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# The effects of market integration: trade and welfare during the first globalization, 1815-1913

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**Abstract**

We investigate the effect of the decline in trade costs on trade, terms of trade and welfare of Europe (the United Kingdom and the Netherlands) and three large exporters (India, Indonesia and the United States) during the first globalization using a 'bottom-up' approach. We measure total route and product specific trade costs for a representative sample of commodities with price gaps predicted by observed trade costs. We use a simple microeconomic model and we buttress our findings with additional econometric testing. We find that price convergence accounted for almost all the improvement in terms of trade of producing countries and increased significantly welfare in both producing and especially consuming countries, while its positive effect on bilateral trade was often swamped by other factors. The findings caution against the substation of proxies to actual measures of trade costs.

**Keywords:** market integration, trade costs, terms of trade, trade, welfare, first globalization.

**JEL Codes:** F14, F15, F43, F63, N70.

1) Introduction

International trade theory holds that trade costs are key determinants of trade and welfare (Donaldson 2015: 621-623). However, actual trade costs are difficult to estimate and thus in empirical work they have often been substituted by distance, as a proxy of transportation costs, together with dummies for borders and other relevant effects. The results have been somewhat puzzling, as shown by the persistence of the distance coefficients surveyed by Disdier and Head (2008). Recent advances in modelling within the gravity framework have led to the development of new measures of aggregate trade costs (Head and Mayer 2014, Meissner 2014), but the results are not robust to small changes in sampling and parameters (Jacks et al. 2011, Hugot 2015). Furthermore, as Hillberry and Hummels (2013) point out, this approach neglects the effect of changes in factor endowment and technological or demand shocks on trade flows.

We complement this 'top-down' approach with a 'bottom-up' strategy. We measure the effects of changes in the costs of exporting a representative sample of primary products from India, Indonesia and the United States to Europe on bilateral trade, terms of trade and welfare during the first globalization, from Waterloo to World War One (Federico and Tena 2016a). In a companion paper (Chilosi and Federico 2015), we measure changes in different types of trade costs and their effect on price differentials. Thus, in this paper we can rely on product and route-specific trade costs, rather than on aggregate estimates based on selected price differentials only, as is the standard practice in microeconomic studies (cf. e.g. O'Rourke and Williamson 1994, Keller and Shiue 2008, Simonovska and Waugh 2014a, Donaldson forthcoming). Only data on primary products are available, but commodities accounted for about 60 per cent of world trade in those years (Lewis 1981) and there is a silver lining: the analysis is simpler as primary products are more homogeneous than manufactures.

Our micro-economic approach contributes to the literature on trade with estimates of the different impacts of bilateral trade costs, in comparison to those of multilateral resistance terms and non-cost related factors, on bilateral flows by country/product: the standard frameworks can distinguish them only imperfectly (for countries) or not at all (for products). Similarly, our estimates of the welfare effects complement the macroeconomic measures of total gains from trade (Arkolakis et al. 2012, Costinot and Rodriguez-Claire 2014, Felbermayr et al. 2015). These latter refer to all gains relative to autarchy (i.e. infinite trading costs), including welfare benefits from more variety. In contrast, our estimate deals with the effect of moving between different levels of trade costs.

Our work also contributes to the historical literature on market integration during the first globalization. Most of this literature deals with trends in price convergence and their causes. These works have not so far been directly related to those on trade and, generally, the effects of integration have been relatively little studied (cf. Lampe and Sharp 2016). Their analysis has focused on changes in factor income and their political consequences (O'Rourke and Williamson 1999). Only two papers (Ejrnæs and Persson 2010 and Steinwender 2014) estimate the welfare gains from integration. Moreover, both of them examine only the short-run impact of the lay-out of transatlantic telegraph lines on efficiency, of the wheat and cotton markets, respectively.

Last but not least, by quantifying the effects of price convergence on terms of trade, we address a gap in the debate on the negative effects of market integration on prospects for growth in the Third World (Williamson 2011).

Our baseline analytical tool is a partial-equilibrium model which allocates changes in trade costs between price increases in producing countries and price decreases in consumer ones. This approach is the only viable strategy for a microeconomic model in the absence of complete information on trade costs and flows for all pairs of trading partners. We also double-check the results with a range of econometric testing techniques from international economics.

In the next section we present some background information about trends in market integration, trade costs, exports and terms of trade for the three exporting countries we consider. We describe the model in Section Three and in Section Four we use it to estimate changes in prices in producing and consuming countries. We deal with the effects of market integration on terms of trade in Section Five, and on the effects on bilateral trade, a bridge between the two literatures, in Section Six. In Section Seven, we estimate the aggregate welfare benefits and we discuss briefly how they were distributed among regions and social groups. Section Eight concludes.

## 2) Market integration, trade costs and the growth of trade: an overview

Our companion paper (Chilosi and Federico 2015) considers 22 products, but we have to drop eight of them from the present analysis as some data are lacking (cf. the list in Table 3). As Table 1 shows, the goods considered here accounted for quite high shares of exports, but for the United States after 1870.

[Table 1 here]

Chilosi and Federico (2015) find that across products price convergence was faster before than after 1870, but the causes differed between periods and countries. Before 1870, convergence was mainly determined by the abolition of barriers to trade – the British Corn Laws for American exports of wheat and the monopolies of the British East India Company in 1815 and of the Dutch trading company in the 1850s. Since 1870, trade was liberalized and further convergence reflects improvements in transportation, with the spread of steam-ships, and communication, thanks to the lay-out of telegraphic cables.

The falls in price gaps for a selected group of commodities are illustrated by Figure 1, together with the lines fitted by panel regressions predicting price gaps from different types of trade costs, such as shipping freights and duties, across routes (Chilosi and Federico 2015: Table 6).[1] These fitted values are here interpreted as 'iceberg' trade costs and as detailed in the next section we use them to measure specific trade costs. The lines show huge differences among products in initial level and the time profile of convergence. In fact, trade costs depended on the size of product-specific barriers to trade, on the price of the product and also on its volume per unit of weight, which determined the unit transport costs (Thomas 1930: 230).

[1] Instrumental variable estimation addresses potential endogeneity of duty and freight factors. The trading monopolies increased price gaps almost entirely through their effect on freight rates. The panels explain three-quarters or more of the variation in price gaps, across trade routes (cf. Chilosi and Federico 2015 for details).

[Figure 1 here]

The data from our countries are consistent with a ‘terms of trade boom’ for primary producers (Williamson 2011): on the eve of World War One, the terms of trade were 50 per cent higher in India and a third higher in the United States than in 1815 and 40 per cent higher in Indonesia than in the mid-1820s.[2]

[Figure 2 here]

However, as Figure 2 shows, each country had its own different medium-term trends. All the improvement in the Indian terms of trade was cumulated since the 1870s while (almost) the opposite is true for the United States, where two thirds of the improvements happened before the Civil War. The series for Indonesia shows a twin peak, in the late 1870s and in the early 1890s, when they were more than double the initial level and almost two and half times higher than in the 1820s (and 53 per cent than in 1913). These differences suggest that movements in terms of trade crucially depended on country-specific factors.

[2] All these figures are computed on the Hodrick-Prescott (HP) filtered series, using the beginning of the series (1800 for United States and India, 1823 for Indonesia) as reference year. Here and subsequently 6.25 is used as smoothing parameter, as recommended for yearly data.

The period of price convergence coincided with a fast increase in world trade and openness (Federico and Tena 2016a, 2016b). The USA, India and Indonesia shared this trend, although with some differences (Figure 3).

[Figure 3 here]

The Unites States' share of world trade at current prices almost doubled, while those of the two Asian countries fluctuated a lot (Table 2). India succeeded to increase its share up to almost 7 per cent in the late 1880s, but then it experience a steep fall to below 4 per cent in the wake of the collapse of exports of wheat and the stagnation of those of jute and cotton cloths (Chaudhuri 1982). Total Indian exports did recover and on the eve of World War One they were about a tenth higher than in the 1880s, but the share never approached the pre-crisis peak. Indonesia's share more than doubled in the 1830s, when peasants were forced to provide growing quantities of coffee, sugar and spices under the Cultivation System (van Zanden and Marks 2012). It peaked at around 1.8 per cent in the early 1840s, but declined in the 1850s and 1860s and fluctuated around 1 per cent until the war.

[Table 2 here]

Europe as a whole absorbed over three quarters of American exports (and the United Kingdom about a half) until the turn of the century, declining to two thirds (and a quarter) on the eve of World War One (Historical Statistics 2006:

series Ee 533, 540 and 541). Exports to Europe accounted for about half of Indian exports throughout the century, but the British share fell from 45 per cent to 25 per cent (Chaudhuri 1982: 862, 864). Similarly, in the early nineteenth century about half of Indonesia's exports were to Europe and this proportion was only slightly lower at the end of our period, but the Dutch share fell from 50 to 30 per cent (Korthals Altes 1991: 93-102).

3) The model

The model considers the interaction between a producing country (subscript $P$) and a consuming one ($C$). We assume linear demand and supply functions with demand ($D_P$ and $D_C$) and supply ($S_P$ and $S_C$) depending on price only, $P_P$ in the producing country and $P_C$ in the consuming country – i.e.:

$$D_C=a+\alpha P_C \qquad 1)$$

$$S_C=b+\gamma_C P_C \qquad 2)$$

$$D_P=c+\beta P_P \qquad 3)$$

$$S_P=d+\gamma_P P_P \qquad 4)$$

Where $\alpha<0$, $\beta<0$, $\gamma_C>0$ and $\gamma_P>0$. The price differential between the two countries, in efficient trading markets, is equal to trade costs $t$ (Federico 2012a).[3] Thus, we substitute $P_C=P_P+t$ and simplify the notation by writing

[3] We prefer this additive notation to the standard 'iceberg' assumption (i.e. $P_C=tP_P$) because we deem the assumption of strict proportionality of transaction costs to prices highly unrealistic. It surely does not hold true for specific duties as the British Corn Laws. Nevertheless, it is straightforward to adapt the model (cf. Online Appendix B) and using the 'iceberg' assumption yields almost identical results.

$P_P=P$ and omitting the constants, which do not affect the comparative statics. The market clears when the total demand equals the total supply:

$\gamma_P P+\gamma_C(P+t)=\alpha(P+t)+\beta P$

or:

$\gamma_P P+\gamma_C P-\alpha P-\beta P=\alpha t-\gamma_P t$

Re-arranging yields an expression for the effect of changes in trade costs on prices in the producing country:

$dP=[(\alpha-\gamma_C)/(\gamma_P+\gamma_C-\alpha-\beta)]dt$ 5)

While the parallel condition for the change in prices in the consuming country is:

$d(P+t)/dt=dP/dt+1$

$d(P+t)=[(\gamma_P-\beta)/(\gamma_P+\gamma_C-\alpha-\beta)]dt$ 6)

We express the unknown coefficients $\alpha$, $\beta$ and $\gamma$ in terms of elasticities of demand ($\eta_C$ and $\eta_P$) and supply ($\varepsilon_C$ and $\varepsilon_P$). To this aim, we select the units of measurement so that in the baseline year $P=1$ and $S_P=1$. Furthermore, we express consumption in the producing country and supply in the consuming country as proportions $x$ and $z$ of production in the producing country ($D_P=xS_P=x$ and $S_C=zS_P=z$). Of course, for tropical products (including cotton) $S_C=z=0$. In this notation, the demand in the consuming country is equal to imports from the producer ($X_P$) plus local supply $D_C=X_P+S_C=S_P-D_P+S_C=(1-x+z)$. Substituting in the standard definition of elasticity and re-arranging, we obtain $\alpha=\eta_C[(1-x+z)/(1+t)]$, $\beta=\eta_P*x$, $\gamma_C=\varepsilon_C\ [z/(1+t)]$ and $\gamma_P=\varepsilon_P$. We thus can re-write 5) and 6) as functions of the elasticities and of the parameters $x$, $t$ and $z$:

$$dP=[(\eta_C*(1-x+z)/(1+t)-\ z*\varepsilon_C/(1+t))]/\ [(\varepsilon_P+\ z*\varepsilon_C\ /(1+t)-\eta_C\ *(1-x+z)/(1+t)-\ \eta_P*x)]dt \qquad 7)$$

$$d(P+t)\ =(\varepsilon_P-\eta_P*x)/[(\varepsilon_P+z*\varepsilon_C/(1+t)-\eta_C*(1-x+z)/(1+t)-\eta_P*x)]dt \qquad 8)$$

These two formulae allow us to estimate how changes in trade costs are allocated and thus affect prices in exporting and importing countries. We can also estimate the effects of the changes in trade costs on trade ($dX_P$) as the difference between changes in demand ($dD_C$) and supply ($dS_C$) in the importing country:

$$dX_P=\alpha d(P+t)-\gamma_E d(P+t)=[\eta_E(1-x+z)/(1+t)-z*\varepsilon_C/(1+t)]*[(\varepsilon_C-\eta_P*x)/[(\varepsilon_P+z*\varepsilon_C/(1+t)-\eta_C(1-x+z)/(1+t)-\eta_P*x)]]dt \qquad 9)$$

Note that, given $\eta<0$ *and* $\varepsilon>0$, the first term in the numerator is negative, the second is positive and the denominator is positive: a decline in trade costs ($dt$<0) causes trade to rise.

[Figure 4 here]

We estimate the effect of price convergence on welfare as the differences between changes in producers' and consumers' surpluses (Figure 3). Following Hufbauer et al. (2002), we assume costs to remain positive rather than becoming nil as in the standard partial-equilibrium analysis of trade liberalization (the Haberger triangles).

A fall in trade costs implies that in the producing country (Figure 3) the price of the exported good rises by $dP_P$ causing demand to fall by $-dD_P$, domestic supply to rise by $dS_P$ and exports to increase by $dX_P$. The consumer surplus decreases by *YBAZ*, the producers' surplus increases by *YCDZ* – so that net gains are equivalent to the area of the trapezoid *ABCD*. The area can be decomposed in two triangles *ABF* and *CED*, which measure the reaction of consumers and producers to change in prices, and in a rectangle *BCEF*, which measures the benefits for producers from the increased prices. The respective areas can be measured as:

a) rectangle *BCEF*: $DWG_i=dP_P*(S_P-D_P)$

b) triangle *ABF*: $DWG_{ii}=-0.5*dP_P*dD_P=-0.5*dP_P^2*\eta_P*D_P/P_P$

c) triangle *CED*: $DWG_{iii}=0.5*dP_P*dS_P=0.5*dP_P^2*\varepsilon_P*S_P/P_P$ 10)

The total gains are obtained as a sum of the three:

$DWG_E=DW_i+DWG_{ii}+DWG_{iii}= dP_P*(S_P-D_P) - 0.5*dP_P^2*\eta_P*D_P/P_P+0.5*dP_P^2*\varepsilon_P*S_P/P_P$ 11)

Multiplying by $P_P/P_P$, dividing by $GNP_P$ and re-arranging yields:

$DWG_P/GNP_P= dP_P/P_P*[(S_P-D_P)*P_P/GNP_P]-0.5*(dP_P/P_P)^2*(\eta_P*D_P*P_P/GNP_P-\varepsilon_P*S_P* P_P/GNP_P)$ 12)

Defining $\delta_P= (D_P* P_P)/GNP_P$ and $\theta_P= (S_P* P_P)/GNP_P$ as the ratio of total consumption and production on $GNP_P$ yields the final formula:

$DWG_A/GNP_A = dP_P/P_P*(\theta_P-\delta_P)-0.5*(dP_P/P_P)^2*[\eta_P* \delta_P- \varepsilon_P*\theta_P]$ 13)

The second term is positive by definition as $\eta_P<0$ and $\varepsilon_P>0$. The first term is positive for net exporters, too, because market integration causes prices to rise ($dP_P/P_P$) and production exceeds consumption ($\theta_P-\delta_P>0$). Note that gains can be substantial for minor products if all production is exported (i.e. if $\theta_P$ and

$\delta_P$ are both very low) and for products mostly consumed at home (high $\delta_P$), if the surplus is large enough.

The reasoning is symmetric for the importing country, yielding:

$DWG_C/GNP_C=-dP_C/P_C*(\delta_C-\theta_C)+0.5*(dP_C/P_C)^2*[\varepsilon_C*\theta_C-\eta_C*\delta_C]$ 14)

The gains are positive in net importing countries because integration causes prices to fall ($dP_C/P_C<0$) and consumption exceeds production ($\delta_C-\theta_C>0$).

Summing up, we obtain expressions to estimate the changes in prices for producers (7) and for consumers (8) and consequently the changes in trade (9) and welfare (13 and 14) for each product given changes in price gaps (*dt*). They need only eight parameters: the elasticities of supply and demand in producing and consuming countries, the ratios of production in the consuming country and consumption in the producing country to production in the producing country, and the shares of production and consumption on GDP in a baseline year.

4) Trade costs and change in prices

As mentioned before the fitted price gaps from Chilosi and Federico (2015) (cf. Figure 1) correspond to 'iceberg' trade costs. We transform them into series of specific trade costs in two steps. First, we transform these ratios into nominal specific (i.e. per unit of weight) trade costs by taking the average of the specific cost implied by the expected (HP-filtered) import and export prices. Second, we deflate the nominal values with the export price index of the producing country.

We use our model to allocate changes in these trade costs *(dt)* on prices in producing ($dP_P$) and consuming countries ($dP_C$). We normalize all data to export prices of 1913, as data for that year are much more abundant than for previous ones (for sources for data on production and consumption and a discussion of the choice of the elasticities see the Online Appendix C). We double-check the results with an econometric test inspired by the literature on the pass-through of tariffs (e.g. Feenstra 1995; Marchand 2012; Nicita 2009). Specifically, we run the regression:

$$ln(p_{ijt})=\alpha_i-Producer*\theta_{p,i}ln(\tau_{it})+Consumer*\theta_{c,i*}ln(\tau_{it})+u_{ijt} \quad 15)$$

Where $p_{ijt}$ is the nominal price of the product *i* (e.g. Indian cotton) in place *j* at time *t*, the constant $\alpha_i$ estimates the natural logarithm of the nominal world price of that product,[4] *Producer* and *Consumer* are indicator dummies and $\tau_{it}$ are product and route-specific nominal trade costs. We interpret unit elasticity as perfect pass through and thus we constrain the sum of the shares of changes obtained by the producer ($\theta_{p,i}$) and by the consumer ($\theta_{c,i}$) to one.

[Table 3 here]

Table 3 reports the results separately since the first year of the series, which differs between goods ('earliest to 1913') or since 1870 ('1870 to 1913'). Note that the counterfactual of the model is an increase in price gaps, but we invert the signs to facilitate the interpretation and comparison with the results of the

[4] The assumption that this price is constant is strong, but all the parameters have the expected signs and expected sizes, and clustered standard errors by product imply that the shares estimated by the regression analysis are all significant at the 1 per cent level. Including linear time trends does not improve the results and there are not enough degrees of freedom to precisely estimate non-linear trends with time dummies.

regression. Estimates from the model and the regression are reassuringly similar: the unweighted averages are very similar and the coefficients of correlation are 0.92 ('earliest to 1913') and 0.85 ('1870 to 1913'). They differ in the allocation of whether producers or consumers saw more substantial price changes in four cases out of fourteen: cotton and linseed from India and sugar and tin from Indonesia. However, in two of them the absolute change in trade costs is very small. The difference is large only for sugar from Indonesia. There a visual inspection of the series suggests that most gains accrued to consumers, as implied by the regression (cf. Online Appendix A).

The message is clear: consumers fared better than producers. Only Indian tea growers and Indonesian coffee-growers received surely most of the gains from price convergence. As just said, in four other cases, results differ according to the method of estimation. Consumers got more in the remaining eight: indigo, jute, rapeseed, rice and wheat from India, wheat and cotton from the United States and rice for Indonesia. This latter case, however, needs some additional information. In fact, since the 1870s Indonesia started to import rice from India because local farmers were unable to meet the domestic demand for low-quality rice (van der Eng 1997: 182-183). According to the model, the 30 per cent fall in trade costs caused price of Indian rice in Batavia to decline by 25 per cent, while prices of local high quality rice increased by 2 per cent. This widening gap is obviously consistent with increasing imports.[5]

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[5] Reassuringly, both estimates imply that the fall in trade costs augmented prices in India by about 5 per cent.

Why did European consumers on average gain more than producers? We explore the issue by re-computing $dP_P$ and $dP_C$ under alternative assumptions about four key parameters: i) net export from producing countries equal to zero ($x$=1); ii) no alternative source of commodities for Europe ($z$=0); iii) inelastic European demand ($\eta_P$=0); iv) inelastic supply of European (or alternative) producers ($\varepsilon_C$=0). The results of latter hypothesis are the most similar to the baseline case.[6] This suggests that the outward shift in Asian supply caused by the decline in trade costs was not compensated by a parallel decrease in supply from other competitors. This interpretation is consistent with the results of the analysis of the export performance of Asian countries (Federico and Tena 2016c). The supply of manufactures was in all likelihood rather elastic and thus we speculate that exporters of industrial goods were more likely to gain from convergence than primary producers.

## 5) The effects of price convergence on the terms of trade

We estimate the contribution of market integration to changes in the terms of trade by comparing the actual movements with counterfactual, no integration ones. We compute these latter with a 'synthetic' export price index, which covers only the goods available in our data-base.[7] The contribution of price

[6] In all four cases, by construction, the predicted differences between the European and Asian shares are greater than in the baseline case. The average difference in case iv) is 11.5 per cent, as compared to 37.3 per cent, 35.3 per cent, and 50.4 per cent, respectively, under the first three alternative hypotheses.

[7] We build the 'synthetic' index for the United States as a Fisher index for wheat and cotton, while for India and Indonesia we estimate two different price indexes for the periods 1849-1870 and 1871-1913, so as to maximize coverage. The (Fisher) indexes for Indonesia include

convergence of our products to the change in terms of trade (*CT*) can be written as:

*CT=C1*C2*C3*  16)

Where *C1=Δexport price index/(Δexport price index-Δimport price index)* is the contribution of the absolute change in export prices to the change in terms of trade, *C2= Δsynthetic export price index/Δexport price index* is the contribution of the change in the 'synthetic' index to the overall change in export prices and *C3=1-Δsynthetic export price index/Δcounterfactual synthetic export price index* is the contribution of market integration to the change in the synthetic price index, and the operator *Δ* refers to total changes.

As a first step, we compute the contribution of actual convergence for the products of the synthetic index to the total improvement in terms of trade – i.e. the two first terms of eq. 16). We consider the period 1849-1913 for all countries for the sake of comparability across countries (the Indonesia series starts only in that year) and for Indonesia only the period 1849-1894, to explore the causes of the boom in the terms of trade (Figure 2).

[Table 4 here]

The results (Table 4) suggest two main points. First, the import side either mattered very little or even had a negative impact on terms of trade – i.e.

coffee, pepper, sugar and rice in 1849-1870 and coffee, pepper, sugar, rice and tin in 1871-1913. For India, we compute a Laspeyres index for 1849-1870 including only jute, indigo, linseed and rapeseed (using linseed as a proxy) and a Fisher one for 1871-1913, adding cotton, wheat and rice.

nominal import prices were rising rather than declining (although of course real prices might have declined). Indeed globalization forces were not as strong as on the export side. There was no massive liberalization of imports in producing countries, as duties on imports were low and constant in India and Indonesia, high and fluctuating in the United States (Federico and Vasta 2015). It is also likely that the decline in transportation costs affected imports much less than exports because imports consisted mostly in manufactures, which had a low freight factor since the beginning. Second, trends in the synthetic price index reproduce fairly well the movements in total export prices for India and the USA. For Indonesia, they over-predict changes in total prices in the long run, but they under-predict the changes before 1894. The bottom line of Table 4 shows that the increase in export prices of the covered commodities more than account for the whole improvement in terms of trade of the three producing countries in the long run. How much of this increase was accounted for by market integration?

We obtain a counterfactual, no-integration, index of prices comparable to the 'synthetic' one in three steps. First, we estimate counterfactual price ratios, hypothesizing that the monopolies of the Western trading companies on Asian trade had not been abolished, that telegraphic connections had not been established, and that duties and transport costs had remained constant at their initial level, and using the long-run elasticities estimated by the route-specific regressions presented in Chilosi and Federico (2015: Table 6). Then, we extract the corresponding prices in producing countries using the split predicted by the model (Table 3) and finally we compute the counterfactual synthetic export price index.

We check the robustness of results with two alternative econometric strategies. First, we estimate the elasticity of the export price index with respect to the price ratios by running the regression:

$ln(PE_{it})=\alpha_i+\Sigma\beta_{ik}ln(PR_{ikt})+\delta_i ln(PT_t)+u_{it}+\lambda u_{i,t-1}$ 17)

Where $PE_{it}$ is the synthetic export price index in country *i* at time *t*, $PR_{ikt}$ is the price ratio between export and import prices for the *k-th* good and $PT_t$ is a generic price index. We use for India and Indonesia an index of prices of tropical products in London (Federico and Tena 2016c) and for the USA a simple time trend, adding also a dummy for the civil war. Then, we compute the counterfactual price index as:

$PECF_{it}^2=Exp[ln(PE_{it})+\Sigma\beta_{ik}ln(PR_{ik0}-PR_{ikt})]$ 18)

Our third approach addresses the possible imprecision in estimating the elasticities $\beta$ from the neglect of changes in weights of the actual price index.[8] The specification is:

$ln(PE_{it})=\alpha_i+\beta_i ln(MI_{it})+\delta_i ln(PT_t)+u_{it}+\lambda u_{i,t-1}$ 19)

Where *MI* is a polity-specific index of market integration, which replicates the methodology used to compute the synthetic export price index, replacing prices with price ratios. We then compute the counterfactual price index as:

$PECF_{it}^3=Exp[ln(PE_{it})+\beta_i ln(MI_{i0}- MI_{it})]$ 20)

We report the contribution of price convergence to changes in the synthetic price index and to the terms of trade in Table 5.

[Table 5 here]

[8] Overall, 90 per cent of these elasticities have the expected sign, but only half of them are significant at the 5 per cent level.

Counterfactual 2 is higher than the other two, but the differences are not so large to force a different interpretation. The upper part of the table shows that price convergence accounted for most change in the synthetic export price index in India and Indonesia (almost all for the period before 1894) and about half of it in the USA. As seen before (Table 1), the products we consider are representative of trends in export prices, which, in turn, account for all the long-run improvement in terms of trade. A simple average of the implicit contribution according to the three counterfactuals (Table 5, lower part) suggests that price convergence of our products explains all the long-term increase in terms of trade for India and Indonesia and about a half for the United States. It caused terms of trade to improve by 120 per cent in India, by 47 per cent in Indonesia (by 62 per cent for the period 1849-1894) and by 5 per cent in the United States, vs. actual increases by 108 per cent, 52 per cent and 14 per cent in the same years.

## 6) The effects of price convergence on trade

We estimate the effects of price convergence on bilateral trade by product according to eq. 9) and we report the results in Table 6, normalizing to exports in 1913. As in Table 4, we consider separately the longest period possible for each product ('earliest to 1913') and the period 1870-1913 ('1870 to 1913').

Clearly, our model does not predict well changes in bilateral trade flows. For instance, it predicts an increase of Indian cotton exports to the United Kingdom from 1870 to 1913 equivalent to 6.7 times the exports in 1913, while actual exports declined by 4.9 times, or by 83 per cent of their 1870 level.

These divergences are not really surprising. Our estimate measures only the effect of changes in trade costs, ignoring all other factors which can affect trade. The list includes i) changes in total demand of the product in consuming and/or producing countries as consequence of technological change, increase in GDP per capita and population growth; ii) changes in trade costs between the consuming country and other suppliers of the good or between the producer and other consumers; iii) changes in supply conditions in the consumer country (e.g. wheat), in the exporting country or in any other competitor, as a consequence of changes in factor endowment and/or technology.

We measure these effects by running a panel regression (Head and Mayer 2014: 151).

$$ln(q_{it})=\alpha_i+\beta_{i1}year+\beta_2 ln(\tau_{it})+ \beta_{i3}D_{it}+u_{it} \quad 21)$$

Where $\alpha_i$ are flow-specific fixed effects, year are flow-specific trends aimed at capturing changes in the multilateral resistance factors (Anderson and von Wincoop 2004), $\tau_{it}$ are our series of (flow-specific and iceberg) trade costs, $D_{it}$ are dummies for relevant events, namely the American Civil War for American cotton and wheat and the introduction of synthetic dyes for indigo (since 1898).[9] We address potential endogeneity of transport costs by instrumenting

[9] Using a negative binomial regression yields a slightly lower $\beta_2$ coefficient, while the estimate of trade elasticity from a IV model with all series is about 40 per cent lower. We have experimented adding the available series of product-specific trade costs but the results have been disappointing: these other series have an opposite expected sign but are highly collinear

them as in Chilosi and Federico (2015).[10] Some products are missing because of our choice to start in 1848, itself as a compromise between the need to have a balanced sample to reduce the sample selection bias from missing trade data (Verbeek and Nijman 1992; Baltagi et al. 2014) and the need to extend our coverage back in time as much as possible to capture the effects of early globalization on trade.

Seven out of the eight fixed effects and product-specific trends are significant and all but two significant trends are positive (i.e. other factors increased bilateral trade, *ceteris paribus*). The trade elasticity ($\beta_2$) is negative and significant at the 1 per cent level. The coefficient (-1.81) is low, as the conventional wisdom suggests figure well in excess of -3 (Caliendo and Parro 2015; Head and Mayer 2014; Hilberry and Hummels 2013; Hugot 2015; Simonovska and Waugh 2014a, 2014b). Head and Mayer (2014) point out that naïve gravity models yield similarly low coefficients because they omit multilateral resistance effects but we control for these factors, albeit imperfectly. Therefore, we speculate that the difference reflects the nature of our data. With a fixed sample of goods, we can capture the intensive margin but we miss the extensive margin and possibly changes in mark-ups due to monopolistic competition (Simonovska and Waugh 2014b). Indeed, our

with the flow-specific ones. Likewise, omitting trends or adding GDP of origin and destinations worsens the results.

[10] Our instrument is a new series where we use the trend component of a HP decomposition of the freight factors to fit price gaps instead of the actual freight factors so as to eliminate the effect of potentially endogenous short-term fluctuations.

aggregate elasticity is consistent with product-specific parameters from Ossa (2015).[11]

We predict total change in bilateral trade as:

$\Delta q_i = exp[\alpha_i + \beta_{i1}*1913 + \beta_2 ln(\tau_{i,1913}) + \beta_{i3} D_{i,1913}] - exp[\alpha_i + \beta_{i1} year_o + \beta_2 ln(\tau_{i,t0}) + \beta_{i3} D_{i,t0}]$ 22)

And the effect of changes in trade costs, *ceteris paribus*, as:

$\Delta q^{\tau} = exp[\alpha_i + \beta_{i1} year_o + \beta_2 ln(\tau_{i,1913}) + \beta_{i3} D_{i,t0}] - exp[\alpha_i + \beta_{i1} year_o + \beta_2 ln(\tau_{i,t0}) + \beta_{i3} D_{i,t0}]$ 23)

The regression predicts fairly well the total change in trade in 1870-1913: the root mean square error (RMSE) is less than a quarter of the root mean square change. This ratio increases to 75 per cent over the whole period ('earliest to 1870') because of large divergences in the series of Indian indigo and Indonesian coffee. In contrast, the regression, as the model, does a poor job at predicting actual bilateral flows from changes in trade costs only, with RMSE over root mean square change ratios of over 200 per cent in the long run. In fact, the prediction errors are very similar between the two methods: the RMSE for the same set of products is higher for the regression in the long run and only slightly lower for the shorter period 1870-1913.[12]

Both approaches fail to capture the collapse in exports of indigo from India and coffee from Indonesia, which can be explained by specific circumstances. Indian exports of indigo were wiped out by the commercial development of

[11] The trade elasticities in 2007 are 1.01 for cotton, 1.7 sugar, 1.83 metallic ores, 2.13 oilseeds, 2.43 rice, 3 wheat and 3.19 coffee

[12] At the level of the product significant differences in the predictions are expected when the assumption of homogenous trade elasticity underlying the regression is violated (cf. Costinot and Rodriguez-Claire 2014: 242, Hilberry and Hummels 2013).

synthetic dyes in the 1890s, as shown by the fairly accurate prediction from the full regression, which, as said, includes a specific dummy for the event.[13] The fall in exports of Java coffee to the Netherlands must be framed in a general change in specialization of Indonesia. Coffee accounted for almost half of its exports in the early 1830s, for 40 per cent forty years later (and Java for a fifth of world trade) and for only 5 per cent on the eve of World War One. Total exports halved from the early 1870s to 1913, below the level of the early 1830s. The other cases of decline in bilateral trade flows can be explained with specific circumstances, too. Exports of Indian cotton to the United Kingdom were exceptionally high in the 1860s but then declined when the (qualitatively superior) American cotton returned to the British market and India re-oriented its exports towards Japan and other European countries. A similar dynamic explains the decline of Indian rice exports to the UK: the British share collapsed in the 1880s and continued to decline thereafter, at the same time as the shares grew for Asian countries like Indonesia and Japan and European ones such as Germany and the Netherlands (Statistical Abstract of British India, various issues).

Last but not least, by definition, as already mentioned, a product-specific approach cannot capture the effect of the decline in trade costs on the range of traded goods. This fact can explain the differences with the result by Estevadeordal et al. (2003: Table III) and Jacks et al. (2011: Table 5), who

[13]In the period 1870-1913 prices gaps for indigo were essentially trendless. Our preferred measure of trade costs detects a slight fall, but the iceberg trade costs detect a slight increase.

estimate that decline of trade costs explain respectively a third and half of the growth of world trade from 1870 to 1913.

7) The effects of price convergence on welfare

We estimate the welfare gains of price convergence for producers and consumers (here represented by the United Kingdom for simplicity), assuming that our estimates of price changes extend to all production or consumption of each commodity (i.e. that the market was not segmented by quality). We calibrate the model to 1913 and estimate the effects of a return of prices at their level at the beginning of the series ('earliest to 1913') or to their 1870 level ('1870 to 1913'), using both estimates of price changes from Table 3. We report gains by product in Table A9 in the Online Appendix, and in Table 7 we group them by major categories.

[Table 7 here]

The overall differences between the two estimates are quite modest, with some exceptions, most notably for Indonesia. Both methods, consistent with the results of the convergence analysis (Chilosi and Federico 2015), yield greater gains in the whole period (column 'earliest to 1913'). Actually, the data understate the difference with the short run (column '1870 to 1913') gains for the United Kingdom and India because these latter include three additional products. The short-run gains for the same set of goods are equivalent to 0.46 per cent of British and 0.83 per cent of Indian GDP according to the model (or 0.49 per cent and 0.61 per cent according to the regression).

The British consumers benefitted more than producers because they obtained most of the decline in trade costs (Section 3). Most of their gains come from wheat in the earliest period and this suggests an important role for the abolition of the Corn Laws. Although these latter were uniquely British, most European countries liberalized wheat imports in the mid-19th century (Federico 2012b), in all likelihood with substantial gains for their consumers. Our estimate of British gains from the integration of the cotton market in the long run is almost as large, because cotton industry was very important in the United Kingdom and used only imported raw material. However, part of these gains did not accrue to British consumers and were transferred back to purchasers of British cotton goods, including Indian ones.

The outcome of integration for the three producers was widely different, reflecting the share of net exports on GDP. Thus, United States gained little, because in 1913 wheat and cotton jointly accounted for only 3 per cent of GDP and most of the gains came from cotton because the United States exported about 60 per cent of its production. India gained little from the exports of rice and wheat because it consumed 93 per cent and 86 per cent of the output. Over two thirds of gains in the long run came from cotton and jute. The total gains for Indonesia depends on the allocation of price changes for sugar and, as said, the results of the regression (and thus the lower estimates of gains) seem more plausible. Furthermore, as a net importer of rice, Indonesia lost from the rise in price of domestic rice but gained from the decline in price of imported (inferior) Indian rice. As Table 7 shows, the net effect was positive.

As a whole, gains from price convergence were substantial but not huge. Admittedly, we neglect general-equilibrium effects, which however can potentially bias our results in either direction (Brockmeier and Bektasoglu 2014; Kokoski and Smith 1987; Narayanan et al. 2010). The size of this bias can be gleaned by comparing our results with available general-equilibrium estimates. According to the Computable General Equilibrium model by Williamson (1990: 136) the Corn Laws just before their abolition reduced British GDP by 1.5 per cent. As GDP grew four-folds between then and 1913, a straightforward comparison would imply that our (long-run) estimate is over twice as big. Taking into account the effect of transportation costs and the differences between 1841 and 1913, the order of magnitude of the two estimates is similar.[14] Federico and Tena (2016b) estimate with the sufficient statistics by Arkolakis et al. (2012) that in 1913 imports increased GDP by 1.41 per cent in the United States, by 2.26 per cent in Indonesia, by 2.31 per cent in India and by 9.08 per cent in the United Kingdom. This latter figure tallies well with our estimate taking into account that this refers about 20 per cent of British imports (Board of Trade 1913) and the different counterfactual (autarky for Arkokalis et al., finite trade costs for ours). The two sets of estimates are broadly consistent also for the producing countries, given the shares on total exports (Table 2) and Arkolakis et al.'s assumption of balanced trade. Thus, our model captures most of welfare gains: if anything, these comparisons suggests it overvalues the gains.

[14] In comparison to 1841, in 1913 the gap between production and consumption of wheat was larger (augmenting the gains *ceteris paribus*), but the share of wheat on consumption lower (reducing the gains).

It would be rash to extend our aggregate estimates to other countries and thus a fortiori to the whole world economy. We will rather perform a back of the envelope estimate of gains from integration of market of a key commodity, cotton, which accounted for about 5 per cent of world trade in 1913 (Federico and Tena 2016c). The United States and India accounted for 65 per cent and 15 per cent of world export and Egypt for a further 13 per cent. The country exported almost nothing else (Panza 2013) – and thus we assume gains from integration to have accounted for 1 per cent of GDP (about twice than the Indian gains). From consumption side, we consider only Western Europe and Japan, omitting minor producers and we assume conservatively that gains from cotton imports amounted to 0.25 per cent of their GDP, a quarter of the British ones. With these parameters, the integration of the cotton market increased world GDP in 1913 by about a quarter of a percentage point.

All these figures refer to nation-wide gains: how were they distributed among regions and between different social groups within regions? In general, the distribution of gains would be the more equitable the wider the production (or consumption) area and the more competitive the markets for factors and commercial services are. In Europe, most people benefitted of integration, as the whole populations consumed wheat, tropical goods and cotton manufactures, and the markets for their distribution were fairly competitive. In contrast, the production for export was often concentrated in a few areas, which consequently reaped most of the gains from integration. In the United States, in 1913 seven states, all in the South, produced each more than 5 per cent of the whole cotton output, jointly accounting for 90 per cent of it.[15] In the Dutch East Indies, two provinces accounted for 74 per cent of exports of tin, 60 per cent of sugar and 45 per cent of pepper and coffee (Clemens et al. 1992: Tables 3 and 4). Production was highly concentrated also in India. The share of the largest producing state ranged from a third for wheat, rice and cotton to almost nine tenths for jute (Bengal), and that of the two top states from a half for cotton to 96 per cent (jute again). On the other hand, these pockets of specialization by product were scattered all over the subcontinent. In fact, eight states produced more than 5 per cent of the total output of the export crops of our sample, and the most important of them, Bengal, did not reach a quarter of the total. We compute the GDP by state as total Indian GDP times the share of each state on population from the 1911 Census (Statistical Abstract) and we estimate the gains.[16] Over the whole period ('earliest to 1913'), they ranged from over 5 per cent in the Central Provinces to less than 0.2 per cent in Burma and Mysore. As implicit in Table 6, gains since 1870 were smaller, but the dispersion across provinces and the ranking were pretty similar, with a notable exception: Assam. It is close to the bottom according to the long run estimate (gains 0.4 per cent of GDP) and comes top in short-run one (3.9 per cent). This jump reflects the change in coverage, as tea, Assam's main staple, is missing from the long-run analysis.

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[15] The data are from the ATICS data-base (Federico and Sharp 2013). Wheat output was less concentrated: only 5 states (all in the West North Central) exceeded 5 per cent of production, with a total share 53 per cent.

[16] By definition $Pi/GDPi=Pi/PT*GDPT/GDPi*Pt/GDPT$, where $P$ is gross output of exportable goods and $i$ and $T$ refers respectively to the province and to British India

The evidence on the organization of local markets for exportable goods is very thin but, with two major exceptions, it does not suggest a very high level of market power. The United States have a solid reputation for being a competitive economy, even if the American wheat farmers complained bitterly of being squeezed by railways companies and middlemen (Persson and Sharp 2013). Yet obviously plantation owners rather than slaves had to enjoy most of the gains from the integration of the world cotton market in the pre-civil war American South. Concentration of export of indigo from Bengal in 1840-1842 was not high: there were, according to a source, 32 exporting houses, and the top six managed about two thirds of the total trade.[17] However, indigo was extracted from a root, and thus benefits could accrue to industrialists rather than to cultivators. Indeed Ray (2011) argues that the final demise of the Bengal indigo industry was accelerated by a change in legislation to favor owners of indigo workshops over peasants. Gupta (1997, 2001, 2005) finds evidence of oligopolistic pricing in inter-war India in the British-dominated jute and tea industries, but collusion was unstable. The only well-documented instance of monopoly is the Dutch Cultivation System, set up in 1830 to extract revenues in kind from Indonesian peasant. The system worked very well: the losses amounted to about 6 per cent of GDP of Java, with peaks over 8 per cent in some years (Van Zanden and Marks 2012: 51). Most of these sums accrued to the Dutch government, and the rest to Dutch business. The transfers amounted to almost 4 per cent of the Dutch GDP in the 1850s, plus another 0.6 per cent for hidden subsidies to shipping (Van Zanden and Van Riel 2004: Table 5.1; GDP from Smits et al. 2000). However,

[17] Personal communication by M. Aldous.

the system was slowly phased out, and since the early 1870s exports were totally free.

Last but not least, all these computations refer to gains from international trade only and thus neglect the additional gains from domestic integration. Without barriers to trade to abolish, gains could be had only by cutting domestic transportation costs. This latter was small and gains consequently limited, for sea-borne trade. For instance, the freight factor for the transport of tin between the mines, in the islands of Bangka, to Batavia, never exceeded 2 per cent over the whole period 1839 to 1928, declining about 1.5 per cent in the 1870s-1880s to 0.7-0.8 per cent in the interwar years (cf. Korthals Altes 1994: Appendix A). In contrast, overland transportation costs fell dramatically. The freight factor for transport wheat from Chicago to New York by rail fell from over 50 per cent in the 1850s to about 10 per cent on the eve of World War One, to rebound in the interwar years as a consequence of rail regulation (Federico and Sharp 2013). For Donaldson and Hornbeck (2013) in the late nineteenth century the American railroads increased GDP by 3.40 per cent per year solely through their impact on land values. There is some evidence of convergence of rice prices also in Indonesia (van Zanden and Marks 2012: 25-26) and price gaps in the 1920s were decidedly smaller than in India (Marks 2010). But in India, too, price gaps for rice and wheat shrank in the second half of the 19$^{th}$ century (Hurd 1975; Studer 2008; Andrabi and Kuehlwein 2010). Indeed, two recent estimates, with different methods, suggest quite high gains from railways in India on the eve of World War One – around 6 per cent according to Bogart et al. (2015), who relies on growth accounting and about 16 per cent according to Donaldson (forthcoming), who uses a general equilibrium model.

## 8) Conclusions

So far, historians and economists have assumed the effects of market integration during the first globalization to be positive and extensive, mostly on the basis of a purely theoretical reasoning. This paper is a first attempt to quantify them, comparing a success-story such as the Unites States with two large peripheral Asian countries with the same analytical framework. We have used a data-parsimonious and thus easily replicable model, buttressing the results with additional econometric testing. We find that:

i) price convergence explains almost all the improvement in terms of trade in producing countries. If improvements in terms of trade on long-run economic growth were harmful as posited by Williamson (2011), the dynamic losses may compensate the static benefits of integration.

ii) price convergence did foster large increases in bilateral trade, but for many products its effect was balanced or overwhelmed by other forces. The comparison between regression-based estimates with and without the (crude) estimates of multilateral resistance factor confirms that the latter were indeed a major determinant of bilateral trade (Anderson Van Wincoop 2004).

iii) price convergence brought substantial (static) benefits to both producers and especially consumers but their size differed rather markedly across countries and time and, in all likelihood, also within producing countries.

In a nutshell, our analysis suggests that trade costs were important for trade and welfare, but their effects fall short from the most extravagant expectation, cautioning against the substation of proxies to actual measures.

# Tables

## Table 1

Percentages of products on total exports

| | India | Indonesia | United States |
|---|---|---|---|
| 1810 | 26.4 | 84.0[a] | 28.4 |
| 1830 | 45.0[b] | 67.1 | 47.0 |
| 1850 | 40.5 | 76.3 | 55.0 |
| 1870 | 55.5 | 73.3 | 59.5 |
| 1890 | 57.1 | 59.4 | 34.5 |
| 1900 | 46.5 | 56.4 | 25.3 |
| 1913 | 53.3 | 43.4 | 27.2 |

*Notes*: [a] 1823, [b] 1828

*Sources*: India: Chaudhuri (1982), Indonesia: Korthals Altes (1991), United States: Historical Statistics (2006: series Ee 571 and 575).

## Table 2

Shares on world exports (in percentage)

| | India | Indonesia | Asia | USA | World (mil $ 1913) |
|---|---|---|---|---|---|
| 1831 | 5.1 | 0.6 | 12.5 | 6.5 | 916 |
| 1851 | 5.0 | 1.4 | 14.2 | 8.9 | 2045 |
| 1870 | 5.4 | 0.9 | 12.5 | 7.9 | 4690 |
| 1890 | 5.9 | 1.0 | 12.3 | 11.3 | 8901 |
| 1900 | 4.0 | 1.1 | 11.0 | 14.4 | 11437 |
| 1912 | 4.5 | 1.4 | 12.2 | 12.9 | 17688 |

*Source*: Federico and Tena (2016a)

*Notes*: The column ‘World’ is at constant (1913) prices, while the shares are computed on three-year moving averages with data at current prices. Trends of shares at 1913 prices are similar, but the decline of India is much steeper.

Table 3
The allocation of price convergence

| | | | | Elasticities | | | | | Model | | Regression | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Good | Origin | Destination | Start | $\eta_P$ | $\eta_C$ | $\varepsilon_P$ | $\varepsilon_C$ | *dt* | $dP_P$ | $dP_C$ | $dP_P$ | $dP_C$ |
| Earliest to 1913 | | | | | | | | | | | | |
| Cotton | India | UK | 1868 | -0.8 | -0.7 | 0.5 | 1 | -50 | 36 | -14 | 17 | -32 |
| Indigo | India | UK | 1823 | -1 | -1.5 | 0.5 | 0.5 | -228 | 72 | -156 | 87 | -141 |
| Jute | India | UK | 1845 | -1 | -1 | 0.5 | 0.5 | -50 | 17 | -34 | 25 | -25 |
| Linseed | India | UK | 1847 | -0.5 | -1.2 | 0.5 | 0.5 | -67 | 49 | -17 | 28 | -39 |
| Wheat | India | UK | 1862 | -0.5 | -1.2 | 0.5 | 0.5 | -84 | 37 | -47 | 29 | -54 |
| Coffee | Indonesia | Netherlands | 1834 | -0.5 | -1 | 0.5 | 0.5 | -30 | 24 | -6 | 19 | -11 |
| Rice | Indonesia | Netherlands | 1849 | -0.5 | -0.5 | 0.5 | 0.75 | -103 | 6 | -97 | 38 | -65 |
| Sugar | Indonesia | UK | 1824 | -0.3 | -1 | 0.5 | 0.5 | -71 | 59 | -13 | 11 | -61 |
| Tin | Indonesia | Netherlands | 1864 | -1 | -0.9 | 1 | 1 | -9 | 3 | -7 | 7 | -3 |
| Cotton | USA | UK | 1816 | -0.65 | -0.7 | 1 | 0.5 | -58 | 18 | -40 | 16 | -42 |
| Wheat | USA | UK | 1816 | -0.5 | -0.5 | 0.75 | 0.75 | -74 | 18 | -57 | 29 | -46 |
| Average | | | | | | | | | | | | |
| India | | | | | | | | -96 | 42 | -54 | 37 | -58 |
| Indonesia | | | | | | | | -54 | 23 | -31 | 19 | -35 |
| USA | | | | | | | | -66 | 18 | -48 | 22 | -44 |
| 1870-1913 | | | | | | | | | | | | |
| Cotton | India | UK | 1870 | -0.8 | -0.7 | 0.5 | 1 | -38 | 28 | -11 | 13 | -25 |
| Indigo | India | UK | 1870 | -1 | -1.5 | 0.5 | 0.5 | -16 | 5 | -11 | 6 | -10 |
| Jute | India | UK | 1870 | -1 | -1 | 0.5 | 0.5 | -35 | 11 | -23 | 17 | -17 |
| Linseed | India | UK | 1870 | -0.5 | -1.2 | 0.5 | 0.5 | -22 | 16 | -6 | 9 | -13 |

Table 3-cont.

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rapeseed | India | UK | 1872 | -0.5 | -1.2 | 0.5 | 0.5 | -43 | 12 | -30 | 18 | -25 |
| Rice | India | UK | 1871 | -0.5 | -1 | 0.5 | 0.5 | -56 | 4 | -52 | 16 | -40 |
| Tea | India | UK | 1894 | -1 | -1 | 0.5 | 0.5 | -21 | 15 | -6 | 15 | -6 |
| Wheat | India | UK | 1870 | -0.5 | -0.5 | 0.5 | 0.75 | -31 | 14 | -18 | 11 | -20 |
| Coffee | Indonesia | Netherlands | 1870 | -1 | -1 | 0.5 | 0.5 | -11 | 9 | -2 | 7 | -4 |
| Rice | Indonesia | Netherlands | 1870 | -0.5 | -1 | 0.5 | 0.5 | -31 | 2 | -29 | 11 | -19 |
| Sugar | Indonesia | UK | 1870 | -0.3 | -1 | 0.5 | 0.5 | -38 | 31 | -7 | 6 | -32 |
| Tin | Indonesia | Netherlands | 1870 | -1 | -0.9 | 1 | 1 | -12 | 4 | -8 | 8 | -3 |
| Cotton | USA | UK | 1870 | -0.65 | -0.7 | 1 | 0.5 | -1 | 0 | -1 | 0 | -1 |
| Wheat | USA | UK | 1870 | -0.5 | -0.5 | 0.75 | 0.75 | -29 | 7 | -22 | 11 | -18 |
| Average | | | | | | | | | | | | |
| India | | | | | | | | -35 | 12 | -22 | 14 | -21 |
| Indonesia | | | | | | | | -23 | 11 | -11 | 8 | -15 |
| USA | | | | | | | | -15 | 4 | -12 | 6 | -9 |

*Sources*: see text and Online Appendix C.

*Notes*: $\eta_P$, $\eta_C$, $\varepsilon_P$ and $\varepsilon_C$ are the elasticities of demand and supply in the origin and destination countries, respectively; *dt* is the change in specific real trade costs as a proportion of the export price in 1913 (in percentage); $dP_P$ and $dP_C$ are the changes in export and import prices resulting from the change in trade costs, measured as a proportion of the export price in 1913 (in percentage).

Table 4
The changes in actual terms of trade

| | 1849-1913 | | | 1849-94 |
|---|---|---|---|---|
| | India | Indonesia | USA | Indonesia |
| Total change | | | | |
| Terms of trade | 110 | 41 | 10 | 125 |
| Export prices (actual) | 93 | 53 | 54 | 63 |
| Export prices (synthetic) | 118 | 108 | 39 | 32 |
| | | | | |
| Contribution (in percentage) | | | | |
| Export prices to terms of trade (C1) | 110 | 92 | 292 | 82 |
| Synthetic export prices to total export prices (C2) | 127 | 203 | 72 | 52 |
| Synthetic export prices to terms of trade (C1*C2) | 140 | 187 | 210 | 42 |

*Sources*: see text, Online Appendix C and Federico and Tena (2015a).
*Notes*: total changes estimated with HP filters; the reference is 1849=100.

Table 5
The contribution of price convergence to the terms of trade (in percentage)

| | 1849-1913 | | | 1849-1894 |
|---|---|---|---|---|
| | India | Indonesia | USA | Indonesia |
| To changes in synthetic export price index (C3) | | | | |
| Counterfactual 1 | 64 | 45 | 15 | 98 |
| Counterfactual 2 | 91 | 79 | 44 | 150 |
| Counterfactual 3 | 76 | 64 | 19 | 110 |
| To changes in terms of trade (C1* C2* C3) | | | | |
| Counterfactual 1 | 89 | 85 | 31 | 41 |
| Counterfactual 2 | 128 | 148 | 92 | 63 |
| Counterfactual 3 | 107 | 119 | 40 | 46 |

*Sources*: see text.

Table 6
The effect of price integration on trade (in percentage)

| Good | Origin | Actual Earliest To 1913 | 1870-1913 | Predicted change, model Earliest To 1913 | 1870-1913 | Predicted change, regression, trade costs only Earliest To 1913 | 1870-1913 | Predicted change, regression, full specification Earliest To 1913 | 1870-1913 |
|---|---|---|---|---|---|---|---|---|---|
| Cotton | India | -593 | -489 | 866 | 668 | | | | |
| Indigo | India | -847 | -1326 | 756 | 52 | 1494 | -163 | -1530 | -1515 |
| Jute | India | 97 | 57 | 82 | 57 | 24 | 32 | 154 | 136 |
| Linseed | India | 98 | 53 | 113 | 37 | 36 | 15 | 131 | 87 |
| Rapeseed | India | | -111 | | 813 | | | | |
| Rice | India | | -64 | | 742 | | | | |
| Tea | India | | 38 | | 13 | | | | |
| Wheat | India | 98 | 99 | 449 | 168 | | | | |
| Coffee | Indonesia | -23 | -172 | 46 | 17 | 342 | 90 | -188 | -98 |
| Rice | Indonesia | 54 | 65 | 1057 | 314 | 32 | 21 | 46 | 31 |
| Sugar | Indonesia | 100 | 95 | 213 | 114 | 0 | 1 | 52 | 47 |
| Tin | Indonesia | 67 | 57 | 7 | 9 | | | | |
| Cotton | US | 97 | 56 | 89 | 2 | 13 | 9 | 98 | 63 |
| Wheat | US | 98 | 56 | 45 | 18 | 6 | 12 | 132 | 107 |

*Sources*: Online Appendix C

Table 7
The welfare effect of price convergence (in percentage of GDP)

| | Model | | Regression | |
|---|---|---|---|---|
| | Earliest to 1913 | 1870-1913 | Earliest to 1913 | 1870-1913 |
| United Kingdom | 2.054 | 0.571 | 2.147 | 0.764 |
| Wheat | 0.989 | 0.351 | 0.773 | 0.336 |
| Cotton | 0.823 | 0.046 | 0.858 | 0.081 |
| Other goods | 0.242 | 0.173 | 0.516 | 0.346 |
| | | | | |
| United States | 0.228 | 0.007 | 0.208 | 0.008 |
| Wheat | 0.008 | 0.002 | 0.018 | 0.011 |
| Cotton | 0.220 | 0.005 | 0.190 | 0.019 |
| | | | | |
| India | 1.362 | 1.016 | 0.999 | 0.885 |
| Cereals | 0.246 | 0.136 | 0.195 | 0.201 |
| Cotton | 0.677 | 0.515 | 0.321 | 0.246 |
| Other goods | 0.439 | 0.365 | 0.483 | 0.437 |
| | | | | |
| Indonesia | 2.166 | 1.550 | 0.594 | 0.579 |
| Rice (exports) | | -0.032 | | -0.162 |
| Rice (imports) | | 0.455 | | 0.318 |
| Other goods | 2.166 | 1.127 | 0.594 | 0.442 |

*Sources*: see text and Online Appendix C

# Figures

## Figure 1

Price ratios and fitted values, selected commodities

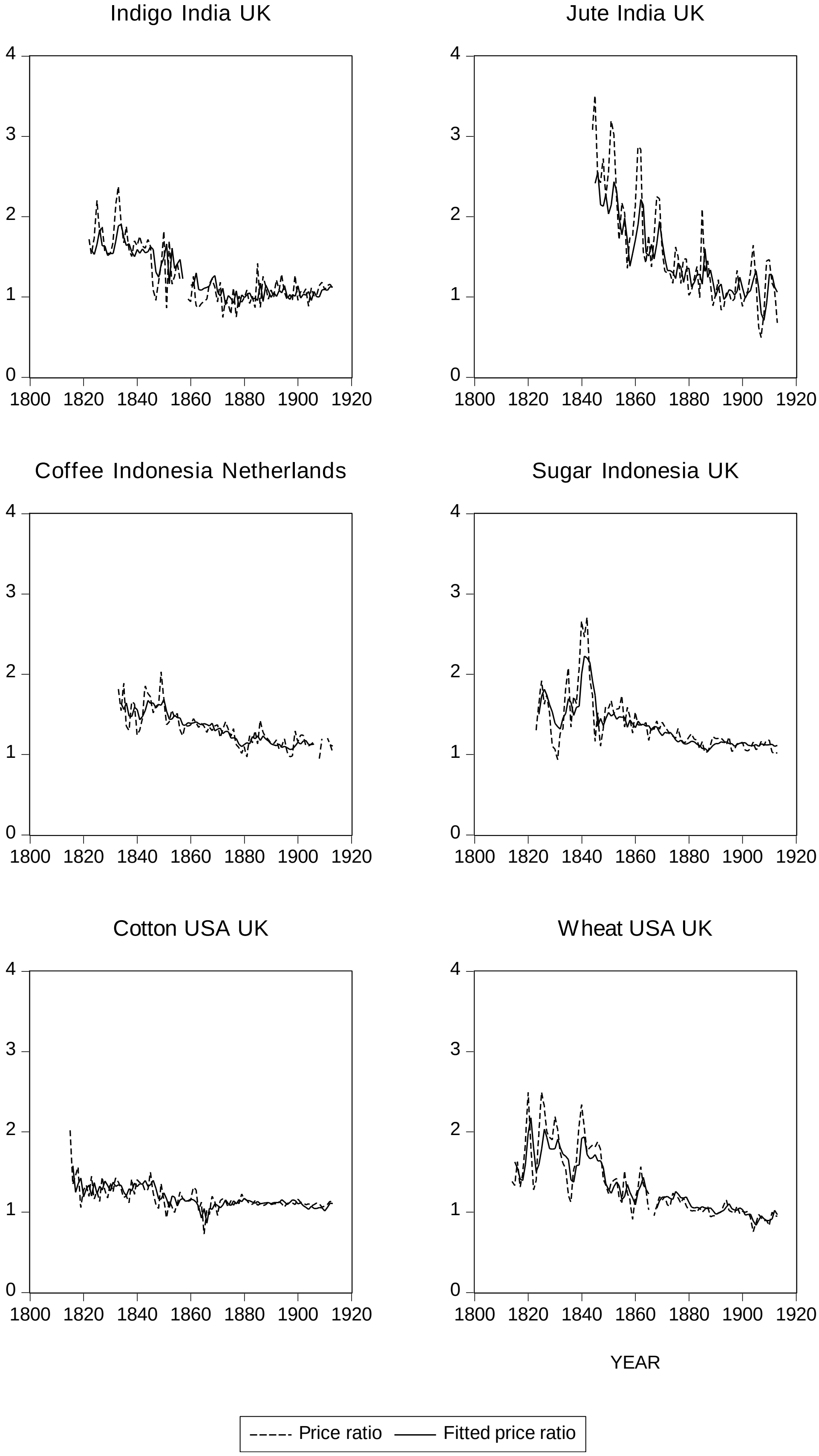
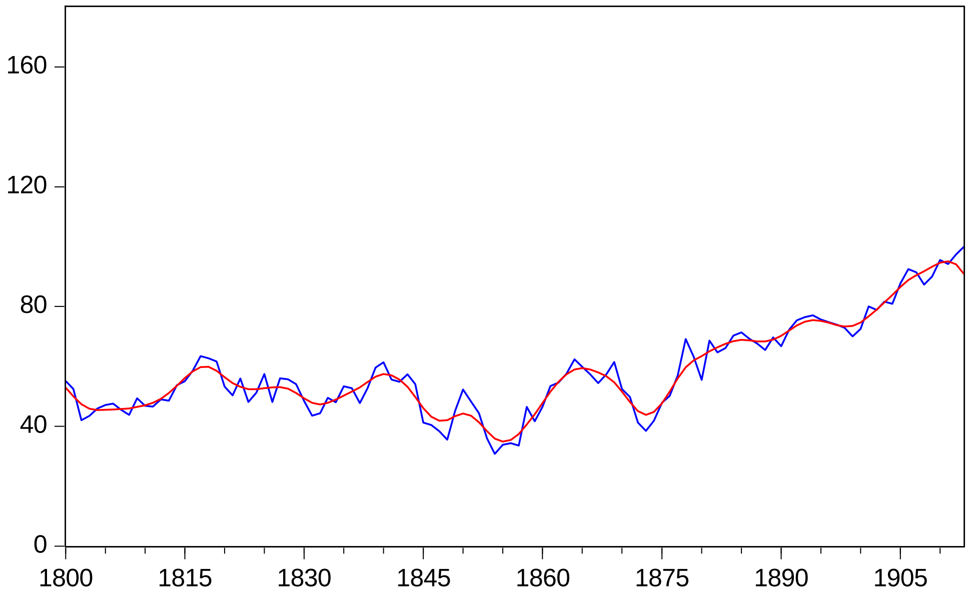
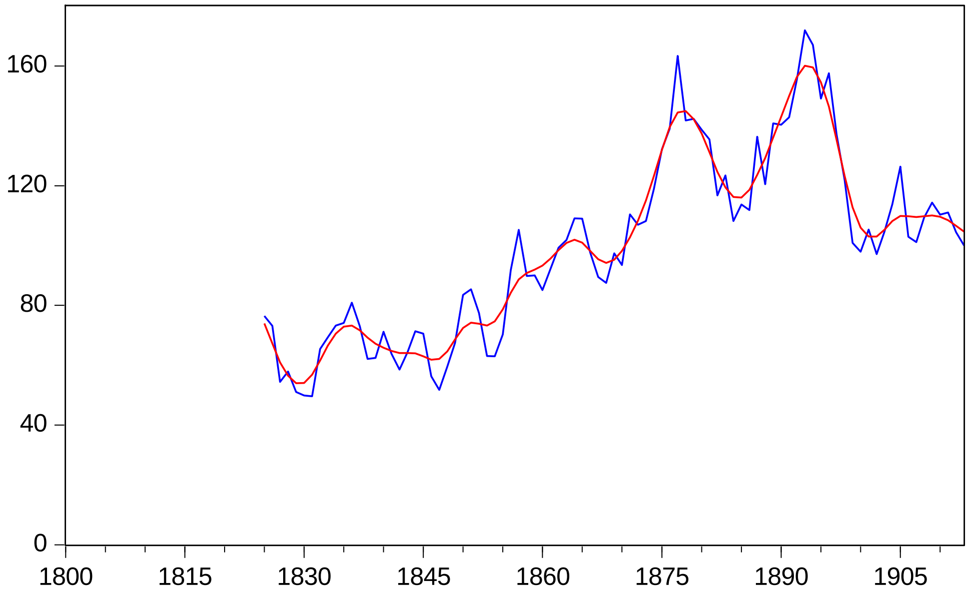


Figure 2
Terms of trade (1913=100)

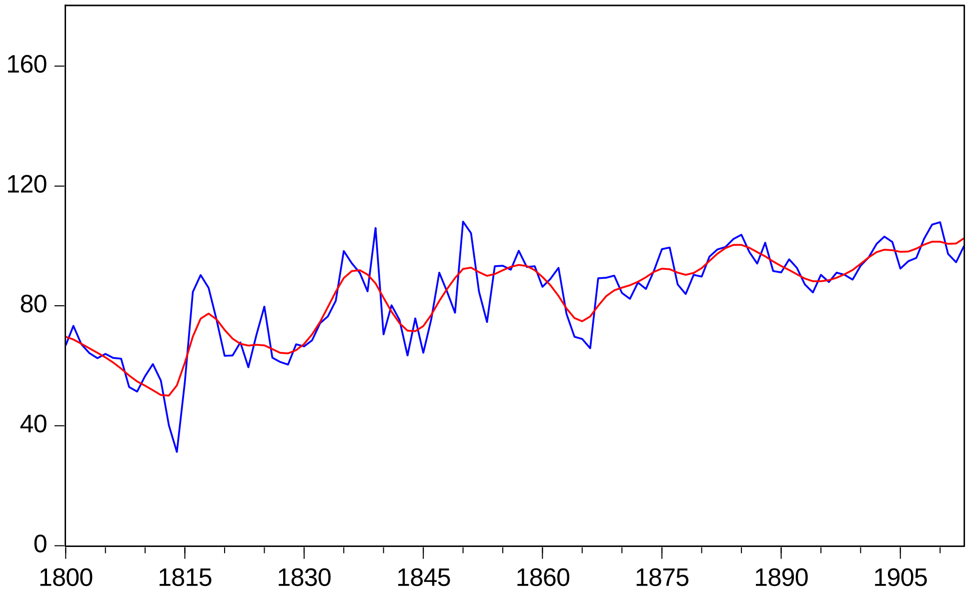
a) India




b) Indonesia

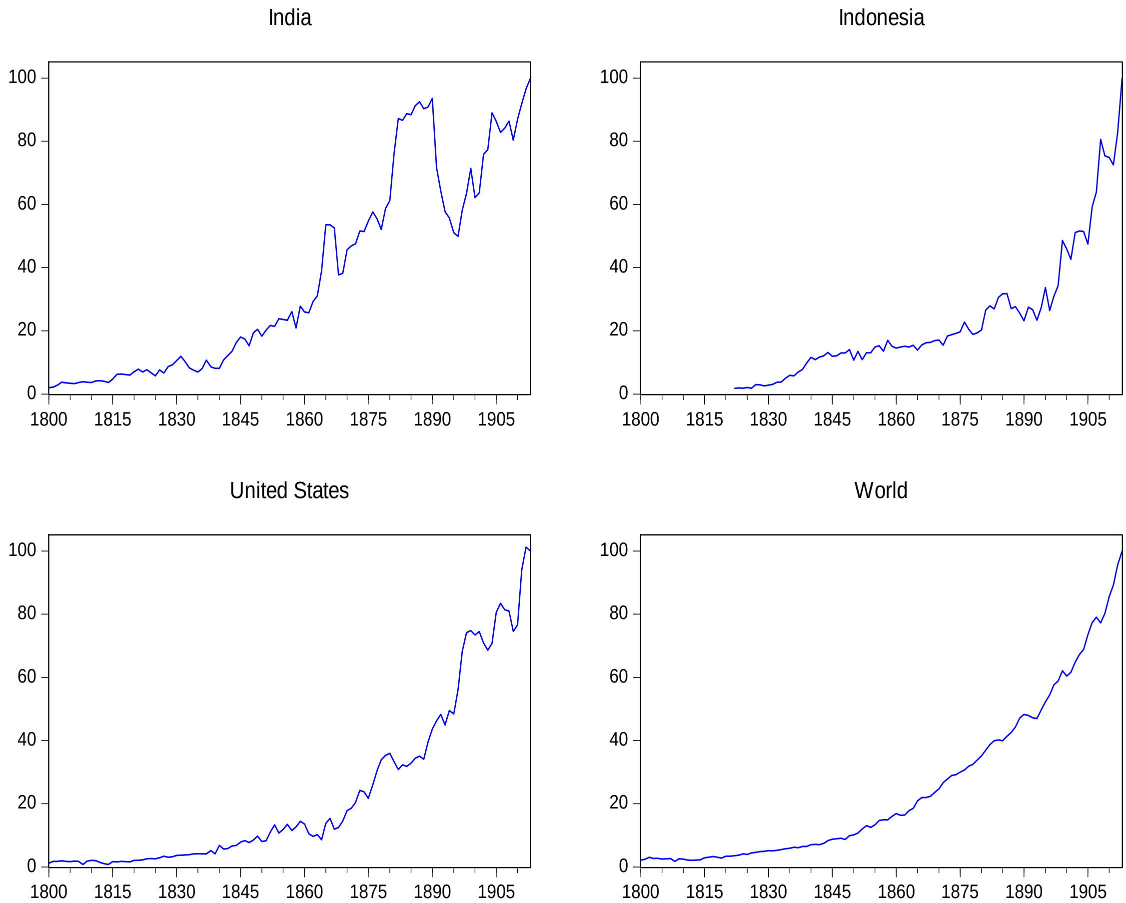


c) United States



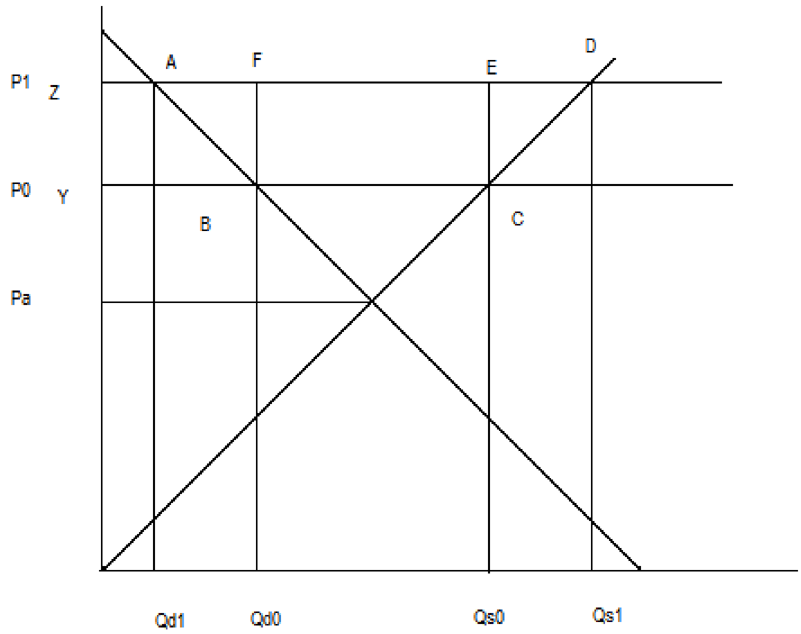

*Sources*: cf. Federico and Tena (2016a).

Figure 3
The growth of exports at constant prices (1913=100)




*Source*: Federico and Tena (2016a).

Figure 4
Welfare gains from integration, producing country



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**Appendix A: statistical appendix**

Table A1
Shares of changes in trade costs for producing countries: regression analysis

| | | | | |
|---|---|---|---|---|
| Constant | | | | |
| Good | Origin | Destination | | |
| Cotton | India | UK | 3.712 | *** |
| Indigo | India | UK | 5.832 | *** |
| Jute | India | UK | 2.614 | *** |
| Linseed | India | UK | 2.348 | *** |
| Rapeseed | India | UK | 2.254 | *** |
| Rice | India | UK | 1.950 | *** |
| Tea | India | UK | 4.590 | *** |
| Wheat | India | UK | 1.928 | *** |
| Coffee | Indonesia | Netherlands | 4.360 | *** |
| Rice | Indonesia | Netherlands | 1.739 | *** |
| Sugar | Indonesia | UK | 2.471 | *** |
| Tin | Indonesia | Netherlands | 5.071 | *** |
| Cotton | Us | UK | 3.602 | *** |
| Wheat | Us | UK | 2.235 | *** |
| | | | | |
| -Share | | | | |
| Good | Origin | Destination | | |
| Cotton | India | UK | -0.209 | *** |
| Indigo | India | UK | -0.381 | *** |
| Jute | India | UK | -0.499 | *** |
| Linseed | India | UK | -0.414 | *** |
| Rapeseed | India | UK | -0.425 | *** |
| Rice | India | UK | -0.281 | *** |
| Tea | India | UK | -0.714 | *** |
| Wheat | India | UK | -0.351 | *** |
| Coffee | Indonesia | Netherlands | -0.642 | *** |
| Rice | Indonesia | Netherlands | -0.371 | *** |
| Sugar | Indonesia | UK | -0.151 | *** |
| Tin | Indonesia | Netherlands | -0.720 | *** |
| Cotton | US | UK | -0.270 | *** |
| Wheat | US | UK | -0.387 | *** |
| | | | | |
| *R-squared* | | | 0.820 | |
| *N* | | | 2358 | |

*Notes*: *N*=number of observations; ***=significant at the 1 per cent level; **=significant at the 5 per cent level; *=significant at the 10 per cent level; standard errors clustered by trade flow.

Figure A1
The price of Java sugar in Indonesia and in the UK (£/long ton)

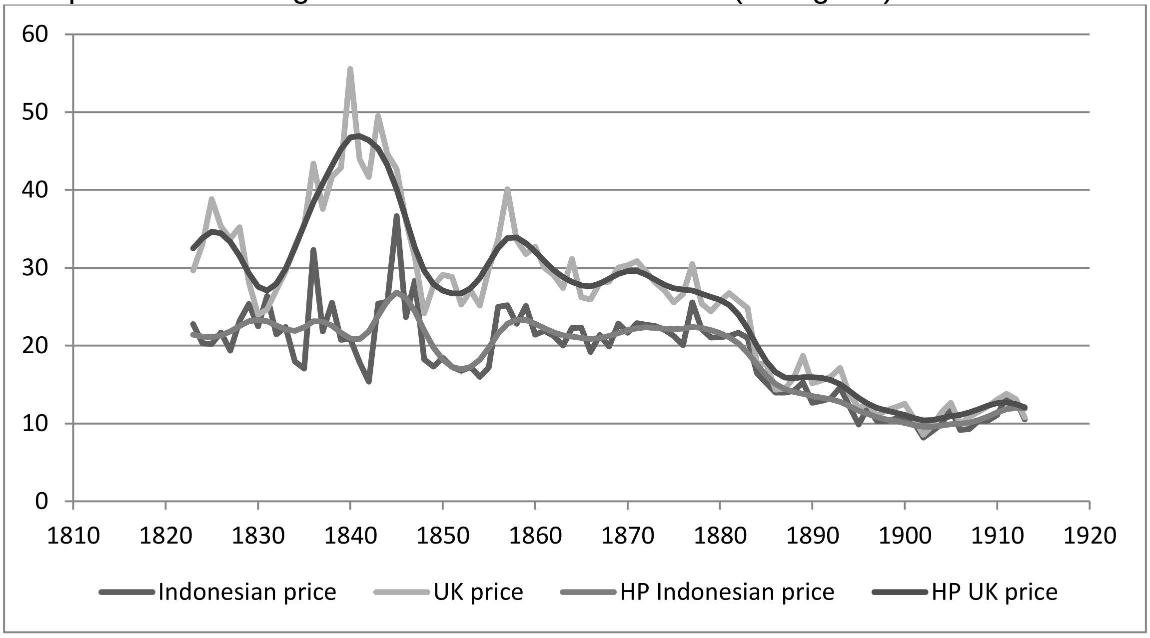


Table A2
Elasticity of the synthetic price index with respect to price ratios: India, 1850-1913

| | | |
|---|---|---|
| *C* | 4.592 | *** |
| *LOG_INDIGO* | -0.097 | ** |
| *LOG_JUTE* | -0.477 | *** |
| *LOG_LINESEED* | -0.408 | *** |
| *LOG_RAPESEED* | 0.089 | |
| *LOG_P* | 0.229 | ** |
| *AR(1)* | 0.929 | *** |
| | | |
| *Adj. R-squared* | 0.921 | |
| *N* | 62 | |

*Notes*: *N*=number of observations; ***=significant at the 1 per cent level; **=significant at the 5 per cent level; *=significant at the 10 per cent level.

Table A3
Elasticity of the synthetic price index with respect to price ratios: India, 1872-1913

| | | |
|---|---|---|
| *C* | 2.744 | *** |
| *LOG_COTTON* | -0.224 | * |
| *LOG_INDIGO* | -0.250 | *** |
| *LOG_JUTE* | -0.156 | *** |
| *LOG_LINESEED* | 0.138 | |
| *LOG_RAPESEED* | -0.052 | |
| *LOG_RICE* | -0.077 | |
| *LOG_WHEAT* | -0.183 | ** |
| *LOG_P* | 0.317 | *** |
| *AR(1)* | 0.885 | *** |
| | | |
| *Adj. R-squared* | 0.911 | |
| *N* | 42 | |

*Notes*: *N*=number of observations; ***=significant at the 1 per cent level; **=significant at the 5 per cent level; *=significant at the 10 per cent level.

Table A4
Elasticity of the synthetic price index with respect to price ratios: Indonesia, 1850-1913

| | | |
|---|---|---|
| *C* | 2.956 | *** |
| *LOG_COFFEE* | -0.516 | *** |
| *LOG_PEPPER* | -0.014 | |
| *LOG_RICE* | -0.024 | |
| *LOG_SUGAR* | -0.405 | *** |
| *LOG_P* | 0.446 | *** |
| *AR(1)* | 0.860 | *** |
| | | |
| *Adj. R-squared* | 0.875 | |
| *N* | 64 | |

*Notes*: *N*=number of observations; ***=significant at the 1 per cent level; **=significant at the 5 per cent level; *=significant at the 10 per cent level.

Table A5
Elasticity of the synthetic price index with respect to price ratios: Indonesia, 1872-1913

| | | |
|---|---|---|
| *C* | 3.0651 | *** |
| *LOG_COFFEE* | -0.168 | * |
| *LOG_PEPPER* | -0.359 | * |
| *LOG_TIN* | -0.12 | |
| *LOG_SUGAR* | -0.274 | * |
| *LOG_P* | 0.3367 | *** |
| *AR(1)* | 0.8716 | *** |
| | | |
| *Adj. R-squared* | 0.842 | |
| *N* | 42 | |

*Notes*: *N*=number of observations; ***=significant at the 1 per cent level; **=significant at the 5 per cent level; *=significant at the 10 per cent level.

Table A6
Elasticity of the synthetic price index with respect to price ratios: United States, 1850-1913

| | | |
|---|---|---|
| *C* | 26.024 | * |
| *LOG_COTTON* | -0.598 | ** |
| *LOG_WHEAT* | -0.202 | |
| *CIVIL WAR* | 0.303 | ** |
| *YEAR* | -0.011 | |
| *AR(1)* | 0.854 | *** |
| | | |
| *Adj. R-squared* | 0.856 | |
| *N* | 64 | |

*Notes*: *N*=number of observations; ***=significant at the 1 per cent level; **=significant at the 5 per cent level; *=significant at the 10 per cent level.

Table A7
Elasticity of the synthetic price index with respect to the market integration index, 1850-1913

| | India | | Indonesia | | US | |
|---|---|---|---|---|---|---|
| C | 5.977 | *** | 6.472 | *** | 27.315 | * |
| LOG_MI | -0.618 | *** | -0.770 | *** | -0.627 | ** |
| LOG_P | 0.353 | *** | 0.369 | *** | | |
| YEAR | | | | | -0.010 | |
| CW | | | | | 0.401 | *** |
| AR(1) | 0.927 | *** | 0.819 | *** | 0.851 | *** |
| *Adj. R-squared* | 0.859 | | 0.834 | | 0.837 | |
| *N* | 64 | | 64 | | 64 | |

*Notes*: *N*=number of observations; ***=significant at the 1 per cent level; **=significant at the 5 per cent level; *=significant at the 10 per cent level.

Table A8
Trade elasticity: IV panel regression analysis

| | | | | |
|---|---|---|---|---|
| Constant | | | | |
| Good | Origin | Destination | | |
| Indigo | India | UK | 30.371 | * |
| Jute | India | UK | -39.872 | *** |
| Lineseed | India | UK | -22.292 | * |
| Coffee | Indonesia | Netherlands | 41.339 | *** |
| Rice | Indonesia | Netherlands | -3.900 | |
| Sugar | Indonesia | UK | -83.700 | *** |
| Cotton | US | UK | -22.243 | ** |
| Wheat | US | UK | -47.396 | *** |
| | | | | |
| Rate of change | | | | |
| Good | Origin | Destination | | |
| Indigo | India | UK | -0.015 | * |
| Jute | India | UK | 0.024 | *** |
| Lineseed | India | UK | 0.015 | ** |
| Coffee | Indonesia | Netherlands | -0.020 | *** |
| Rice | Indonesia | Netherlands | 0.004 | |
| Sugar | Indonesia | UK | 0.046 | *** |
| Cotton | US | UK | 0.015 | *** |
| Wheat | US | UK | 0.029 | *** |
| | | | | |
| Trade elasticity | | | -1.813 | *** |
| | | | | |
| Dummies | | | | |
| Civil_war_cotton_US | | | -2.278 | *** |

| Table A8-cont | | |
|---|---|---|
| Civil_war_wheat_US | 0.360 | |
| Synthetic_dye | -1.333 | *** |
| | | |
| Exogeneity chi-square test | 4.761 | ** |
| Exogeneity F test | 4.608 | ** |
| First stage R-square | 0.981 | |
| N | 509 | |

Table A9
The welfare effect of price convergence (in percentage of GDP)

| | Model | | Regression | |
|---|---|---|---|---|
| | Earliest to 1913 | 1870-1913 | Earliest to 1913 | 1870-1913 |
| United Kingdom | 2.571 | 0.649 | 3.013 | 0.913 |
| Wheat | 1.118 | 0.393 | 0.930 | 0.375 |
| Cotton | 1.101 | 0.047 | 1.175 | 0.083 |
| Tea | | 0.025 | | 0.027 |
| Indigo | 0.002 | 0.000 | 0.002 | 0.000 |
| Jute | 0.094 | 0.062 | 0.068 | 0.045 |
| Linseed | 0.054 | 0.017 | 0.135 | 0.039 |
| Rapeseed | | 0.007 | | 0.006 |
| Rice | 0.087 | 0.039 | 0.051 | 0.029 |
| Coffee | 0.006 | 0.002 | 0.012 | 0.004 |
| Sugar | 0.108 | 0.056 | 0.640 | 0.305 |
| | | | | |
| United States | 0.260 | 0.010 | 0.263 | 0.015 |
| Wheat | 0.025 | 0.005 | 0.062 | 0.011 |
| Cotton | 0.235 | 0.005 | 0.202 | 0.004 |
| | | | | |
| India | 1.799 | 1.162 | 1.272 | 1.100 |
| Wheat | 0.522 | 0.126 | 0.376 | 0.095 |
| Cotton | 0.799 | 0.588 | 0.350 | 0.263 |
| Tea | | 0.112 | | 0.109 |
| Indigo | 0.019 | 0.001 | 0.026 | 0.001 |
| Jute | 0.263 | 0.177 | 0.417 | 0.278 |
| Linseed | 0.196 | 0.059 | 0.103 | 0.032 |
| Rapeseed | | 0.029 | | 0.045 |
| Rice | | 0.070 | | 0.276 |
| | | | | |
| Indonesia | 2.186 | 1.569 | 0.615 | 0.746 |
| Sugar | 1.989 | 1.000 | 0.327 | 0.173 |
| Coffee | 0.115 | 0.042 | 0.092 | 0.034 |
| Rice (exports) | | -0.029 | | -0.020 |
| Rice (imports) | | 0.455 | | 0.318 |
| Tin | 0.082 | 0.101 | 0.197 | 0.242 |

**Appendix B: The model with the 'iceberg' assumption**

Following the 'iceberg assumption' the price ratio between the producing and the consuming country, in efficient trading markets, is equal to one plus transaction costs, or t. Thus, we substitute $P_C=P_Pt$ and simplify notation by writing $P_P=P$. By definition total demand equals total supply

$D_C+D_P = S_C + S_P$

We start by substituting 1)-2) in the equation

$\gamma_A P+ \gamma_E Pt= \alpha Pt + \beta P$

or

$P= Pt(\alpha- \gamma_C)/(\gamma_P-\beta)$

Re-arranging yields an expression for the effect of changes in transaction costs on the prices of the producer

$dP/dt =dP/dt^* t(\alpha- \gamma_C)/(\gamma_P-\beta)+ P(\alpha- \gamma_C)/(\gamma_P-\beta)$

or

$dP = P(\alpha- \gamma_C)/[\gamma_P-\beta-t(\alpha- \gamma_C)]^*dt$ A1)

while the parallel condition for the change in prices of the consumer is:

$d(Pt)/dt= tdP/dt+P$

$d(Pt) =\{tP(\alpha- \gamma_C)/[\gamma_P-\beta-t(\alpha- \gamma_C)]+P\}^*dt$ A2)

We express the unknown coefficients α, β or γ in terms of elasticities of demand ($\eta_C$ and $\eta_P$) and supply ($\varepsilon_C$ and $\varepsilon_P$). To this aim, we select unit of measurement so that at time zero P=1 and $S_P=1$. Furthermore we express European supply and Asian consumption as proportions z and x of Asian production ($S_C=zS_P=z$ and $D_P=xS_P=x$). Of course, for tropical products (including cotton) $S_C=z=0$. In this notation, the consumer's demand is equal to imports from the producer ($X_P$) plus local supply $D_C= X_P + S_C =S_P-D_P+S_C=(1-$

x+z). Substituting in the standard definition of elasticity and re-arranging, we obtain $\alpha=\eta_C(1-x+z)/t$, $\beta=\eta_P*x$, $\gamma_C = \varepsilon_C*z/t$ and $\gamma_P= \varepsilon_P$. We thus can re-write 5) and 6) as function of the elasticities and of the parameters x,t and z

$dP = [\eta_C(1-x+z)/t - \varepsilon_C*z/t)/[\varepsilon_P - \eta_P*x-\eta_C(1-x+z)+\varepsilon_C*z)]*dt$ A3)

$d(Pt) =\{(\eta_C(1-x+z) - \varepsilon_C*z)/[\varepsilon_P - \eta_P*x-\eta_C(1-x+z)+\varepsilon_C*z)]+1\}*dt$ A4)

Substituting A3) and A4) in the identity dt=d(Pt)-tdP we allocate dt

We can also estimate the effects of changes in transaction costs (dt) on trade ($dX_P$) as the difference between changes in the consumer's demand ($dD_C$) and in its supply ($dS_C$)

$dX_P= \alpha d(Pt) - \gamma_E d(Pt)= [\eta_C(1-x+z)/t-\varepsilon_C*z/t]*\{P(\eta_C(1-x+z) - \varepsilon_C*z)/[(\varepsilon_P - \eta_P*x)-(\eta_C(1-x+z)-\varepsilon_C*z)]+1\}*dt$ A5)

**Appendix C: sources**

1. Elasticities

The elasticities are drawn from an extensive survey of the literature, cross-checking the different sources for consistency. We rely on estimates which match our products, period and areas as closely as possible and significant violations of our assumptions are unlikely. A close match in all three respects was possible for the European demand for wheat, cotton and jute, the American demand for cotton, the European and American supplies of wheat and the Indian and American supplies of cotton. 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, a recent 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 figure used by Allen (2000: 14) for the demand for agricultural products in pre-modern Europe (-0.6). We therefore use -0.5. The European elasticity of demand for cotton is based on the values estimated by Irwin (2003: 283) for Indian cotton in the UK in 1820-1859. The elasticity of the European demand for jute is estimated as -1, as done by the producers in India at the time (Chakrabarty, 2000: 43). The elasticity of demand for cotton in the US is based on Wright's (1971: 119) estimate for the mid-nineteenth century.

Turning to the supply elasticity of wheat, 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 the UK and the US. 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. 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.

All the remaining elasticities of demand in Europe, but that of indigo, are based on recent estimates for Italy in 1870-1913 taken from Federico and Vasta (2014). Specifically we use their figures as follows (the name in parentheses refers to the group upon which our estimates are based): rice (cereals), tea, coffee and pepper (tea, coffee and spices), tin (metals), rapeseed and linseed (oil seeds).  Given that by the early twentieth century Germany produced synthetic substitutes for indigo, we assume that the demand for this specific product was comparatively elastic, both in India (-1) and especially in Europe (-1.5). Like O'Rourke and Williamson (1994), we assume that the elasticity of demand for wheat in the US was the same as in the UK, where diet and incomes were very similar. For the Asian demand, there are pre-1914 estimates only for cotton and hardware. 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). The elasticity is also close but somewhat higher to the value used for the UK (0.7), where it is reasonable to assume that income and climate made cotton relatively more necessary than in India. Murti and Sastri (1951: 320) also estimates that the elasticity of demand for hardware in inter-war India was close to -1; this vale is used for the demand elasticity of tin in the Dutch East Indies.

For the remaining goods the Asian demand elasticities rely on measures made in present-day India. For Swamy and Bisanwager (1983: 681-682) Indian demand is more inelastic for wheat (-0.23 to -0.32) than for rice (-0.58 to -0.70), which is odd. For Kumar et al. (2011: 11-12) for the very poor the demand elasticity for both wheat and rice is about -0.5, which matches those of the UK and the US before 1913; hence, we use this value for both wheat and rice in Asia. Kumar et al.'s (2011: 11-12) estimates for the very poor also suggest demand elasticities in Asia of -0.5 for rapeseed and lineseed (edible oils), -0.3 for sugar, and -1 for jute, tea, coffee and pepper (other food & non-food). These values imply equal or lower elasticities of demand for food in Asia than in Europe, which is consistent with inelastic demand for items of staple food in low-income economies with few available substitutes.

For the Asian supply elasticities, we mainly rely on Askarin and Cummins (1976) and Krishna (1963: 485) who report pre- 'green revolution' figures for rice, wheat, rape, cotton, jute, sugar and tea. Reassuringly the figures do not suggest major changes between the inter-war years and the post-1945 period. Indeed for cotton they tend to be very close to the nineteenth-century estimates quoted earlier: discounting for an obvious outlier (American cotton in Punjab in 1900-19139 yields a figure of 9.74) the average (0.59) is very close to 0.5. In general, the production of agricultural commodities emerges as inelastic and the figures suggest that 0.5 is a reasonable approximation. For tin, too, we rely on present-day (1955-1975) estimates in Indonesia and other producing areas, which suggest that a value of 1 is appropriate (Chhabra et al., 1978: 13). Although mining technology obviously did change significantly since 1913, for Matthews (1990: 23) in the nineteenth-century, too, tin production was inelastic in the short-run, but more elastic in the long-run. With the only exceptions of wheat, whose supply elasticity has already been discussed, and Indian cotton, which was mainly substituted by American cotton, for Europe, in all cases the main alternative sources were other tropical countries. Hence, the Asian supply elasticities are used for the European elasticities for all the remaining goods. As implied earlier, at least for cotton, that this assumption is reasonable is borne out by the data. By the same token, the American elasticity is used for Europe when examining Indian cotton.

2. Quantitites

Atlantic. Until 1853 the sources for cotton are: House of commons Parliamentary Papers (HPP) (1809: 1, 1848a:2, 1854a: 255). These report continuous imports in the UK from the US of ‘cotton wool’ in lb (0.4536 kg) from 1806, but with a hole in 1809-1814. The sources for wheat are: HPP (1827a: 9, 1827b: 2-3, 1832: 2-5, 1843: 59, 64, 1844: 6, 1847a: 8, 1854a: 4). These report continuous imports in the UK from the US of 'wheat', 'wheat meal and flour' or 'wheat and wheat flour' in quarters since 1800. From 1854, our source is *Annual Statement of Trade of the United Kingdom of Foreign Countries and British Possessions* (ASTUK), for both 'raw cotton' (in cwt, i.e. 112 lb, or centals of 100 lb) and 'wheat' (in cwt). In both cases, the series of exports from the US to the UK are without holes.

India. Continuous data on exports of Indian indigo into the UK in lb from 1785 until 1857, with just one hole in 1813, can be found in HPP (1813, 1818, 1820, 1821: 368-369, 1823: 6-7, 1827a: 15, 1827b: 2, 1828: 24, 1832: 19, 1833: 5-18, 1836: 2, 1840: 42, 1847b: 10, 1848b: 3, 1850: 3, 1854b: 5, 1858: 5). Continuous data on exports of jute from Bengal (in cwt) between 1828/1829 to 1872/73 can be found in HPP (1874: 63-65). Although the source usually does not specify the destination, the figures for the US and France are very small in comparison to the total, suggesting that the great bulk of these exports was destined to the UK. This is also confirmed by ASTUK data from 1855 (cf. below). Continuous data on exports to the UK of linseed and flaxseed in quarters (416 lb) for 1844-1857 were found in HPP (1854c: 4-5, 1858: 6). ASTUK reports continuous data on exports to the UK from 1855 (unless otherwise specified) to 1913 for cotton (in cwt, data from Bombay starts in 1864), indigo (in cwt), jute (in cwt or long ton), linseed (in quarters or long tons, flax and linseed for 1855-1858, 1871 ff.), rapeseed (in quarters or long ton), rice (in cwt, data from Burma starts in 1871), tea (in lb) and wheat (in cwt or quarter, the data starts in 1856, but becomes continuous from 1871).

Indonesia. De Bruijn Kops (1857: 132-137, 166-169, 186-190, 198-201) documents continuous exports of coffee and tin from Java and Madura to the Netherlands (in pikols of 67.7613 kg) for 1825 to 1856. The same source reports data on exports of sugar to the UK (also in pikols) for the same years, but with gaps from 1826 to 1832. *Statistiek van den In-, Uit-en Doorvoer* reports data on Dutch imports from the Dutch East Indies (in ponds of 1 kg) from 1846 for coffee, rice and tin; in our years the only gaps are found in 1871, 1881, 1891, 1898, 1913. Continuous data on exports of rice from Java to the Netherlands (in 1000s tons) between 1827 and 1916 can be found also in Korthals Altes (1978). ASTUK reports data on imports of Java sugar into the UK (in cwt) from 1855, with gaps in 1864-1867 and 1902.

3. Welfare analysis

The parameter $\theta$ (Formulae 13 and 14) is the share of the *i-th* product on total GDP. The numerator should be the value added (VA), but all sources report the gross output, inclusive of expenditures. We thus estimate the VA by product by multiplying gross output by a country-specific ratio gross output/VA from Federico (2004). We estimate $\delta$ under the assumption that consumers buy raw materials (cotton, wheat etc.) separately from processing and selling services. Thus, we compute the consumption as gross output less net exports, which is equivalent to imports for goods not produced in the country (e.g. tea in the United Kingdom).

In all cases, we compute the welfare gains separately by product. We cover ten products for European consumers (coffee, cotton, indigo, jute, linseed, pepper, rice, sugar, tea and wheat), two for American producers, eight for Indian producers (cotton, indigo, jute, linseed, rapeseed, rice, tea and wheat) and four for Indonesian producers (coffee, rice, tin, sugar). For the United States, we obtain data on gross output of wheat and cotton from Strauss and Bean (1940, Tables 13 and 25) and on GDP, consumption and net exports from Carter et al. (2006, Tables Ca188, Cd1, Ee571 and Ee575). The ratio VA/output is 0.84. We get data on gross output of wheat in the United Kingdom, from Ojala (1952: 208-209) and we use a VA/GDP ratio of 0.66. Imports are from Annual Statement of Trade (1913); total consumption and GDP are from Feinstein (1972, Table T9). For India, we assume a VA/output 0.95 and we take data on gross output by product and total GDP from Sivasubramonian (2000, Tables 3 (c) and 6.10), averaging two consecutive crop years and on value of trade from the Statistical Abstract of British India (1913 issue).[18]

The Dutch Indies are an exception because the estimates of national accounts by van der Eng (1992, Table A4) divide total agricultural production in three categories, food crops, cash crops (from peasant farms) and estate crops. We assume that sugar and coffee accounted for 65 per cent and 10 per cent respectively of the sum of cash and estate crops and rice 75 per cent of the output of food crops, with an output/VA ratio of 0.95. Likewise, we assume that tin accounted for half of mining output and that VA accounted for

[18] The source does not report data on trade in linseed. We assume exports accounted for 15 per cent of gross output, as for rapeseed.

90 per cent of the value of production. Finally, we assume that tin and coffee were entirely exported, that domestic consumption of sugar was about 1 per cent of production and that imports supplied 10 per cent of rice consumption (van der Eng 1997: 182).

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