5.0% in 1830, 6.5% in 1850, 7.3% in 1870, 5.0% in 1890, 3.8% in 1900 and 4.7% in 1913) are computed by dividing the value of cotton trade from Federico and Tena-Jungito 2017b by the world total exports in current dollars from the Federico and Tena-Jungito World Trade website. The total value of trade in wheat is computed by multiplying the average quantities in 1854-58 and 1884-1884 from Stern (1960: tab 1) and in 1909-13 from Bacon and Schloemer (1940: 62-63) by the 'world' prices from Federico and Tena-Jungito World Trade website.

long run cotton trade increased roughly as much as total trade. In contrast, the share of wheat has been declining steadily, from 3.7% in the mid-1850s to 2.9% in the mid-1880s to 2.3% on the eve of World War One, corresponding to an increase of 'only' 4.3 times.

In principle, the multi-market approach should include separately all producing and consuming countries, but as the number of parameters increases, their estimates become less precise. Thus, for cotton we consider the three main producers, United States, India and Egypt, and the two main importers, Europe (here considered as a single area, as costs were similar) and Japan, which opened up to world trade in 1853 and started to import massively cotton in the 1890s (Panza 2013; Otsuka et al. 1988: 25-26). For wheat we distinguish the United Kingdom from the rest of Western Europe, for their different trade policies (see commentary to Table 2, below), and we consider two main producing areas, North America (United States and Canada) and Eastern Europe (mostly Russia).

Table 1: The growth of cotton and wheat trade

a) wheat (000 tons)

	1815		1830		1870		1913	
Exporters	Quantity	Share	Quantity	Share	Quantity	Share	Quantity	Share
North America	1.5	0.8	2.5	0.7	872.1	29.9	3656.8	33.3
Eastern Europe	198.2	99.2	364.7	99.3	2046.4	70.1	7328.5	66.7
Total	199.7		367.2		2918.5		10985.3	
Imports								
UK	11.1	5.5	22.8	6.2	1403.2	48.1	2719.1	24.8
Western Europe	188.7	94.5	344.4	93.8	1515.3	51.9	8266.2	75.2
Total	199.8		367.2		2918.5		10985.3	41.6

Table 1-continued
b) cotton (000 tons)

	1816		1830		1870		1913	
Exporters	Quantity	Share	Quantity	Share	Quantity	Share	Quantity	Share
US	37	71.8	127.0	68.4	544.1	63.2	2177.1	75.4
India	14.6	28.2	49.8	26.8	248.9	28.9	429	14.9
Egypt	0	0	8.9	4.8	67.6	7.9	281.2	9.7
Total	51.6		185.7		860.6		2887.3	
Imports								
Europe	51.6	100	1879.8	100.0	860.6	100	2586.5	89.6
Japan	0	0	0	0	0	0	300.8	10.4
Total	51.6		1879.8		860.6		2887.3	

Sources: See Appendix A.
Notes: North America is Canada and US, Eastern Europe is Austria-Hungary, Bulgaria, Romania, Russia and Serbia, Western Europe is Belgium, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Portugal, Spain and Sweden, and Europe is Austria-Hungary, Belgium, France, Germany, Italy, Netherlands, Russia, Spain, Switzerland and UK.

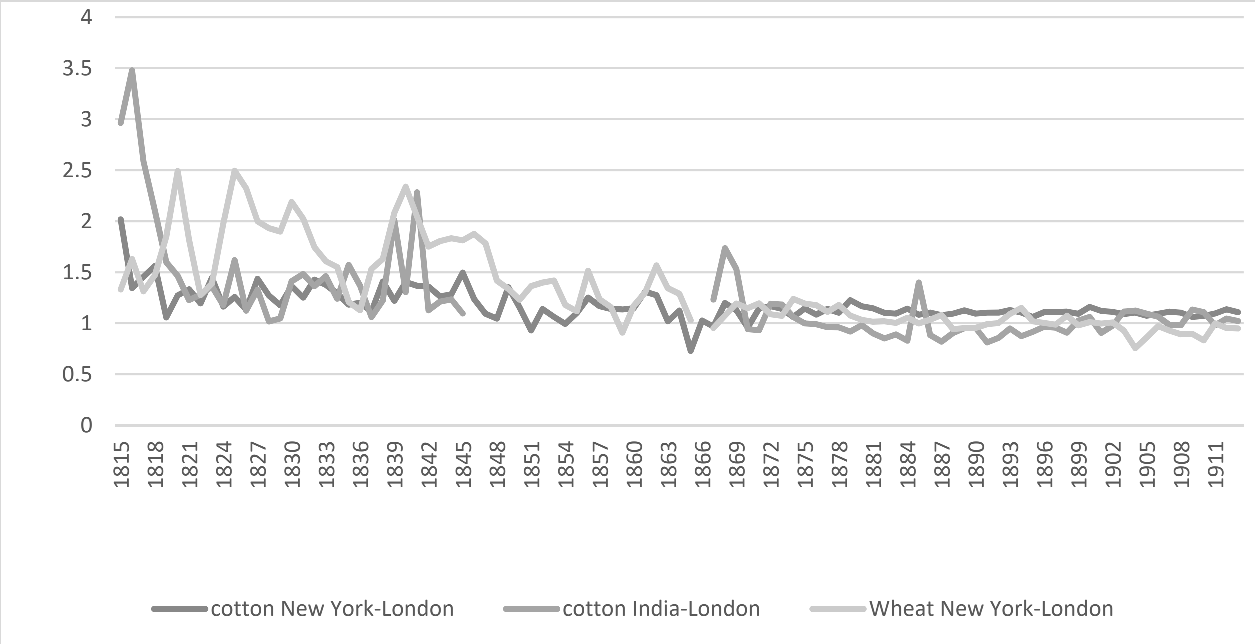
Our country coverage is almost complete on the demand side for both products and on the supply side for cotton. The three producers of cotton accounted for 80% of the value of trade in 1820 (with 11% to Brazil), 91% in 1870 and 94% in 1913 (Federico and Tena-Junguito 2017b).[3] Europe and Japan accounted for 97% of world imports of cotton in 1909-13. The United Kingdom and Western Europe accounted respectively for 34.1% and 47.9% of world import of wheat on the eve of World War One (Bacon and Schloemer 1940: 62-63, 417). The country coverage is less complete for the wheat supply. Other producers accounted for 46.9% of exports in 1854-1858, for 19.1% in 1884-1888 (Stern 1960: tab 1A) and for 34.7% in 1909-13 (Bacon and Schloemer 1940: 62-63).[4]

By definition, trade can grow either because of shifts in demand and/or supply or for declines in trade costs. If the market is reasonably efficient, trade costs can be estimated with price gaps between producing and consuming countries. Indeed, the 'long 19th century' was characterized by

[3] Egypt did not export any cotton before the discovery of the long-staple Jumel (or Mako) variety in 1820.
[4] Stern (1960) does not specify which countries are included in his 'other countries' aggregate in the first period, but one would presume Prussia accounted for a large share of it. The major exporters outside North America and Eastern Europe were India (10.7% in 1884-1888 and 7.1% in 1909-13), Argentina (1.4% and 13.2%) and Australia (2.4% and 6.9%).

a wide-ranging process of convergence in prices, both within Europe and between Europe and overseas producers. The process of price convergence involved also wheat and cotton (Figure 2).

Figure 2: Price ratios producer/consumer market



Source: Chilosi and Federico (2015).

The size of price gaps varied a lot between routes and commodities, depending on the specific barriers to trade. De Zwart (2016) shows how gaps between East Indies and Amsterdam differed across products according to the power of the VOC (the Dutch East India Company) on the source of supply. The gaps in wheat prices between the United Kingdom and East coast of North America were low when the latter was a British colony, widened in the 1780s, exploded during the Napoleonic Wars and remained high after 1815 because of the adoption of almost prohibitive duties in the United Kingdom (Sharp and Weisdorf 2013: Fig 1). The price gap between India and the United Kingdom were kept artificially high by the monopoly of the East India Company. Chilosi and Federico (2015) estimate, with a panel regression for a representative sample of commodities, that the abolition of monopoly of the East India Company in 1813 accounted for two thirds of convergence of Indian prices (and telegraph for a quarter) in the 'long 19th century'. In contrast, the convergence in wheat and cotton prices between the United States and Britain was determined mostly by the decline in freights, with a sizeable contribution of the liberalization of imports in 1846.

In principle, one could use price gaps as a measure of trade costs, but, as shown by Figure 2, the ratios are rather volatile in the short run. Thus, whenever possible, we use the values fitted by panel regressions that estimate route- and product-specific price gaps with freights, duties and other determinants of trade costs (see columns 7-8 in Table 6 at pages 14-15 of Chilosi and Federico 2015 for a complete list of the explicative variables). We first combine the coefficients from the regression with the values of explicative variables to predict the price ratios between the US and the United Kingdom (for cotton and wheat) and between India and Europe (for cotton) in each benchmark year.[5] Then we convert the ratios in current pounds per ton.[6] Finally, we deflate them with the British GDP deflator, following Hummels (2007), to obtain specific trade costs in constant 1913 pounds, which we need for the multi-market model (Section Four).

We estimate the costs on other routes with two different procedures. As a second best, we proxy trade costs with price ratios, after smoothing them with a Hodrick-Prescott filter. We use this method for cotton exports from Egypt and cotton imports into Japan, from both India and the United States, in 1913. As before, we convert the fitted price gaps in current pounds per ton and deflate them with the British GDP deflator. Our price data for Egypt start in 1822, and thus we extrapolate the series to 1816 with the US-Europe costs. We assume trade costs for export to Japan

[5] The results for British import of wheat in 1815 are vulnerable to downward bias because the Corn Laws were approved in April prohibited imports unless a price threshold was reached. Thus, for this year only, we rely on an alternative estimate of trade costs: the sum of freights, duty and other transaction costs, assumed to be in the same proportion as in 1830.

[6] To this aim, we average the implicit specific cost implied by the expected (i.e. HP-filtered) import and export prices. If, for instance, the fitted gap is 1.15, the specific cost implied by the export price is 0.15 times the export price; that implied by the import price is 0.13 (=0.15/1.15) times the import price. The nominal specific cost is the average between the two. Here and subsequently we use 6.25 as smoothing parameter of the H-P filters, as usually done with yearly data.

to have been prohibitively high in 1816 and also in 1870, as the shipping market was highly regulated before 1875 (Kemble 1940: 345, Yasuba 1978).[7]

Lastly, we use an indirect approach to estimate costs of exporting wheat from Eastern Europe to the United Kingdom and Western Europe because the available price series refer to different qualities and thus their difference do not measure trade costs precisely enough for our purposes. We use the US-UK trade costs as a baseline and we add up differences in transport costs or duties, with different assumptions for exports to Great Britain and to Western Europe. For imports into Great Britain, we assume that duties and other transaction costs were the same from North America and from Eastern Europe and any difference in trade costs reflected transportation costs. Consequently, our estimate is the sum of the trade costs from North America to the United Kingdom and of the difference in freight rates between the two routes, using a suitably extrapolated series of freights from Odessa to London (Harley 1988 and 1989). In the case of export to Western Europe, we assume that transport and other transactions costs were the same as to the United Kingdom and we obtain total trade costs as the costs into the UK plus the difference in duties. We estimate the British unit duty in 1815 and 1830 as a three years moving average of revenues from tariff divided by the total weight of the wheat imported, while we compute duties for countries in Western Europe as the weighted average of specific duties in the benchmark years (O'Rourke 1997, Federico 2012), using as weights the shares of imports from the US (North America) and Russia (Eastern Europe) in 1913.

For the sake of comparability in time and space, in Table 2 we report our estimates as the ratio of trade costs to the price at the origin.

[7] One consequence of the exceptionally high freights was that in 1870 Japan imported only very small quantities of cotton (14 tons, corresponding to 0.004% of the imports in 1913) from China and none from India and the US (Japan Statistical Bureau 1988, Vol. 3: 48-49; Otsuka et al. 1998: Table 3.2).

Table 2: Trade costs as percentage of price at origin

a) Wheat

Origin	Destination	1815	1830	1870	1913
North America	UK	93.9	90.7	20.7	0.58
North America	Western Europe	65.3	59.7	21.7	38.4
Eastern Europe	UK	152.2	85.1	33.3	4.1
Eastern Europe	Western Europe	111.8	58.3	34.7	46.5

b) Cotton

Origin	Destination				
US	Europe	58.3*	22.9	6.1	8.7
US	Japan				25.2
India	Europe	230.9*	23.0	17.9	0.0
India	Japan				9.9
Egypt	Europe	199.6*	35.8	11.1	5.9

Sources: see the text and Appendix A.
Notes: * is 1816.

Our estimates confirm the conventional wisdom (Section Two). All costs were proportionally very high at the end of the Napoleonic Wars, but henceforth trends differed across products and routes. Costs for exporting cotton collapsed quickly. They were fairly low already in 1830, as outside Japan barriers to trade were limited, with the partial exception of Egypt. The export of Egyptian cotton was stifled by the state monopoly on cotton, which channeled cotton towards domestic industries (Panza and Williamson 2015). Great Britain imposed a modest fiscal duty on imports (about 5%). The duty was reduced in 1838 and abolished in 1846, while the Egyptian monopoly had been abolished three years earlier. Since 1846, cotton imports were free all over Europe and thus any subsequent decline in trade costs was caused by improvement in transport technology.

Duties accounted for most of the trade costs for wheat. The 1815 British Corn Laws were more restrictive than any trade barrier on the continent (Barnes 1930, Sharp 2010, Federico 2012). Prussia was a net exporter of wheat and France and other Continental European countries waited the early 1820s before imposing very high duties. Protection remained fairly high both in Britain and on the continent until the 1840s. The repeal of the Corn Laws in 1846 is the most famous of a spate of measures which liberalized wheat trade all over Europe, leaving only minimal fiscal duties in few countries, including the United Kingdom. This last duty was abolished in 1869. Imports into the United Kingdom remained free until War World One and thus the United Kingdom benefitted from the reduction in transportation costs. The major continental European countries reacted to the 'grain invasion' of the 1880s (O'Rourke 1997) by increasing duties, which more than compensated the technical progress in transportation. Trade costs into Western Europe increased from 1870 to 1913. Duties were equal for all provenances, and thus the somewhat higher costs of importing from Eastern Europe than from North America depended on transportation costs.

4) The model

Our model deals with the effects of an exogenous change in trade costs (*t*) on demand and supply of a given commodity in *N* exporting and *M* importing markets. Following the standard Armington (1969) assumption, the quality of the good produced in each place differs. Exporters only consume the local variety. Importers can consume the local variety and those produced by any of the exporters. Under the *ceteris paribus* assumption of constant factor endowment and technology in the rest of the economy, we can model demand and supply of the good produced in place *i* consumed in place *j* as functions of prices and real income per capita only. Following Steinwender (2018) we assume linear functions:[8]

$D_{ij}=a_{ij}+\Sigma_k \beta_{ijk} P_{kj}+\delta_{ij} Y_j$ 1a)

$S_i=b_i+\gamma_i P_{ii}$ 1b)

Where $j=1$ to $N+M$, for the exporters $i=j$ and $k=1$, for the importers $i, k=1$ to $N+1$, a_{ij} and b_i are stochastic intercepts, $\beta_{ijk}<0$ if $j=k$ or for complements and >0 for substitutes, $\delta_{ij}>0$ and $\gamma_i \geq 0$ for all *i* and *j*. We assume 'specific' rather than 'iceberg' trade costs because we deem the assumption

[8] We cannot reproduce her approach to market efficiency because it needs high-frequency data which are not available.

of strict proportionality of trade costs to prices highly unrealistic. It surely does not hold true for specific duties as the British Corn Laws nor, to some extent, for freights which depended on the volume per unit of weight (Thomas 1930: 230). Each pair of exporting and importing markets are related by arbitrage by representative traders, who choose the profit-maximizing level of exports E_{ij} between markets *i* and *j*:

$\pi_{ij} =(P_{ij}-P_{ii}-t_{ij})E_{ij}$ 2)

Neither $(P_{ij}-P_{ii})<t_{ij}$ nor $(P_{ij}-P_{ii})>t_{ij}$ can be equilibrium solutions, as traders would lose money in the former and would want to export an infinite amount in the latter. Hence, the only equilibrium with positive trade is:

$(P_{ij}-P_{ii})=t_{ij}$. 3)

In this case, traders are indifferent with respect to the quantity exported, which is thus determined by the markets' clearing conditions (Steinwender 2018). The market clearing conditions are:

$\Sigma_j D_{ij}=S_i$ 4a)

For all *i* and *j*. Moreover, when $i \neq j$:

$E_{ij}=D_{ij}$ 4b)

It is straightforward to compute the parameters of the demand and supply functions with prices and quantities in the baseline year and elasticity estimates, by substituting in the formulae of the elasticities (eg. $\beta_{ijj}=\eta_{ijj}D_{ij}/P_{ij}$ where η_{ijj} is the own-price elasticity of the demand of the good produced in *i* and consumed in *j*). We make the standard assumption that the change in trade costs implies a change in income per capita equal to the change in the producer's surplus and that this surplus is equally redistributed to domestic consumers:

$dY_i=(dP_iS_i+0.5*dP_idS_i)/L_i$ 4c)

Where *d* is the difference operator and L_i is the population of market *i*. As usual in multi-market partial equilibrium analysis (cf. e.g. Minot and Goletti 1998, Robinson et al. 2015), new equilibrium prices and quantities produced, consumed and traded with changed trade costs are computed by solving the system of equations 1a), 1b), 3), 4a) and 4c) with the Mixed Complementarity Programme solver, implemented with the software GAMS.

Following a standard approach in multi-market welfare analysis (Boadway and Bruce 1984: ch. 7), we estimate the welfare effect of a change in trade costs with the compensating variation of the resulting change in prices and quantities.[9] In other words, as in the standard partial equilibrium analysis of protectionism (e.g. Feenstra 1995), we measure the value of transfers which are needed to sustain the 1913 levels of welfare for each consumer with pre- globalization trade costs, given 1913 endowments and technology. However, the change in the set-up from bilateral to multi-lateral trade implies that the computation becomes more complex than with the classical Harberger's triangles. Taking the second order approximation of the change in the expenditure function (i.e. neglecting all terms higher than the first order in the Taylor series expansion of the expenditure function) and using the Slutsky equation for consumer demand to determine the substitution effects, the per capita compensating variation in market *j* is:

$$CV_j=-\Sigma_i(D_{ij}/L_i)dP_{ij}-0.5\Sigma_i\Sigma_k(\beta_{ijk}+D_{kj}\delta_{ij}/L_j)dP_{ij}dP_{kj}+dY_j \qquad 5)$$

Where the notation is as before. Summing up, we can estimate the effect on trade and welfare of changes in trade costs between each year and the baseline one, given prices, incomes per capita, populations, demands and supplies in the baseline year and the relevant elasticity parameters (own-price elasticities of supply and own-price, cross-price and income elasticities of demand). The next Section deals with these parameters.

[9] In addition, following Guerra and Sancho (2018), we use as numeraire the world price of the commodity (wheat or cotton), estimated as the average of the local sample prices weighted by share of consumption.

5) The elasticities

We estimate the parameters of British demand with a linear approximation of the AIDS (LA/AIDS) model developed by Deaton and Muellbauer (1980). We prefer the linear approximation to the original version because it outperforms the true AIDS model, especially when the prices are highly correlated, as is the case here (Alston et al. 1994). In particular, we estimate the following two equations, for wheat:

$w_{it}=\alpha_i+\Sigma_j\gamma_{ij}lnp_{jt}+\beta_i\, ln(x_t/P_t)+ \delta_{1i}\, t + u_{it}$ (6a)

and cotton:

$w_{it}=\alpha_i+\Sigma_j\gamma_{ij}lnp_{jt}+\beta_i\, ln(x_t/P_t)+D_i\, CW_t + \delta_{1i}\, t+ \delta_{2i}\, t^2 + u_{it}$ (6b)

Where w_{it} is the market share of the good of quality i at time t, p_{jt} is the price of the good of quality j at time t, with $i, j=1$ to 3 for both wheat and cotton, x_t is the total expenditure on the good (wheat or cotton), and $ln(P_t)$ is the weighted average of the natural logarithm of the prices of the various qualities of the good, where the weights are determined by the quantities consumed, as usual in the LA/AIDS model. The time trends capture the changes in market shares determined by the evolution of comparative advantage and technology. For cotton, we add a quadratic term, since trends are clearly non-linear and a dummy (CW_t) to control for the shock of the American Civil War (1861-1865), which temporarily dried up supplies from the US, by far the largest producer (see Figure A4 in Appendix B). With the coefficients from equations 6a and 6b, it is straightforward to compute the demand elasticities (Green and Alston 1990) (for the regression outputs see Table A2 in Appendix B).[10]

We estimate equation 6a for wheat, following the standard approach, with a seemingly unrelated regressions specification. We prefer to estimate equation 6b for cotton with a fractional

[10] Since for cotton we rely on the fractional multi-logit model, we use the average marginal effects of the natural logs of prices and real expenditure on market shares.

multi-logit model because the market shares are often close to the boundaries (0 or 1). This specification takes into account that the dependent variables are fractions summing up to one (Buis 2017). We consider three different qualities of cotton, American, Indian and Egyptian (to which we assimilate the equally high-quality Brazilian variety), and as many for wheat, domestic, and high and low quality imports. We define imports of high (low) quality if the average value in 1913 was higher (lower) than the median one.[11] Eastern European grain was decidedly inferior, while American wheat improved steadily and in 1913 was comparable to the domestic one (Federico and Persson 2007, Ejrnæs et al. 2008). The Wald and likelihood ratio tests accept the hypotheses of homogeneity and symmetry for wheat, but not for cotton.[12] These rejections are common in the study of cotton demand elasticities and the imposition of restrictions causes bias when they are rejected (Chang and Nguyen 2002: 106-107). We therefore use an unrestricted model for cotton. We convert the estimates of expenditure elasticities by quality from the model into income elasticities by multiplying them by the aggregated income elasticity of cotton or wheat since, by definition, the expenditure is unit elastic with respect to the quantity demanded.[13]

Table 3 reports the results together with the other elasticities we use for the estimation of our model. We use the British demand elasticities estimated with equations 6a) and 6b) for other consumer countries as well. We extract elasticities for producing countries and aggregated income elasticities from an extensive review of the literature (Appendix B). As a sensitivity test, in all the following sections we report in brackets also results with elasticities one third higher or one third lower than our baseline parameters.

[11] We obtain average values with a panel regression on origin and year dummies.

[12] Carried out on a simple SUR specification for cotton. The chi-squared statistics of the likelihood ratio tests are 98.18 (significant at the 1% level) for cotton and 1.98 (not significant) for wheat.

[13] Formally, $dln(D_i)/dln(Y)=[dln(D_i)/dln(x)][dln(x)/dln(D)][dln(D)/dln(Y)]= [dln(D_i)/dln(x)][dln(D)/dln(Y)]$ since $dln(x)/dln(D)=dln(pD)/dln(D)=[d(PD)/dD][D/PD]=P/P=1$, where, as before, D is the demand (of quality of i when subscripted and total of th(croe good otherwise), Y is the income per capita, P is the price of the good and x is the expenditure on the good.

Table 3: Elasticity parameters

a) Wheat

Origin	Destination	Demand Own-price	Cross-price by origin UK	W. Europe	N. America	E. Europe	Income	Supply Own-price
N. America	N. America	-0.5					0.35	0.75
E. Europe	E. Europe	-0.5					1.50	0.75
UK	UK	-1.41			0.28	-0.23	0.48	0.75
N. America	UK	-2.36	0.94			1.36	0.02	
E. Europe	UK	-3.07	-0.82		1.96		0.68	
W. Europe	W. Europe	-1.41			0.28	-0.23	0.48	0.75
N. America	W. Europe	-2.36		0.94		1.36	0.02	
E. Europe	W. Europe	-3.07		-0.82	1.96		0.68	

b) Cotton

Origin	Destination	Demand Own-price	Cross-price by origin India	US	Egypt	Income	Supply Own-price
India	India	-0.8				0.50	0.50
US	US	-0.65				0.50	1.00
Egypt	Egypt	-0.8				0.50	0.50
India	Europe	-0.44		1.02	-0.5	0.46	
US	Europe	-1.85	-0.03		0.18	0.64	
Egypt	Europe	-1.34	-0.13	2.05		0.12	
India	Japan	-0.44		1.02		0.46	
US	Japan	-1.85	-0.03			0.64	

Sources: see the text and Appendices A and B.

The results for cotton are very close to the estimates by Irwin (2003) for the early part of the 19th century (1831-1860): the coefficient of correlation between the two set of estimates is as high as 0.95.[14] Indian cotton was a shorter staple than the American variety, and thus not wholly suitable for all spinning technologies, most notably ring spinning (Panza 2013: 863). Consequently, its demand was inelastic with respect to its own price and it was a poor substitute of US cotton, as shown by the negative and very low cross-elasticities of demand for American and Egyptian cotton to changes in prices of Indian cotton (-0.03 and -0.13 respectively). Vice-versa, the demand for

[14] In addition, the absolute values are substantially lower than the comparable parameters for silk, which was a luxury good (Federico 1996).

Indian cotton was responsive to changes in the price of US cotton (cross elasticity 1.02). As it is well-known, the United Kingdom turned to India to substitute American cotton at the time of the US civil war. Indian cotton was a complement rather than a substitute for the (top-quality) Egyptian cotton, while the (fairly good) American cotton was a substitute.

Our estimates of elasticities of demand for wheat are consistent with the results of studies with an approach similar to ours.[15] The wheat cross-price elasticities (like those of cotton) suggest a lower level of substitutability between qualities than the elasticities of substitution usually assumed in the literature (e.g. Jacks et al. 2011: 189). In fact, the demand for high quality British wheat turns out to be inelastic with respect to the price of imports. The low-quality Eastern European wheat shows up as a complement for British wheat, with negatively signed cross-price elasticities across the two varieties. The British land-owners may have overstated the threat posed by foreign competition in the wake of the repeal of the Corn Laws in 1846. The market share of imported wheat increased only slowly: in the 1850s over 80 per cent of the wheat consumed in the UK was still locally produced; it is only in the 1880s that the market share of imported wheat became larger than that of local wheat (see Figure A3 in Appendix B).

6) The results: trade

The multi-market model produces separate estimates of the effect of price convergence on each bilateral flow (e.g. from North America to Western Europe). We sum them up to get aggregate estimates by producing area (North America to World), by consuming area (World to Western Europe) or for the whole trade (World to World). We report the results as ratios to actual flows in Table 4.

[15] Our averages (-2.28 own-price elasticity and 0.58 cross-price elasticity) compare well with the same averages by Wilson and Gallagher (1990) and Mohanty and Peterson (1999) - respectively -1.58 and 0.48 and -1.78 and 0.47. Mohanty and Peterson (1999) also find a complementary relationship between high and low qualities of wheat in the European Union, as millers blend them to obtain desired characteristics.

Table 4: The effect of market integration: predicted over actual change in trade (%)

a) wheat

From	to	1815-1913	1830-1913	1870-1913
North America	UK	70.99	60.04	32.94
		(47, 100)	(40, 90)	(22, 50)
North America	Western Europe	6.96	0.94	-11.54
		(5, 11)	(0, 1)	(-8, -17)
North America	World	39.75	31.17	5.43
		(27, 56)	(21, 46)	(3, 8)
Eastern Europe	UK	101.32	96.86	123.44
		(87, 101)	(64, 102)	(82, 186)
Eastern Europe	Western Europe	36.47	13.46	-6.38
		(24, 56)	(9, 22)	(-5, -10)
Eastern Europe	World	44.08	23.37	-0.58
		(31, 62)	(15, 31)	(-1, -1)
World	UK	80.36	71.33	50.36
		(60, 100)	(47, 94)	(33, 76)
World	Western Europe	29.96	10.64	-8.03
		(19, 46)	(7, 17)	(-5, -12)
World	World	42.61	26.05	1.49
		(29, 60)	(17, 37)	(1, 2)

b) cotton

From	to	1816-1913	1830-1913	1870-1913
India	Europe	30.29	-5.76	-9.96
		(17, 50)	(-6, -2)	(17, -50)
India	Japan	100	100	100
		(100, 100)	(100, 100)	(100, 100)
India	World	65.33	52.33	117.24
		(59, 75)	(47, 48)	(113, 123)
US	Europe	64.54	3.43	-3.41
		(42, 99)	(1, 7)	(-4, -3)
US	Japan	100.00	100.00	100.00
		(100, 100)	(100, 100)	(100, 100)
US	World	66.08	7.80	2.44
		(44, 99)	(5, 11)	(2, 3)
Egypt	Europe	31.07	5.28	7.20
		(21, 47)	(4, 8)	(5, 11)
Egypt	World	31.07	5.28	7.20
		(21, 47)	(4, 8)	(5, 11)
World	Europe	58.04	2.98	-1.99
		(38, 89)	(1, 6)	(-3, 0)
World	Japan	100.00	100.00	100.00
		(100, 100)	(100, 100)	(100, 100)
World	World	62.49	13.77	13.14
		(44, 90)	(12, 17)	(12, 15)

Sources: see the text and Appendix A.

Notes: The figures in parentheses use two thirds and three halves of the elasticities in the baseline specification.

For instance, for our baseline estimate, the collapse in costs of exporting wheat from North America to the United Kingdom from 7.59 pounds per ton in 1815 to 0.05 in 1913 increased exports by about 1.33 million tons. Since they actually increased by 1.87 million tons, price convergence explains more than two thirds of the growth over the whole period. The rest of the increase in imports was determined by the increase in population of the Kingdom, from 18 to 45 million people, and changes in comparative advantage, as the UK specialized in the exports of industrial products and coal.

The table highlights three main points. First and foremost, in the long 19th century, price convergence did matter a lot for the growth of world trade, accounting for almost two thirds of the increase for cotton and for over a third for wheat. Second, most of this effect showed in the early post-Waterloo years for cotton, with the notable exception of Japan, and in the mid-19th century for wheat. This is hardly surprising, given the time pattern of convergence (Figure 2) and of the effect of policies on trade costs (Section Three), but it calls for separate analysis for wheat and cotton. Third, changing elasticities within a plausible range (figures in brackets), does not affect qualitatively the results. The sign of the effect changes only for Indian exports to Europe since 1870: the higher elasticity yields a decline, as in reality, rather than a rise, but the absolute difference is really minimal (the predicted change being a decline by ca 18000 tons vs. an increase by 4000 in the baseline case).

The interpretation of changes in American cotton exports is straightforward. The United States dominated the world market for cotton and trade costs from the United States to Europe fell by four fifths in second half of the 1810s, from 54 £/ton to 10-15 £/ton. According to our model, this massive decline explains about a half of the total increase of cotton exports in long run from our three countries. Since the early 1820s, trade costs from the United States to Great Britain declined little, and the contribution to increase in trade was correspondingly modest. One has to infer that most of the growth in exports was driven by the shift in demand, which, in the case of Great Britain, included a large foreign component. The case of Egypt was broadly similar, while India was different. First, unlike in other cases, trade costs were higher in 1870 than in 1830 because the market had not yet returned to normal after the bonanza of the years of the American Civil War. Second, Indian exports were affected more than those of the other exporters by the opening of Japan, which by 1913 accounted for a tenth of the world trade of raw cotton (Table 1). Under our assumption of prohibitive trade costs in 1816 and 1870, by construction, the market integration account for all the increase in trade from all exporters. However, India was better located than the United States to supply the Japanese market and its low quality but cheap cotton was suited to Japanese coarse production more than to the European one. The attraction of the Japanese market was so great as to cause Indian exports to Europe to decrease by about a tenth, while, given the substantial decline in costs, the model predicts a small increase in trade (hence the negative sign in Table 4).

Our estimate shows the powerful impact of different trade policies on exports of wheat. As said, the abolition of Corn Laws, in either version, had a powerful effect on American exports to the United Kingdom. The effect of liberalization was even greater for imports of Eastern European wheat, which had to compete on price to overcome the inferior quality. In fact, all their increase was determined by the fall in trade costs. In contrast, the contribution of market integration to the growth of imports into Western Europe was much smaller since 1815 (ca 30% considering both North American and Eastern European corn) and negative since 1870 (-7%). This is clearly the outcome of the return to protection in the 1880s. In 1913, importing wheat from North America and from Eastern Europe cost 41% and 31% more than in 1870, and only 26% or 37% less than in 1815. The combination of rising trade costs into Western Europe and falling into the United Kingdom shifted exports towards the latter. The model predicts a decrease of imports into Western Europe by about half a million tons from 1870 to 1913, while they increased by almost 7 million tons.

7) The results: welfare

As expected, market integration benefitted both producers and consumers (Table 5).

Table 5: The effect of market integration: welfare (% GDP)

a) wheat

	1815-1913	1830-1913	1870-1913
Eastern Europe	0.100	0.069	0.006
	(0.1, 0.091)	(0.075, 0.057)	(0.01, 0.064)
North America	0.018	0.015	0.004
	(0.020, 0.015)	(0.017, 0.013)	(0.005, 0.003)
UK	0.400	0.400	0.200
	(0.6, 0.3)	(0.5, 0.3)	(0.2, 0.2)
Western Europe	0.200	0.075	-0.100
	(0.2, 0.2)	(0.075, 0.077)	(-0.1, -0.1)

b) cotton

Cotton	1816-1913	1830-1913	1870-1913
Egypt	5.000	0.900	1.000
	(5.3, 4.6)	(1, 0.9)	(1, 1)
India	0.400	0.300	0.300
	(0.5, 0.3)	(0.4, 0.2)	(0.5, 0.2)
US	0.400	0.091	0.042
	(0.5, 0.3)	(0.1, 0.079)	(0.057, 0.0314)
Europe	0.500	0.037	-0.009
	(0.5, 0.4)	(0.017, 0.049)	(-0.029, 0.004)
Japan	4.200	4.200	4.200
	(6.2, 2.8)	(6.2, 2.8)	(6.2, 2.8)

Sources: see the text and Appendix A.

Notes: The figures in parentheses use two thirds and three halves of the elasticities in the baseline specification.

The results are robust to changes in elasticities, even more than those for trade (Table 4). In one case only, cotton in Europe in 1870-1913, the sign of the effect depends on the parameter, but the absolute range is anyway very narrow. Unsurprisingly, given the changes in trade costs (Table 2), gains were much larger in the 'long 19th century' than during the 'first globalization' since 1870. The gains for Japan are equal in all periods by construction, as we assume it opened the market only after 1870.

There are only two exceptions to the generalization that countries gained from market integration, both for consumers since 1870. The losses for European cotton importers are minimal (as the change in trade costs) and, as said, not robust to changes in elasticities. The losses for wheat importers in Western Europe are rather more substantive and a self-inflicted wound from the protectionist trade policy.

Table 6: Shares of wheat and cotton on GDP and trade in 1913

	Products	Openness	% Trade	% GDP	% Consumption
USA	Wheat and Cotton	11.6	15.5	3.1	1.9
UK	Wheat	50.4	3.7	0.3	2.2
India	Cotton	20.0	9.0	2.8	1.0
Japan	Cotton	28.5	15.3	0.0	4.4
Russia	Wheat	14.3	7.1	8.0	7.4
Egypt	Cotton	53.7	47.6	24.3	2.5
W. Europe	Wheat	37.6	3.5	1.9	3.8
Europe	Cotton	35.7	4.7	0.0	1.7

Sources: GDP and total trade Federico and Tena Jungito (2017a); trade cotton and wheat Table 1; production of cotton and wheat in India and the United States from Chilosi and Federico (2016), in Egypt from Owen (1969) in Japan from Otsuka et al. (1988); gross output of wheat in Russia from Falkus (1968); gross output of wheat in other European countries estimated as total production (Mitchell 1998) times prices in capital cities or representative cities from Federico et al. (2018); Value Added in wheat production is estimated as gross output times the country ratio VA/output ratios from Federico (2004).

The size of gains differs widely across areas, depending on the openness of the country and the share of wheat and cotton in production and consumption (Table 6). The United States gained relatively little (at most half a percentage point in the long run) because the country traded little and wheat and cotton accounted for a small proportion of its GDP, even if they still accounted for a relatively high share of trade in 1913. Russia was barely more open than the United States, but it was still an agricultural country and wheat loomed large in its GDP and exports. Of course, small, open producers gained more. Thus Egypt, who exported almost only cotton and consumed only a small share of its cotton production, gained handsomely. European countries were quite open, but by 1913 wheat and (raw) cotton accounted for a small share of their trade and consumption.

By definition, our analysis can capture only a part of total gains from integration. It does not include the gains from increasing market efficiency, the general equilibrium effects of price convergence and, above all, it does not cover the gains from integration of markets for other products. In 1913 other products accounted for a minimum of a half of trade for Egypt to over 90% for European consuming countries. As said before, the most important improvement to market functioning in the 19th century was the telegraph. Steinwender (2018 Tab. 13) and Ejrnæs and Persson (2010 tab 3) have estimated the effects on American and British GDP of the lay-out of the first transatlantic cable between the United States and Great Britain in 1866. The gains (respectively 0.0073% of US GDP for cotton and 0.0015% of US GDP for wheat) are an order of magnitude smaller than our estimates and thus add very little to the overall benefits.[16]

There is one only estimate of aggregate welfare gains from liberalization of trade for a single product, the Computable General Equilibrium model on the impact of the British Corn Laws by Williamson (1990). Protection reduced the UK's GDP of the 1840s by 1.5%, which corresponds to a 0.35% of the (4.3 times bigger) 1913 GDP. The two estimates are thus very close, especially if one takes into account the additional gains from the decline in transportation costs (about a third in the same period). This comparison suggests that for British imports of wheat general equilibrium effects were not that large.

In theory, one might estimate total gains by rescaling our product estimates according to the (inverse of the) share of the covered products on total trade. For instance, using wheat as a yardstick total British gains would be over a tenth of GDP (0.4/0.037), corresponding to nearly a fifth of UK's

[16] Both estimate a range of gains at current prices, respectively 1.7 to 5.4 million $ in 1866 (with a baseline value of 3.5) for cotton and from 0.6 to 2.1 million in 1883-1889 for wheat. We compute the corresponding shares on GDP at 1913 prices by deducting 10% to convert in VA (Federico 2004) and by deflating with UK deflator share on GDP 1913. We quote in the text the lower-bound estimate by Ejrnæs and Persson (2004) because they are obtained with the parameters (demand elasticity -0.5 and supply elasticity 0.5) quite close to ours. The upper bound gains are 0.0056% of American GDP.

economic growth in the 'long 19th century'.[17] However, this computation would ignore differences across products in levels and changes in trade costs, as well as in demand and supply parameters. For instance, the price of British coal, a very bulky product, was 57% higher in Genoa than in London in 1870 and 40% higher in 1913 (compare with Figure 2).[18] Nevertheless, the assumption that our commodities are representative is less heroic for Egypt, where the implied total gains from market integration are similarly high: they are equivalent to about one fourth of economic growth between 1815 and 1913.

It is also possible to compare our estimates with other estimates of aggregate gains from trade. Bernhofen and Brown (2005) compute Japanese consumers' welfare gains from opening to world trade in the 1850s to be 8-9% of GDP, which corresponds to 3% of 1913 GDP. The gains were so low because they are obtained comparing the prices in the 1850s and in the 1870s, when transaction costs were still very high. Federico and Tena-Jungito (2017a) estimate gains from moving to autarchy to free trade with the sufficient statistics by Arkolakis et al's (2012), assuming the 'standard' value of 3.78 for the elasticity of trade to trade costs. One would expect total gains to be larger than our estimates for each single product and, a fortiori, for total trade. This is indeed the case for the results for gains in 1913 (1.41% of GDP in the United States, 7.53% in Canada, 2.31% in India, 9.08% in the United Kingdom, 7.73% in Egypt and 4.40% in Japan). These estimates are however sensitive to the choice of the elasticity (the higher elasticity, the lower gains) and the baseline statistics by Arkolakis et al. (2012) underestimates total gains (Costinot and Rodriguez-Clare 2016).

The gains from international market integration for large countries, the United States and India, may have been in the order of half the gains from domestic integration. The partial equilibrium

[17] Here and below we rely on the latest figures from the Maddison project, kindly given to us by Jutta Bolt.
[18] The figures are obtained from a Hodrick-Prescott filtered series of the ratio between prices in Genoa (Felloni 1958 and Cianci 1933) and British export prices (Mitchell 1988: 748-749).

estimate by Federico and Sharp (2013) suggests that the combination of constant nominal railroad rates and falling prices inflicted substantial losses to the American economy during the Great Depression, ranging, according to hypotheses on specialization of output and to assumption about elasticities, from 0.55% to 3.1%. Donaldson and Hornbeck (2016) estimate that the static welfare gains from the building of railroads in the US amounted to 3.4% of its GDP if the alternative was, à la Fogel, the construction of canals and 5.3% if the alternative was no transportation. In another paper, Costinot and Donaldson (2016) compare the contribution of market integration and of technical progress to the growth of agricultural output in the US from 1887 to 1997. Market integration increased output by 62% from 1887 to 1920 and by 55% from 1954 to 1997 (vs. respectively 30% and 70% for technical progress). Market integration accounted for about a tenth of total growth in American GDP before 1920.[19] Assuming that the welfare gains from cotton and wheat were representative of trade, these figures compare with gains from international integration of 2.7% percent, equivalent to 3.7% of total economic growth between 1815 and 1913. Last but not least, Donaldson (2018) shows that in India the establishment of a railway connection increased agricultural income by 16% on average in the period 1870-1930 (equivalent to about 8% of GDP) and that about half of this increase is explained by the additional trade caused by the railway. Again the figure is in the order of twice as much as the total gains from international integration suggested by our figures under the assumption that cotton was representative of Indian trade (4.4% of Indian GDP). In the absence of estimates on the gains from domestic integration we cannot make the same comparison for small open economies. However, our estimates for the UK and Egypt reviewed above suggest that during the first globalization for smaller open economies the gains from international integration were comparable to domestic gains for large economies, like the US.

[19] Agriculture produced about 27% of GDP in 1890 and the additional gross output corresponded to about 18% of GDP (assuming a GDP/output ratio around 0.90).

8) Conclusions

Our multi-market analysis exercise highlights two main points. First, the effects on trade were, predictably, large and concentrated in the periods of falling trade costs. Market integration accounted for as much as 60% of the growth of cotton trade and 40% of the growth of wheat trade over the long nineteenth century. The effects on welfare were timed similarly. As expected, they were larger for small open economies, but substantial also for large countries such as India and the United States. Furthermore, as any partial equilibrium static analysis, our estimate cannot capture the general equilibrium and the dynamic effects of integration.

Second, the effects of market integration depended mostly on political decisions rather than on technical progress. As recently stressed by de Bromehead et al. (2019), trade policy matters. In the cotton market, by far the biggest gains were made as a result of the end of trading monopolies, the liberalization of Egyptian cotton exports and the resumption of political stability after Waterloo. Henceforth – with the only exception of Japan, which was forcibly opened to trade in 1853 – the effects of market integration were rather modest. The return of protectionism in Western Europe in the later nineteenth century cost its consumers dearly. Over the very long-run, their gains were much lower than those enjoyed by British consumers. In the classical age of the first globalization (1870-1913) protectionism hindered the growth of wheat trade and led to welfare losses for Western European consumers, more than offsetting the effects of the spread of the telegraph and the steamship.

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Appendix A Sources

A.1 Prices and trade costs

a) cotton

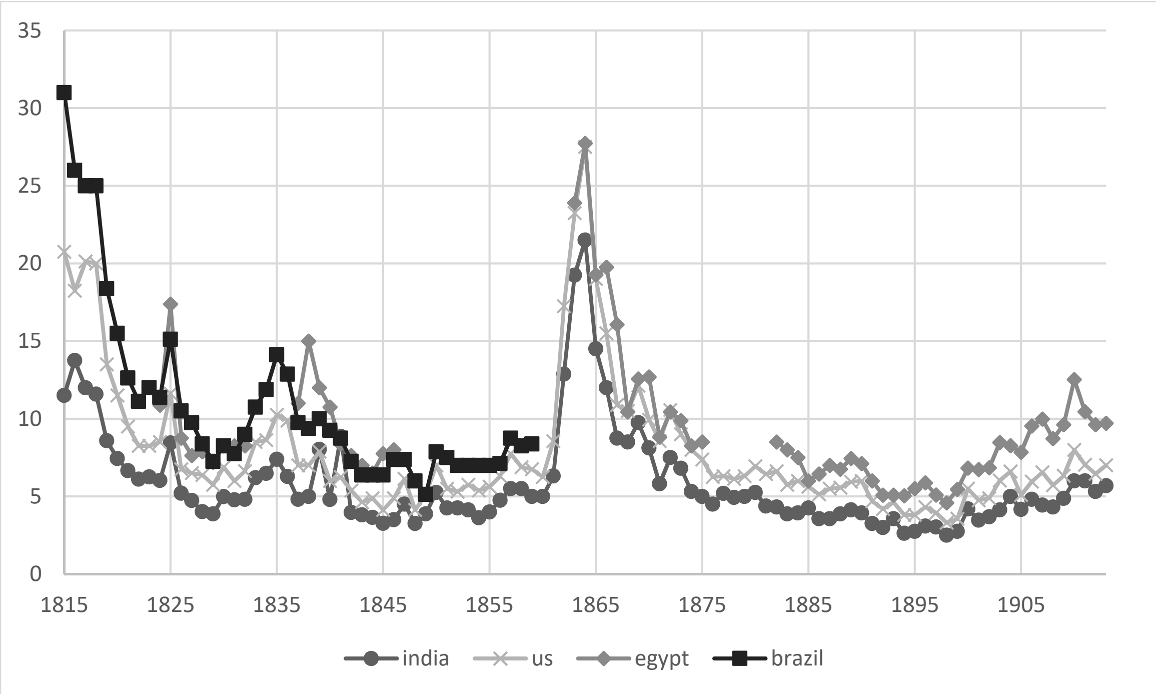
Price ratios between New York and Liverpool are used to estimate trade costs between the US and Europe. The prices in New York in US $ per lb are for 'middling Upland' and are from Carter et al. (2006, series cc 222-223). In Liverpool the prices in pence per lb are for 'middling American' and are from Mitchell (1988: 760-761). Hence it is reasonable to assume that the quality is homogeneous both within and between markets, for these series.

Price ratios between Calcutta (until 1845) and Mumbai (from 1867) and London are used to estimate trade costs between India and Europe. The prices in Calcutta are from the *Bengal Commercial Reports*, and have been converted from rupees per maund into shillings per lb. All the prices from this source are drawn from yearly issues from 1795/96 to 1845/46 and have been adjusted from fiscal to calendar years; the computations are based on averages between highest and lowest yearly prices. Specifically, the prices used are of 'Naugpore' until 1828/29, and 'Talloon' between 1829/30 and 1845/46. Hence, the quality is not homogeneous; nonetheless years with overlapping series show small differences in price between these two qualities. The prices in London compared with those in Calcutta are from Tooke and Newmarch (1928). All prices from this source are also based on averages between highest and lowest prices, which are reported up to four times during each year. The cotton prices are in shillings per lb and all refer to 'Cotton wool, Bengal and Surat'. Thus, we can be sure that they are prices of cotton imported from India.

The Mumbai prices are from *Prices and Wages in India*. The prices have been drawn from various issues (1891, 1902, 1913, 1915) and are for selected months, usually January and July; at times, they refer to the yearly average of the available monthly data. In 1867-1869 and 1899-1939 the prices have been quality-adjusted to 'Dohllera fair' on the basis of 'Broach', in 1870-1898 the prices refer to ‘Dohllera Fair’. Here, as with the other series, the quality-adjustment is made on the basis of the average of the ratios between prices of different qualities when the series overlap. The Mumbai prices have been converted into shillings per lb from rupees per candy. The London series is from Sauerbeck (1886 and ff.) and refers to ‘Fair Dohllera’ in shillings per lb. In short, the assumption of homogeneous quality within and across markets is reasonable for this series.

Our source for prices of Egyptian cotton in Liverpool is the book by Owen (1969), which reports three distinct price series for 1863-1866 (1969: 91), 1822-1832, 1837-1846 and 1863-1875 (1969: 163) 1880-1889, and 1889/90 to 1913/14 (1969: 203). We piece together our series for 1822-1913 by averaging in years with more than one observation (i.e. 1863-1866), adjusting from financial to calendar years after 1890 and filling the remaining gaps by using the price of Brazilian cotton imported in the UK (Mann 1860: 96) as a proxy. In fact, Brazilian and Egyptian cotton were very close substitutes (Irwin 2003: 281) and the premium of both over American cotton was almost identical (Figure A1).

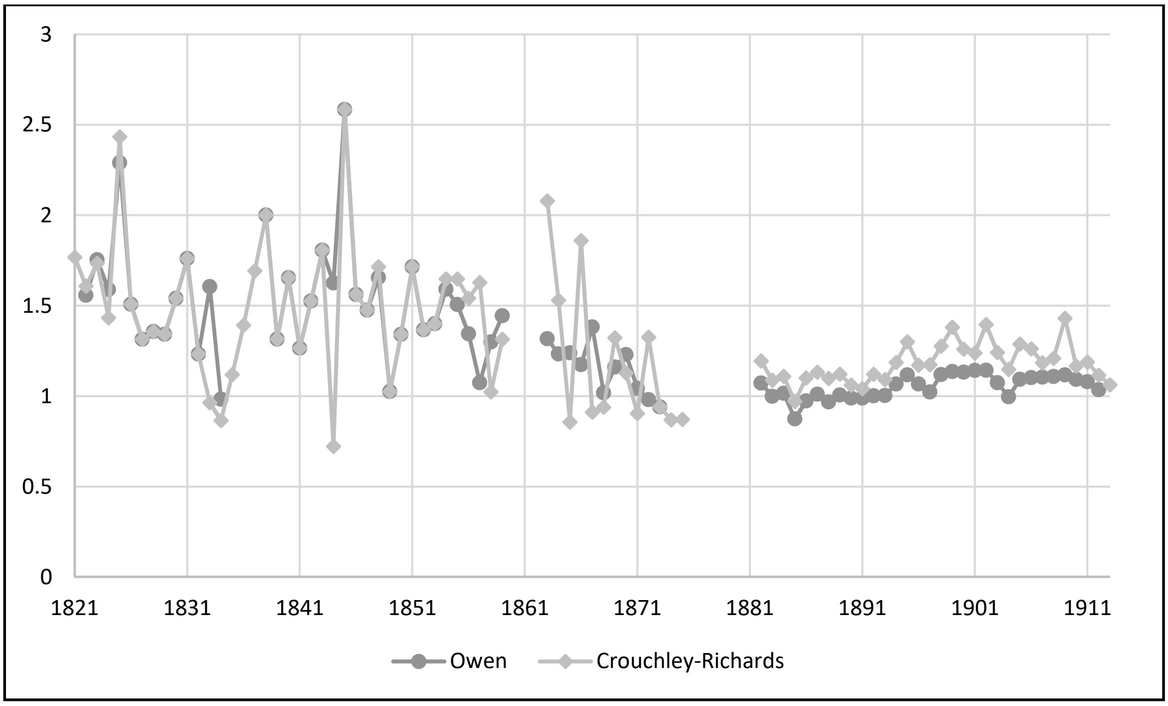
Figure A1: price of cotton in the UK by origin, 1815-1913 (pence/lb)



Sources: see the text.

Data on export prices of Egyptian cotton are fairly abundant although not always consistent. Both Crouchley (1938: 262-263) and Richards (1997: 227-228) report yearly data for the export price of Egyptian cotton in rials per cantar, respectively for 1821-1879, and 1858-1914, with a gap in 1859. Owen (1969: 34, 73, 91, 126, 197) reports five different series (the export price of Jumel cotton in talaris per Egyptian quintal in 1822-1834, the export price in Alexandria in Egyptian $/Egyptian quintal in 1838-1859, the Alexandria price for 'good fair' cotton in Egyptian $/Egyptian quintal in 1861-1866, the export price in Pt/cantar in 1866-1873 and 1879, and the Egyptian price in Egyptian £/cantar in 1879/80-1912/13). We convert all data in pound per 100 lb, and when necessary we adjust from crop to calendar year to get three separate series, by Crouchley (1821-1879), Richards (1858-1914) and Owen (1822-1912). The correlation between the two former ones is perfect, but it is surprisingly low between them and the series by Owen (respectively 0.81 and 0.83). Ultimately, we prefer this latter because the Liverpool/Egypt price ratios seem more plausible (Figure A2). The ratio to the Crouchley-Richards' series is highly volatile, falls quite often below one and exhibits a surprising upward trend after 1882 (see Figure A2). We therefore mainly rely on Owen and use the other two sources only to fill in the gaps.

Figure A2: cotton price gaps between Egypt and the UK, Owen vs. Crouchley-Richards, 1821-1913



Sources: see the text.

We obtain cotton prices (in shillings/lb) in Japan in 1913 with the series of the average cost of cotton from all provenances (in yen/60 tons) from Japan Statistics Bureau (1988a: 383). We estimate separate prices of Indian and American cotton by using the data on market shares and on the premium for American over Indian cotton.[20] The export prices of Indian and US cotton used to obtain price ratios are from the same as those used for price ratios with the UK.

b) wheat

The prices series in New York and London 1800-1913, which we use to estimate trade costs between North America and the UK, have been kindly provided by David Jacks (Jacks, 2005). These sources

[20] Indian and American cotton accounted respectively for 64 and 28 per cent of Japanese imports in 1911-1913 (Japan Statistics Bureau 1988b: 49), making it safe to neglect cotton from other places. US cotton commanded a 27 premium

do not allow controlling for quality differentials. The quality-adjusted series by Persson (2004), however, covers only the period 1850-1900 and are converted in gold (rather than paper) dollars from 1862 to 1878. The ratio between the two series is close to one (0.96) and the two series are co-integrated at 2 per cent; the coefficient of correlation for the whole period is 0.565 and for 1878-1900 is 0.872.

We use the English Gazette price (from Sauerbeck 1886 and ff.) for the British wheat price in 1913. For the prices of North American and Eastern European wheat in the UK in 1913, we use the average value of wheat (in £/cwt) from these origins from the *Annual Statement of Trade of the United Kingdom of Foreign Countries and British Possessions* (henceforth ASTUK). The other 1913 wheat prices are computed adding to these prices trade costs (for the prices in North America and Eastern Europe) or the difference in trade costs (for the prices in Western Europe).

c) Weight conversion rates.

1 candy=784 lb (from *Statistical Abstract of British India*), 1 maund=82 lb, 1 cwt=112 lb (from *Prices and Wages in India*), 1 lb=0.4536 kg (from *International Yearbook of Agricultural Statistics*). Egyptian quintal=110.3 lb until 1834 and 98.5 lb henceforth (Owen 1969: 34, 383-385).

d) Exchange rates.

US $ into British £: Carter et al.'s (2006). Indian rupees (Sicca rupees until 1835) to British £: 1797-1801: *Bengal Commercial Reports* (1795-1802 and 1796-1802 volumes, adjusted from financial to calendar years); 1802-1818: linearly interpolated; 1819-1843: Denzel (2010: 500); 1844 to 1913: *Prices and Wages in India* (1891, 1902, and 1920 issues, selected months); Japanese yen in US $ are from Japan Statistics Bureau (1988a: 104-107) (averages of highest and lowest yearly values). 1

over Indian cotton in 1926-1933 according to trade statistics (Ishibashi 1935: 394-395). As the series of average values is rather smooth, no H-P filter was applied in this case.

rial=1 Jumel talari=1 Egyptian $=20 Pt, 1 Egyptian £=100 Pt, 1 UK £=97.5 Pt (Crouchley 1938: 262; Owen 1969: 34, 383-385).

A.2 Freights and duties

a) Freights

There are at least eight available series of freights for transport of wheat across the Atlantic, from six works, by five different authors i) North (1958) freight factor for American (East Coast), 1826-1913, which can be transformed back into shilling/quarter by multiplying by the Gazette price (Mitchell 1988), which North used as denominator; ii) Harley's (1988) "New York grain series", for 1855-1872, presumably in cents/bushel; iii) Shah-Williamson's (2004) indexes (1884=1) of freights from East North America, 1869-1938 and from the Gulf Coast 1884-1939; iv) Persson (2004) freights from Liverpool to London, 1850-1900 in shillings/quarter; v) Klovland's (2006) series of freights from New York to London or Liverpool, 1848-1861 in pence/bushel; vi) Harley's (2008) rates for 'Cork for order' (i.e. for specialized tramp shipping) for 1863-1908 and for 'New York Liverpool berth' (i.e. for transport as supplementary cargo in ships carrying live animals or frozen meat) for 1868-1913. Table B1 reports the coefficients of correlation among the five most important (in terms of length and representativeness) series, by North, Persson, Harley (1 stands for 'Cork for order' and 2 for liner) and Shah-Williamson (1 stands for East Coast, 2 for the Gulf).

Table A1

Correlation coefficients between Atlantic freights for wheat

	North	Harley 1	Harley 2	Persson	Shah-W 1
North					
Harley 1	0.952				
Harley 2	0.920	0.968			
Persson	0.932	0.935	0.988		
Shah-W 1	0.761	0.760	0.747	0.672	
Shah-W 2	0.778	0.830	0.717	0.671	0.526

Sources: see the text.

The coefficients of correlation between the series by North, Harley and Persson are quite high, and thus ultimately the choice of any of them would not affect the long-term trends. However, the levels differ hugely, as the transport by liners cost about half: the average ratio of Harley 1 to Harley 2 is 0.60 (DS 0.15), to Persson is 0.44 (DS 0.05) and to North is 0.51 (DS 0.07). Thus, any change in the market share of liners would affect the average freight. Although data are very scarce, the anecdotal evidence suggests a sharp increase in that share since in the 1880s, up to about 60-70 per cent in the mid-1890s (Harley 2008). To capture this effect, the final series of freights to 1913 is a weighted average of the series of tramp freight by North and of liners rates by Harley, assuming the weight of the latter to have increased from 1 per cent in 1860 to 10 per cent in 1880, and to 66 per cent in 1890. The tramp freights are taken from North (1958), which extends back to 1832, with a ten years break from 1833 to 1842. In those years, and in the years 1814-1832, the series is interpolated, *faute de mieux*, with the series of overall freight by North (1968).

The freights from Eastern Europe are also for grain and refer to Odessa-London (Harley 1988: 874-875 and 1989: 336-337). As the series starts only in 1818 and has a gap in 1827-1839, the 1815 and

1830 values are extrapolated with the New York-London series. Harley (1989) reports the freights in shillings/ton, but does not specify the unit of measurement in the series from his earlier paper. We therefore convert the early series into shillings/ton using the values in overlapping years between the two series (1850-1872).

b) Duties

We estimate the British unit duty in 1815 and 1830 as a three years moving average of revenues from tariff divided by the total weight of the wheat imported,[21] while we compute duties for countries in Western Europe as the weighted average of specific duties in the benchmark years (O'Rourke 1997, Federico 2012), using as weights the shares of imports from the US (North America) and Russia (Eastern Europe) in 1913. The use of three years moving averages is motivated by the fact that tariffs are only available for a subset of countries and we are after typical duties in our years. We have specific duties in 46% of the country/year observations. In Spain in 1830 the duty was prohibitive. For the purpose of the analysis we assume that this duty was equal to the sample maximum. This assumption has very little impact on the aggregate duty: as said before, the Western European tariff is weighted with volume of trade in 1913, when Spain did not import any wheat from the US and accounted for only 4% of the Russian exports.[22] In the remaining cases we assume that the duty was equal to the cross-sectional average of the available observations in a given year. This assumption is relatively undemanding, as the available data signal low levels of dispersion in the Western European tariff levels in all years but 1830 (the standard deviations in shillings per quintal in 1815, 1830, 1870 and 1913 are 0.27, 2.86, 0.29, 0.87, as compared with estimated

[21] The results for British import of wheat in 1815 may not be fully representative, because the Corn Laws were approved only in April and large quantities of wheat were imported in the first months of the year in prevision of the change in trade policy. Thus, for this year and the subsequent year only, we rely on an alternative estimate: the weighted (by months) average of the explicit and the implicit duty, which we define as the difference between the domestic ('Gazette') price and the threshold (80 shillling/quarter) to let import free.

[22] See below for sources on trade.

difference with UK duties for American wheat in the same years of -6.55, -4.32, 0.19 and 6.02).

A.3 Quantities and GDP

a) Cotton trade

Total cotton exports from the US (in lb) are available for 1815-1816 from American commercial statistics (*Trade by Products*, p. 53). Trade by destination become available in 1822 (*Commerce and Navigation for the Year 1822*, p. 84) and show that at the time 99.6% of the exports were towards Europe. This share is used to estimate the size of European imports in 1816. Exports towards Europe in 1830 and 1870 are from *Commerce and Navigation* (1830 issue, p. 158-159, 1870 issue, p. 162 and 1871 issue p. 254). In 1913 we also rely on US commercial statistics (in 500 pound bales), *Commercial Relations of the United States with Foreign Countries*, published by the Department of Commerce (1918 issue, table 31 at p. 65) for exports to Japan as well as to Europe.

Prinsep (1823: Appendix C, no 1) reports values of cotton exports in Rupees in 1815-16 and 1816-17, which we convert into quantities using the export price (from the *Bengal Commercial Reports*) and from fiscal into calendar year to obtain our estimate for 1816. Chaudhuri (2008) reports values of cotton exports in Rupees in 1820-21, which we convert into quantities using the export price (from the *Bengal Commercial Reports*) to obtain our estimate for 1830. The source for 1870 and 1913 (in cwt) is *Statistical Abstracts for British India*. The same source also reports the value of exports by destination countries in 1911-2, 1912-13 and 1913-14, which we use to divide up the total exports in 1913 between Japan and Europe.

Egypt did not export cotton in 1816. Total cotton exports from Egypt are available for 1829, 1830 and 1831 (in quintals of 50 kg), 1869-1870 and 1870-1871 (in quintals of 99 lb, adjusted from fiscal to calendar years) and 1910-1913 (in cantars of 99 lb) from Owen (1969: 34, 123, 198). Owen (1969:

199) also reports that in 1910-1913 90% of the exports were towards Europe (with the rest going to the US).

b) Wheat trade

Total exports of wheat in tons from the United States are available from 1817 from Carter et al. (2006: series Ee569-589). Three years moving averages (1817-1819, 1829-1831, 1869-1871 and 1911-1913) are used to produce figures for 1815, 1830, 1870 and 1913. These quantities need to be allocated to Western Europe, the UK and the rest of the world. Exports by destination become available from 1820-1821 in *Commerce and Navigation*. We use that share to identify exports into the UK and Western Europe in 1815. For 1830 we rely on the shares recorded in the 1829-30 issue of *Commerce and Navigation*. The 1870 figure for Western Europe is from the 1869-1870 issue of *Commerce and Navigation* (in bushels, p. 158-159). We use the share from the 1909-1911 *Commercial Relations of the United States with Foreign Countries* to identify the quantities going into Western Europe in 1913. The 1870 and 1913 figures for wheat exports from the US into the UK are from ASTUK (in cwt).

To obtain the total figure of exports from North America we need to add exports Canada. For Canada there are less data than for the US and we need to rely more heavily on extrapolation. Yet, in the 19th century the size of Canadian exports was much smaller than the American ones and in the aggregate the resulting error is likely to be small. For the UK in 1870 and 1913 imports from Canada are available in cwt from ASTUK. Total yearly exports from Canada in tons are available from Stern (1960: 58) in 1854-1858, 1884-1888 and 1909-1913. The last figure is used to estimate Canadian exports into Western Europe in 1913, assuming that the share exported there was the same as that exported from the US. The 1854-1858 and 1884-1888 figures from Stern include also US data and we use them to estimate the size of total exports from Canada relative to the US in 1870, with linear interpolation. This figure allows extrapolating the total size of Canadian exports in 1870 on the basis of US total exports. To estimate the 1870 exports from Canada into Western Europe again we assume that the share going to Western Europe was the same as for the US. Total exports from Canada in 1815 and 1830 are computed under the assumption that the size of total exports from Canada relative to the US was the same as in 1854-1858. The quantities going into Western Europe and the UK are computed under the assumption that their shares of total exports are the same as for the US.

We compute three year averages of wheat exports from Eastern Europe into the UK in 1870 and 1913 with data from ASTUK (in cwt), using three/five year averages.[23] Valetov Timor has kindly provided us with Russian commercial statistics on wheat exports (in puds=16.38 kg) by destination in 1827, 1870 and 1913. Stern (1960: 58) reports yearly total exports in tons from Russia and the Danube countries (Romania, Bulgaria, Serbia and Hungary) in 1854-1858, 1884-1888 and 1909-1913. Our 1913 figure for Western European imports from Eastern Europe is equal to total yearly exports from the Danube countries in 1909-1913 minus the exports from Danube countries into the UK in the same years plus an estimate of yearly exports from Russia to Western Europe in the same years, computed with the UK figure (from ASTUK) and assuming that the ratio of Russian exports to the UK and Western Europe was the same as in 1913 (the ratio is from Russian commercial statistics). The assumption that Danube countries only exported into Europe does not appear particularly strong: 98% of Russian exports in 1913 were directed towards Europe (with the rest mainly going to Turkey, which however was a more important destination in the early part of the 19th century). For the ASTUK series, which starts in 1855, the Danube countries started exporting in the UK only in 1876. Hence in 1815, 1830 and 1870 we assume that they only exported in Western Europe. For 1870 we estimate these exports linearly interpolating between the 1854-1858 and

[23] For 1913 we use the five years' average (1909-1913) to make it directly comparable with the Stern (1960) data.

1884-1888 quantities from Stern (1960). Russian statistics give us the 1870 exports from Russia into Western Europe. For 1830 we rely on 1827 Russian commercial statistics for the exports into the UK and Western Europe. We estimate the Danube countries exports to Western Europe assuming that their share in Eastern European exports was the same as the average one from the second half of the nineteenth century, again relying on Stern's figures (1960) (the average is the appropriate measure here because, differently from the Canadian share in North American exports, it tended to be stable at just over 40%). Finally, for 1815, we rely on Attman's (1981: 196) figures on yearly total grain exports (almost exclusively wheat) from Russia in 1811-1815 and assume that the shares going into the UK and Western Europe were the same as in 1827. Exports from the Danube countries into Western Europe in 1815 are again estimated assuming that their share in Eastern European exports was the same as the average one from the second half of the nineteenth century.

c) Supply and demand

Mitchell (1988) reports quantities produced by country in 1913 for both wheat and cotton and for all countries in our sample, with coefficients adjusting for animal feeds and seeds. The demand in each place for each commodity, distinguished by origin, is computed as supply plus net trade.

d) GDP and population

1913 GDP figures in millions of 1913 $ are from Federico and Tena-Jungito (2017) for all countries in our sample except for Romania and Serbia. In these two cases we extrapolate using the Bulgarian GDP at current prices and the ratios of real GDP in 2011 $ from the 2018 Maddison database (available at www.ggdc.net/maddison, consulted in January 2018). The population figures are also from the Maddison database. To convert nominal GDP per capita into real GDP per capita, we use as numeraire the world price of the commodity (wheat or cotton), estimated as the average of the local sample prices weighted by share of consumption.

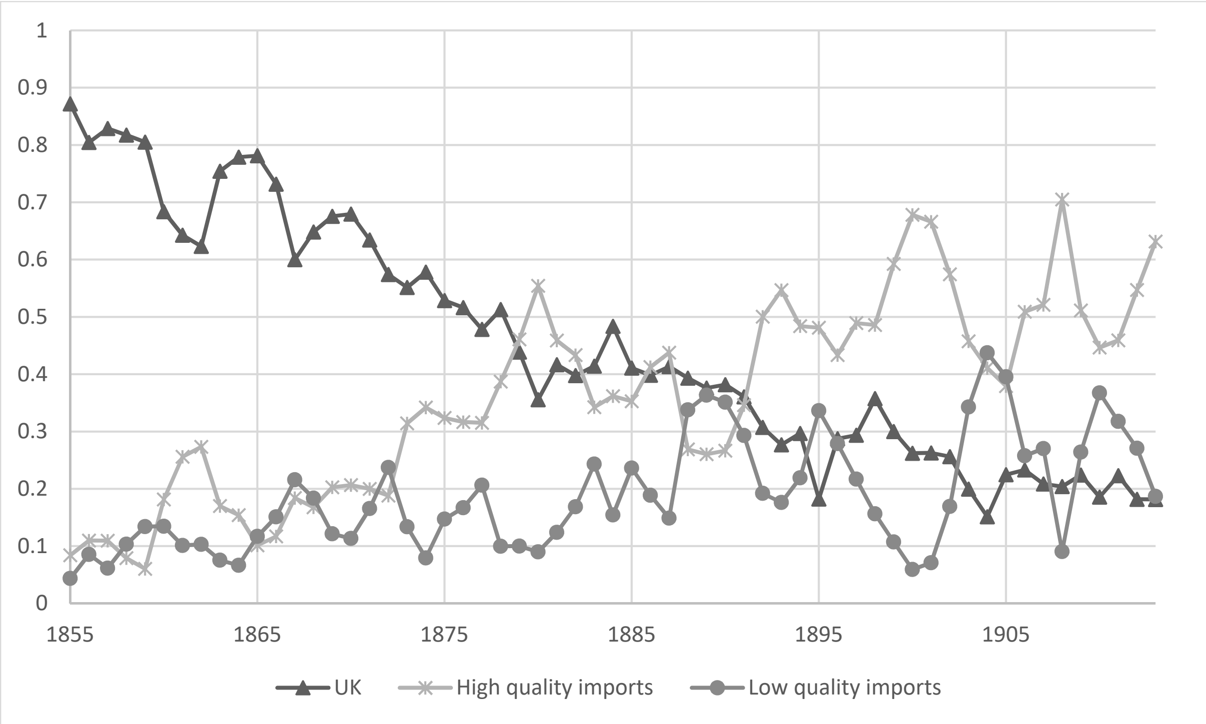
Appendix B: elasticities

B.1 The estimate of UK demand

The demand own-price and cross-price and expenditure elasticities of the importers are estimated with an LA/AIDS model applied to the UK market, as explained in the main text of our paper (Section 5). The model needs data on value market shares, prices and quantities, where market shares are computed with prices times quantities. We build a series of production of wheat in the United Kingdom piecing together the series by Lawes and Gilbert (1893: 132) for from 1852-3 to 1891-2 and by Mitchell (1988: 196) from 1885 to 1913.[24] We estimate the consumption as imports (from ASTUK) plus a varying share of domestic production – 90 per cent before 1885, 85 per cent in 1886-1893, 80 per cent in 1894-1910, and 75 per cent in 1911-1913 – to adjust for seeds and animal feeding (Ojala 1952: 192-193). We assume domestic production to differ from imports, and we further distinguish two varieties of imported wheat. We run a panel regression to fit the unit values of wheat from each country, and we classify as high (low) quality wheat if its price is above (below) the median fitted value in 1913. For the price of UK wheat, we use the English Gazette price from Sauerbeck (1886 and ff.). As Figure A3 shows, the share of domestic wheat has been steadily declining, and most of the market has been occupied by high quality stuff (mostly from the US), while the share of low quality wheat (mostly from Russia) has grown much less

[24] We convert the series by Lawes and Gilbert, in quarters per harvest years, into thousands of metric tons per year by averaging and assuming 1 quarter =416 lb. The differences between the two series, when overlapping (1885-1892) are small. The ratio between Lawes and Gilbert (1893) and Mitchell (1988) ranges from 0.94 to 1.24, with an average of 1.05.

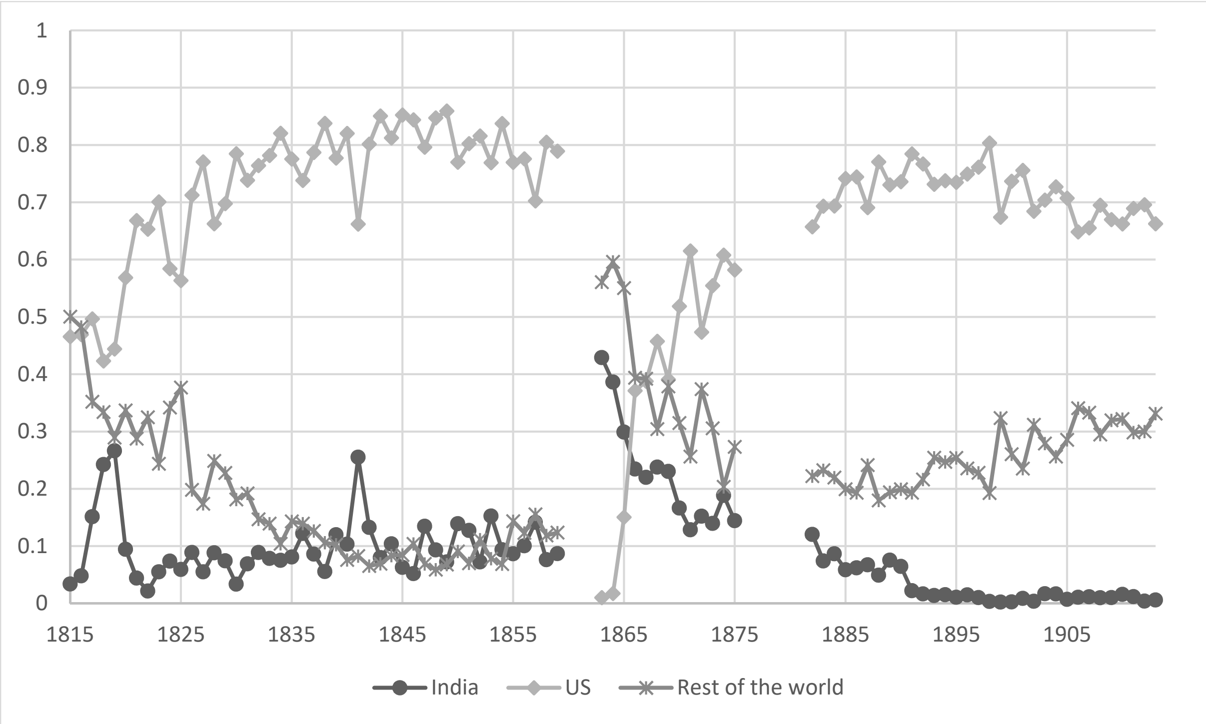
Figure A3: Wheat markets shares by quality in the UK, 1855-1913



Sources: see the text.

We divide cotton imports into the UK by three origins: US, India and the rest of the world. The sources of prices and quantities from the US and India are in Appendix A. Imports from the rest of the world are computed as total imports minus imports from India and the US. For total imports we rely on Mann (1860: 112) until 1854 and on ASTUK henceforth. Most of the cotton from the rest of the world came from Brazil and Egypt, whose cotton prices, as said before, were similarly high in comparison with those from India and the US (see Figure A1). Hence, similarly to Irwin (2003), we use their prices to estimate the price of cotton from the rest of the world. In years when prices from both Egypt and Brazil are available, we compute a weighted average using the quantities imported (from Mann 1860: 112) as weights. All quantities are converted into '000 metric tons. Figure A4 shows the cotton market shares.

Figure A4: Cotton market shares by origin in the UK, 1815-1913



Sources: see the text

In particular, we estimate the following two equations, for wheat:

$w_{it}=\alpha_i+\Sigma_j\gamma_{ij}lnp_{jt}+\beta_i\,ln(x_t/P_t)+\delta_{1i}\,t+u_{it}$ (A1a)

and cotton:

$w_{it}=\alpha_i+\Sigma_j\gamma_{ij}lnp_{jt}+\beta_i\,ln(x_t/P_t)+D_i\,CW_t+\delta_{1i}\,t+\delta_{2i}\,t^2+u_{it}$ (A1b)

Where w_{it} is the market share of the good of quality i at time t, p_{jt} is the price of the good of quality j at time t, with $i, j=1$ to 3 for both wheat and cotton, x_t is the total expenditure on the good (wheat or cotton), and $ln(P_t)$ is the weighted average of the natural logarithm of the prices of the various qualities of the good, where the weights are determined by the quantities consumed, as usual in the LA/AIDS model. The time trends capture the changes in market shares determined by the evolution of comparative advantage and technology. For cotton, we add a quadratic term, since trends are clearly non-linear and a dummy (CW_t) to control for the shock of the American Civil War

(1861-1865), which temporarily dried up supplies from the US, by far the largest producer (see Figure A4). With the coefficients from equations 1a and 1b, it is straightforward to compute the demand elasticities (Green and Alston 1990).[25]

We estimate equation 6a for wheat, following the standard approach, with a seemingly unrelated regressions specification. We prefer to estimate equation 6b for cotton with a fractional multi-logit model because the market shares are often close to the boundaries (0 or 1). This specification takes into account that the dependent variables are fractions summing up to one (Buis 2017). The Wald and likelihood ratio tests accept the hypotheses of homogeneity and symmetry for wheat, but not for cotton.[26] These rejections are common in the study of cotton demand elasticities and the imposition of restrictions causes bias when they are rejected (Chang and Nguyen 2002: 106-107). We therefore use an unrestricted model for cotton. Table A2 shows the regression results.

[25] Since for cotton we rely on the fractional multi-logit model, we use the average marginal effects of the natural logs of prices and real expenditure on market shares.

[26] Carried out on a simple SUR specification for cotton. The chi-squared statistics of the likelihood ratio tests are 98.18 (significant at the 1% level) for cotton and 1.98 (not significant) for wheat.

Table A2: LA/AIDS regressions results

a) wheat (SUR model)

Independent/Dependent variable	Share English wheat	Share high quality imports	Share low quality imports
Constant	21.421	-11.688	-8.733
	(20.79)***	(-6.5)***	(-5.01)***
Ln(price English)	-0.111	0.186	-0.074
	(-1.04)	(1.42)	(-0.64)
Ln(price high quality imports)	0.186	-0.615	0.429
	(1.42)	(-2.24)**	(1.87)**
Ln(price low quality imports)	-0.074	0.429	-0.355
	(-0.64)	(1.87)*	(-1.5)
Real expenditure	0.166	-0.340	0.175
	(2.06)**	(-2.83)***	(1.53)
Year	-0.013	0.010	0.003
	(-16.03)***	(7.92)***	(2.51)**
R-squared	0.93	0.77	0.37
N	59	59	59

b) cotton (fractional multi-logit model, average marginal effects)

Independent/Dependent variable	Share US cotton	Share Indian cotton	Share cotton from RoW
Ln(price US)	-0.451	0.088	0.363
	(-4.8)***	(1.28)	(4)***
Ln(price India)	-0.004	0.050	-0.047
	(-0.05)	(0.76)	(-0.82)
Ln(price RoW)	0.167	-0.048	-0.119
	(2.02)**	(-1.51)	(-1.5)
Real expenditure	0.181	-0.008	-0.173
	(3.19)***	(-0.25)	(-3.09)***
US civil war	-0.292	0.062	0.230
	(-2.67)***	(1.82)*	(2.84)***
Year	-0.320	0.259	0.061
	(-2.85)***	(3.79)***	(0.6)
Year squared	0.000	-0.000	-0.000
	(2.83)***	(-3.84)***	(-0.54)
N	90	90	90

z-statistics are in parentheses; ***=significant at 1%, **=significant at 5%, *=significant at 10%, RoW=rest of the world

Sources: see the text.

B.2 Other elasticities

The demand elasticities of the exporters and all income and supply elasticities are drawn from the literature. Like O'Rourke and Williamson (1994), we assume that the overall price elasticity of demand for wheat in North America was the same as in Europe, where the diet was similar. While O'Rourke and Williamson (1994: 914), basing themselves on old estimates, assume that the elasticity of the UK's demand for wheat in 1870-1913 was -0.3, an estimate by Barquin (2005: 264) for Europe in 1884-1913 implies a somewhat higher elasticity (-0.45). A correction in the same direction is also implied by the figures used by Allen (2000: 14) for the demand for agricultural products in pre-modern Europe (-0.6) and Ejrnæs and Persson (2010: 370) for the demand of American wheat in nineteenth-century Britain (-0.5/-1). We therefore use -0.5 for both North America and Eastern Europe.

Our price elasticity of demand for cotton in the US, -0.65, is based on Wright's (1971: 119) estimate for the mid-nineteenth century. Desai's (1971: 353) estimate of the demand elasticity for cotton in India between 1814 and 1904 (-0.80) is admittedly rough; nevertheless, it is reassuringly close to Murti and Sastri's (1951: 320) estimate for the inter-war years (-0.89). Desai's elasticity is also close but somewhat higher to the value used for the US, where it is reasonable to assume that income and climate made cotton relatively more necessary than in India. On grounds of climate and income -0.8 is used for Egypt, too.

For the supply elasticity of wheat, Ejrnæs and Persson (2010: 370) use the range of 0.5 to 1.5. Similarly, O'Rourke and Williamson (1994: 119) justify a value of 1 by citing Harley (1986), who, in turn, cites Fisher and Temin (1970) for the US and Olson and Harris (1959) for the UK. Fisher and Temin (1970) offer estimates by US state for the period 1867-1914 and their average is indeed very close to 1. However, after eliminating an obvious outlier (Iowa, where the figure is 10.76), the mean becomes 0.74. Olson and Harris' (1959) estimate (greater than 1.6) would imply that the supply in the UK in 1873-1894 was much more elastic than in the US, which is hardly plausible. Ward's (2004: 251) recent estimate for the UK 1864-1880 is 0.68, which is in line with expectations. The figure is also close to estimates reported by Askari and Cummings (1976) for the UK in the inter-war years (0.72) and the US in 1867-1914 (0.8). We therefore use 0.75 for the elasticity of the supply of wheat both in North America and in the European markets.

Wright's (1974: 617) estimates of the supply elasticity of Indian cotton in the mid-nineteenth century range from 0.32 and 0.75; the value of 0.5, which is also close to those found by Wright (1974: 617-618) for Brazil and Egypt at the same time and is chosen by Irwin (2003: 284), too, is used here for India and Egypt. Estimates by Wright (1974) and Duffy et al. (1994) agree that the supply was more elastic in the mid-nineteenth century U.S., in the order of twice as much (Irwin, 2003: 286), justifying a value of 1 there.

Clark et al. (1995: 216) assume that the income elasticity of demand for food in England during the Industrial Revolution was 0.6; Roderick Floud et al. (2012: 105) recommend a downward revision and argue for an income elasticity of demand for calories of 0.26. Wallis et al. (2018: 889-890) find that in England the income elasticity at the mid-point between 1750 and 1850 was 0.34. They also confirm a sharp decline in food demand elasticity with income (Clark et al. 1995): between the 1530s and the 1750s, when income was lower, the demand for primary products was still inelastic, but the value of the mid-point elasticity, 0.70, was substantially higher. Consistent with this claim, Goodwin and Grennes (1998: 418) find that in pre-WWI Russia the demand for wheat was actually income elastic, with an elasticity of 1.5, a value that also reflects the local preference for rye as the grain of choice. Present day studies on Africa also detect a negative correlation between the income elasticity of demand for food and GDP. In these studies, the average income elasticity for grains in Africa, where the GDP per capita is higher than in Eastern Europe in 1913 but still substantially lower than it was in Western Europe and the US in 1913, is 0.57 (Melo et al. 2015: Table 8). We therefore use 1.5 for Eastern Europe and 0.35 for the other places.

In contrast to food, recent research has found that the income demand elasticity for cotton and other textile fibres is remarkably stable across income ranges. Thus, values close to 0.5, the figure used here, have been found in diverse countries, like China, India, Egypt and the US (Macdonald et al. 2014: 516; Capps Jr et al. 2016: 59).

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