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# FOREIGNERS KNOCKING ON THE DOOR:
# TRADE IN CHINA DURING THE TREATY PORT ERA

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**ABSTRACT**

We employ a new, commodity-level dataset on the flow of goods between fifteen major treaty ports to estimate a general-equilibrium trade model for China around the year 1900. The distribution of welfare effects depends critically on each port's productivity, China's economic geography because it affects trade costs, and the extent of regional diversity in production because this affects the potential gains from trade. We utilize this framework to quantify the size and distribution of welfare effects resulting from new technology and lower trade costs that came with the treaty ports. Findings show that domestic markets resulted in ripple effects which transmitted the effect of the international trade opening beyond the foreign concessions. However, because differences in relative productivity across regions were relatively low, the welfare gains from domestic trade improvements were limited.

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China's economic development has taken major turns over the last couple of centuries. From a relatively prosperous worldwide standing during the Song era (960-1279), China saw Western European countries surging ahead in the great divergence of the late 18th century. Over the last twenty-five years, China experienced rates of growth of close to 10% per year, doubling per-capita income more rapidly than in any other sizable country in world history. While recent research has begun to shed light on these turning points, still very little is known on the legacy of China's 19th century opening.

Starting in mid-19th century, under military action from Western countries, China opened an increasing number of ports to foreign traders. In this paper we examine the implications of this opening for China's internal trade and welfare. Treaty ports were the conduits of goods, but they were also the carriers of Western influence. Foreigners introduced steam ships to China, dredged harbors, built lighthouses, and under the Chinese Maritime Customs authority assessed not only tariff revenue, but also collected data on goods trade, weather, and other aspects of the Chinese economy.

We employ a new, commodity-level dataset for fifteen major treaty ports to estimate a general-equilibrium trade model for China around the year 1900. After the collapse of the Qing dynasty in 1911, a small but significant modern sector based on factory production started to grow at rates well over 2% and lasted until the Japanese invasion of 1937 (Chang 1969). This industrialization centered on the treaty ports. While it was started by the foreign presence, the strength of domestic market expansion contributed to its growth. What has been less clear is whether the developments of the 1912-1937 period, and more generally the opening of trade that precipitated these developments, had wider effects that went beyond the treaty ports.

We show that the distribution of welfare effects depends critically on each port's productivity, China's economic geography because it affects trade costs, and the extent of regional diversity in production because it shapes the potential gains from trade. We utilize this framework to quantify the size and distribution of welfare effects resulting from new technology and lower trade costs that came with the treaty ports. Specifically, a 20% increase in Shanghai's productivity raises welfare in Shanghai by about 1.5%; because of trade, however, Shanghai's gains are only part, about 40%, of the total welfare gains. Another 28% of the welfare gains accrue to Ningbo, Chinkiang, and Wuhu, located in the geographic vicinity of Shanghai. Because factor costs, income, and production patterns respond endogenously, welfare in some ports can actually fall when Shanghai's technology improves, as it does in the relatively distant Tianjin. We also study the effects of changes in trade costs on welfare.

There are two main findings. First, we show that through trade, a change in any one of the treaty ports has ripple effects throughout China; it is not bottled up within the foreign concession. These effects, conditioned by China's economic geography, yield a new estimate of the extent to which China was influenced by foreign contact, and is based on commodity-level trade data. Second, across China during the treaty port era, the evidence for regional diversity in productivity across goods is relatively small; smaller at any rate than for trade in manufactured goods across high-income countries in the late 20th century. This puts a lid on the aggregate size of welfare gains because differences in productivity across goods–comparative advantage–is the source of the gains from trade in our framework.

This paper contributes to a small but growing literature on China's trade during the treaty port era (1842 to 1943). An important contribution is Mitchener and Yan (2014) who study the factor price implications of China's foreign trade during the early 20th century.[1] China's substantial foreign trade notwithstanding, the size of China's domestic trade exceeded it by far. In 1904, for example, Shanghai's exports to Great Britain were similar in size to Shanghai's exports to the Shandong treaty port of Yantai (Chefoo), while exports from Tianjin (Tientsin) to

[1]Keller, Li, and Shiue (2011, 2013) provide overviews of China's foreign trade during the treaty port era all the way to today. China's trade statistics during the treaty port era are discussed in Hsiao (1974) and Lyons (2003).

Shanghai were about *five* times the size of Tianjin's exports to all foreign countries combined.[2] By shifting the focus on China's internal trade we observe the effects of greater international integration within the country, something that is possible only in rare cases.[3] Our analysis complements earlier work on China's internal trade in this era (Kose 1994, 2005; Keller, Li, and Shiue 2012) by quantifying the size and analyzing the structure of the welfare gains from trade.

This research also contributes to the re-assessment of the broader implications that Western pressure had on China during the 19th and early 20th century. Earlier views on the impact on China ranged from very negative to mildly benign (see the overview in Dernberger 1975).[4] While the intrusion of the West has often been seen as detrimental to China's economic development, some authors consider positive demonstration effects (Feuerwerker 1983). There were also changes in traditional sectors (Rawski 1989, Richardson 1999). Recent work has begun to see the treaty ports in a more positive light (Keller, Li, and Shiue 2011, So and Myers 2011), noting in particular that city size grew more rapidly in treaty ports than in other cities (Jia 2013). Given China's size, did the developments in the treaty ports matter for China more broadly? We provide an initial estimate on the geographic scope of the West's impact in China from the point of view of a general-equilibrium trade model.[5]

Finally, we contribute to the analysis of trade by asking how a general-equilibrium model can capture the welfare gains from trade. While much progress has been made with Heckscher-Ohlin models (O'Rourke and Williamson 1994, 1999; Mitchener and Yan 2014), when the size of the country suggests that economic geography aspects could be important, as in the case of a large country such as China, our Ricardian framework based on Eaton and Kortum (2002) is preferable to a

[2]See CMC (2001a), Vol. 39. These figures underestimate the relative size of domestic trade because it ignores domestic trade outside of the realm of the Chinese Maritime Customs service (see below).

[3]The paucity of information on internal trade is closely related to the absence of internal trade taxes in many countries; e.g. the Import-Export Clause, Article 1, Section 10, Clause 2 of the U.S. Constitution.

[4]See also the accounts of Morse (1926) and Fairbank (1978).

[5]The effect of China's 19th century opening on her capital markets is examined in Keller and Shiue (2015).

Heckscher-Ohlin framework because it remains highly tractable in the presence of trade costs, generating bilateral trade predictions in a multi-region setting. This allows us to investigate in a counterfactual setup the size and structure of welfare effects as well as the factors which were central in explaining these outcomes. This Ricardian framework has been applied for welfare analysis to trade of regions and countries, multinational activity, and migration (see the review in Costinot and Rodriguez-Clare 2013). We add China to the short list of countries for which historical analyses exist.[6] In particular, our paper complements Donaldson's (2015) analysis of agricultural income gains due to railroad introduction in India by a focus on trade via ships of a broader set of commodities. While the quality of our data on China does not match that for British India, we know the precise volume of trade on ships, in contrast to British India where only data on the location of railroad tracks and the total trade volume is available.

The paper is structured as follows. The following section gives a brief summary of the historical setting, with more details given in Fairbank (1978); Cassel (2012) and Keller and Shiue (2012, 2014, 2015). The model is described in section 3, with more details given in Eaton and Kortum (2002). Next is a description of the data, with additional information provided in the Appendix. In section 5 we present the empirical results, beginning with the estimation of key parameters, followed by welfare calculations based on counterfactual analysis. The paper concludes with a summary and discussion of future research directions in section 6.

## I. Historical Background: Trajectories from the Past

After her defeat in the First Opium War (1840 – 1842), China signed the Treaty of Nanjing (1842) which expanded the rights of Western countries to trade at a total of five Chinese ports, four more than the one (Canton) that they had been allowed. Other stipulations included that Hong Kong would become a British colony, and that foreigners would be subject to the laws of their own countries, as opposed to

[6] On India, see Donaldson (2015), while for Argentina, see Fajgelbaum and Redding (2015).

Chinese law (extraterritoriality). Additional ports were opened to trade with the West in subsequent years. Given that the post-1842 increase in trade did not live up to Western expectations, and that trade taxes went largely unpaid during the Taiping Rebellion (1850-64), in the year 1854 it was decided that China's customs system would be run by Western officials who formally would be employed by China's central government. The organization that was founded for this task was the Chinese Maritime Customs Service (CMCS; Imperial Maritime Customs Service before 1911), with Horatio Nelson Lay as its first leader. Operations of the CMCS began in full in the year 1859 in Shanghai, with other ports following over time. Robert Hart became Inspector-General of the CMCS in the year 1863. His influence was shaping China's trade opening for decades to come.

While this paper is focused on the welfare effects of China's domestic trade around the turn of the century, given the unprecedented growth of trade and foreign direct investment in China since 1978 it is important to ask how the 19th century fits in with China's long-run development (see also Brandt, Ma, and Rawski 2014). For the following analysis we focus on Shanghai, which is the largest port in the world today by several measures (see Keller, Li, and Shiue 2013).

We begin by considering foreign trade. In Figure 1, we show Shanghai's exports to the European continent between 1865 and 2009. Extrapolating the trend from 1865 to 1900, we see that the level of Shanghai's exports in the early 2000s was close to what one would have predicted based on the 19th century trend. Figure 2 shows that French foreign direct investment (FDI) in Shanghai is well below what a simple extrapolation of the 1872-1921 trend would yield.[7] This might be explained in part because outward globalization—exports—is politically easier than globalization in terms of inward FDI. At the same time, Figure 3 shows that the number of Germans in Shanghai today is quite close to what one would expect based on extrapolating the 19th century trend.

Overall, these findings suggest that although the post-1949 era differs from the

[7] On our measures of FDI in the two periods, see Keller, Li, and Shiue (2013).

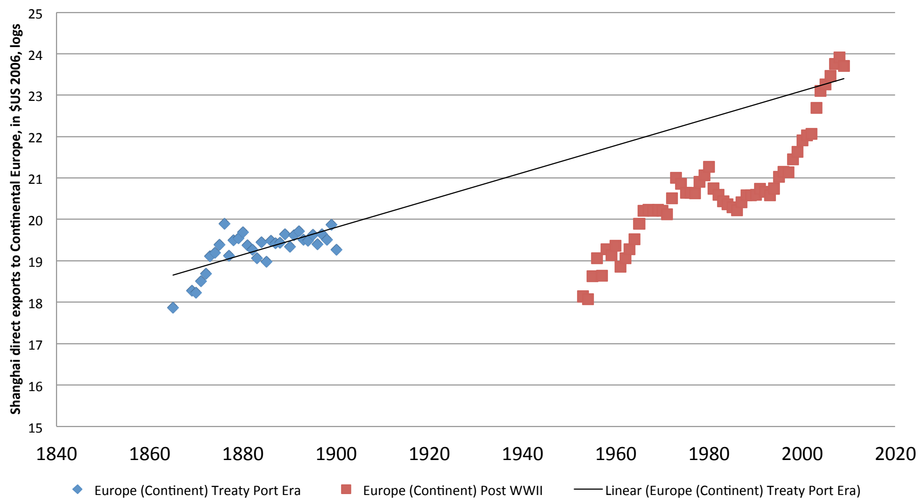



Figure 1. Shanghai's Exports to the European Continent, 1865 to 2009

*Source:* Chinese Maritime Customs.

19th and early 20th century in that China had become a fully sovereign country, it is hard to overstate the importance of trajectories from history that China appears to be returning to now. To put this differently, it will be much harder to predict China's trajectory over the next four decades than it was to predict where China was going for the roughly four decades since 1978.

We now turn to our analysis of trade in China around the turn of the century.

## II. Model

The framework for our empirical analysis is the Ricardian trade model of Eaton and Kortum (2002), which is adapted to our particular context; these authors provide more details on several key results.

### *A. Economic Environment*

Let the economy consist of $N$ regions. In the empirical analysis below these regions will be the customs districts of fifteen treaty ports in China. In each

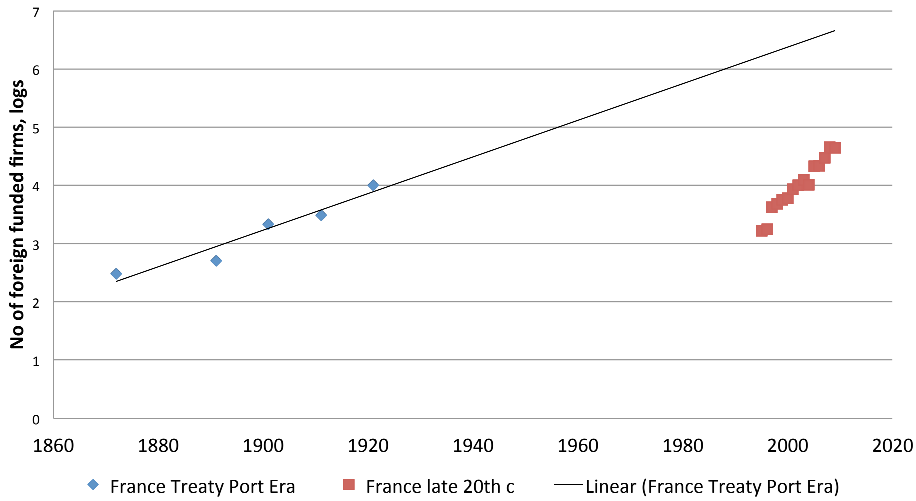



Figure 2. French FDI in Shanghai

*Source:* Chinese Maritime Customs.

region, competitive firms produce a continuum of goods $j \in [0, 1]$. Technologies differ across regions and goods, with region i's efficiency in producing good j denoted by $z_i(j)$. Regions can trade with each other, though trade is costly. Specifically, trade costs are modeled as "iceberg" costs, $d_{ni}$, where $n$ and $i$ denote destination (importer) and source (exporter) region, respectively. Trade costs of $d_{ni}$ mean that d units of the good have to be shipped from i in order for one unit to arrive in region n. As it is customary, we set $d_{ii} = 1\ \forall i$ and $d_{ni} > 1$ if $n \neq i$.

Goods can be purchased in an amount $Q(j)$ for final consumption by consumers, or as intermediate inputs by firms. Consumers maximize a CES utility function:

$$U = \left[\int_0^1 Q(j)^{(\sigma-1)/\sigma}\right]^{\sigma/(\sigma-1)} \tag{1}$$

subject to region $n$'s total spending, $X_n$, where $\sigma > 0$ is the elasticity of substitution between each pair of goods.

Region $i$'s efficiency in the production of good $j$, $z_i(j)$, is stochastic and drawn


FIGURE 3. GERMAN POPULATION IN SHANGHAI

*Source:* Chinese Maritime Customs.

from a Fréchet distribution with cumulative distribution function:

$$F_i(z) = e^{-T_i z^{-\theta}} \tag{2}$$

The parameter $T_i > 0$ describes region $i$'s specific technology. A higher value of $T_i$ increases the probability of drawing a higher level of technology, and hence $T_i$ is a measure of absolute advantage. The parameter $\theta > 1$ is inversely related to the variance of the distribution. A lower value of $\theta$ indicates a higher degree of heterogeneity in relative productivity. Thus, we refer to $\theta$ as the comparative advantage parameter.

Let $c_i$ denote the input cost of production in region $i$ . With competitive firms, a constant-returns-to-scale technology, and the above-mentioned geographic barriers to trade, the price a buyer in region $n$ would pay for 1 unit of good $j$ produced in region $i$ is:

$$p_{ni}(j) = \left(\frac{c_i}{z_i(j)}\right) d_{ni} \tag{3}$$

A buyer will purchase the good from the cheapest source. Therefore, the price the buyer actually pays is:

$$p_n(j) = min\left\{p_{ni}(j); \quad i = 1 \ldots N\right\} \tag{4}$$

Since $z_i(j)$ is stochastic, from (3) and (4) we see that so are $p_{ni}(j)$ and, consequently, $p_n(j)$. Let $P_{ni}$ denote the random variable of which $p_{ni}(j)$ is a realization.[8] From (2), it follows that the distribution of $P_{ni}$ is given by:

$$G_{ni}(p) = Pr(P_{ni} \leq p) = 1 - exp\left(-\left[T_i(c_i d_{ni})^{-\theta}\right] p^{\theta}\right). \tag{5}$$

Similarly, the lowest price a buyer faces is the realization of another random variable $P_n = min\left\{P_{ni}; \quad i = 1 \ldots N\right\}$. The price distribution for region $n$'s actual purchases is:

$$G_n(p) = Pr(P_n \leq p) = 1 - exp\left(-\Phi_n p^{\theta}\right). \tag{6}$$

Here, $\Phi_n = \sum_{i=1}^{N} T_i \left(c_i d_{ni}\right)^{-\theta}$ captures the dependence of region $n$'s prices not only on its own state of technology and input costs but also on those of other regions, as well as region n's geographic barriers with each potential trade partner. Assuming $\sigma < \theta + 1$, the price index for the CES utility function of buyers (1) is given by:

$$p_n = \gamma \Phi_n^{-1/\theta}, \tag{7}$$

[8]See Eaton and Kortum (2002) for details on the following results.

where $\gamma$ is defined as $\gamma \equiv \left[\Gamma\left(\frac{\theta+1-\sigma}{\theta}\right)\right]^{1/(1-\theta)}$, and $\Gamma$ is the Gamma function. This price index will be critical for the welfare analysis. Two additional results are key to this.

First, one can show that the probability that region $i$ is the cheapest source of a good for destination $n$ is given by:

$$\pi_{ni} = \frac{T_i \left(c_i d_{ni}\right)^{-\theta}}{\Phi_n} \tag{8}$$

Since there is a continuum of goods we can apply the law of large numbers, and (8) also gives the fraction of goods region $n$ buys from $i$.

Second, it can be shown that the price distribution (6) does not depend on the source region. Thus, since the price of a good purchased by a region $n$ buyer does not vary with the source, the share of region $n$'s expenditure on goods produced in region $i$ must be equal to the fraction of goods bought from that region, given by (8):

$$\frac{X_{ni}}{X_n} = \pi_{ni} = \frac{T_i \left(c_i d_{ni}\right)^{-\theta}}{\sum_{k=1}^{N} T_k \left(c_k d_{nk}\right)^{-\theta}} \tag{9}$$

where $X_{ni}$ is region $n$'s expenditure on region $i$'s goods and $X_n = \sum_{i=1}^{N} X_{ni}$ is region $n$'s total expenditure.

Multiplying both sides of (9) by $X_n$ gives that equation a gravity interpretation: bilateral trade $X_{ni}$ is increasing in the importer region's total expenditure. It is also increasing in the size of the exporter region, related to its state of technology, $T_i$. Finally, it is decreasing in the size of geographic barriers, $d_{ni}$. Thus, the model captures the effects of technology and geography on bilateral trade.

### *B. Model Equilibrium*

We assume that production takes place by combining labor and intermediate inputs. Region $i$'s input cost is then

$$c_i = w_i^{\beta} p_i^{1-\beta} \tag{10}$$

where $w_i$ is the wage in region $i$ and $p_i$ is region $i$'s price index as given by (7). Labor's share in production is given by the parameter $\beta$, $0 < \beta < 1$.

Substituting (10) into the expression for $\Phi$, and the result into (7) yields a system of equations that relates each region's price index to wages as well as technology and comparative advantage parameters in all other regions:

$$p_n = \gamma \left[ \sum_{i=1}^{N} T_i \left( w_i^{\beta} p_i^{1-\beta} d_{ni} \right)^{-\theta} \right] \tag{11}$$

Also, substituting (10) into (9), we can express trade shares as a function of wages and the parameters of the model:

$$\frac{X_{ni}}{X_n} = \pi_{ni} = T_i \left( \frac{\gamma d_{ni} w_i^{\beta} p_i^{1-\beta}}{p_n} \right)^{-\theta} \tag{12}$$

To determine the equilibrium in the labor market, we assume that workers are immobile between the sector producing manufacturing goods, modeled so far, and another sector producing non-manufacturing goods.[9] We make this assumption both because it is not unreasonable for this historical setting, and because it gives us a conservative estimate (lower than the mobile labor case), which seems reasonable given the debate on the welfare impact of the foreign opening on China.

Manufacturing labor income in region $i$ is given by labor's share in the value of that region's total sales of manufacturing products (to local buyers and to other

[9]We use the term manufacturing for brevity; as will become clear below it also includes agricultural and other goods.

regions):

$$w_i L_i = \beta \sum_{n=1}^{N} \pi_{ni} X_n \tag{13}$$

where $L_i$ denotes the number of workers.

Total expenditures in manufacturing are given by:

$$X_n = \frac{1-\beta}{\beta} w_n L_n + \alpha Y_n \tag{14}$$

where $Y_n$ denotes aggregate final expenditure, and $\alpha$ is the fraction spent on manufacturing products. Final expenditure is the sum of value added in manufacturing, $Y_n^M$, and income generated in the non-manufacturing sector, $Y_n^{NM}$. We assume that trade costs in non-manufacturing are negligible, so that it can be used as our numeraire.

Combining (13) and (14), we obtain the labor-market condition:

$$w_i L_i = \sum_{n=1}^{N} \pi_{ni} \left[ (1-\beta+\alpha\beta) w_n L_n + \alpha\beta Y_n^{NM} \right] \tag{15}$$

Equations (11), (12), and (15) characterize the equilibrium of the model and can be solved numerically for prices, trade shares, and manufacturing wages. These allow us to construct a measure of overall welfare at the regional level, given by real GDP

$$W_n = \frac{Y_n}{p_n^{\alpha}} \tag{16}$$

where, since non-manufactures are taken as numeraire, $p_n^{\alpha}$ denotes the price level in region $n$. Our counterfactual analyses in Section 5 look at the effects of changing technology and trade barriers on welfare as defined by equation (16). In the following section we describe the data, followed by the estimation of the parameters of the model.

## III. Data

We examine China's internal trade around the year 1900. This section summarizes the data that will be employed, with more details given in the Appendix. The analysis includes fifteen of China's foreign treaty ports, which are listed in Table 1 according to the ports' names as recorded by the British CMC service as well as the English transliteration of the port name (in Pinyin), and the 20th century provincial jurisdiction. The port of Guangzhou in Guangdong province, for example, is called Canton in the Maritime Trade publications. These treaty ports are defined on the basis of the customs district of each port, which includes not only the port but also the surrounding area. One might therefore prefer to think of the treaty ports as regions; we will use the terms ports and regions interchangeably. Our choice of these 15 ports is based on their importance for China's maritime trade. The three largest ports during the 19th century were Shanghai, Wuhan (Hankow), and Tianjin (Tientsin).

Figure 4 shows the locations of the fifteen ports. The figure shows that we cover broad regions of China, mainly along its coast but also along the Yangzi river. The distance between Canton (Guangzhou) and Newchwang (Niuzhuang), which are located in Guangdong and Liaoning province, respectively, is about 2,700 kilometers.

The Maritime Trade statistics include only the trade that went through the Chinese Maritime Customs Service (CMC). Although our analysis excludes land-based trade, the amount of other water-borne trade in China (which was covered by the Native Customs system but not by the CMC) was small in comparison to the CMC portion (see CMC 2001a).[10] While land-based trade was significant, especially over short-distances, there is no reason to believe that the omission of land-based trade creates a bias in our analysis.

[10]The importance of railroads in China around the year 1900 was still quite limited.

Table 1—Summary Statistics

| 19th c. Port | Province | Pinyin Name | Wage | Chinese Pop. size | Foreign Pop. size | Labor Force | Total Exports | Total Imports |
|---|---|---|---|---|---|---|---|---|
| Amoy | Fujian | Xiamen | 1.000 | 114,000 | 1,685 | 59,925 | 660,419 | 3,018,895 |
| Canton | Guangdong | Guangzhou | 1.534 | 900,000 | 951 | 466,692 | 3,921,659 | 16,279,439 |
| Chefoo | Shandong | Yantai | 0.857 | 75,000 | 838 | 39,284 | 8,686,666 | 6,354,247 |
| Chinkiang | Zhejiang | Zhenjiang | 0.851 | 167,000 | 229 | 86,625 | 6,290,754 | 5,818,371 |
| Foochow | Fujian | Fuzhou | 0.893 | 624,000 | 818 | 323,655 | 3,915,828 | 1,543,331 |
| Hankow | Hubei | Hankou | 0.987 | 870,000 | 1,828 | 451,607 | 57,000,371 | 11,211,702 |
| Ichang | Hubei | Yichang | 1.200 | 45,000 | 88 | 23,356 | 1,304,921 | 1,677,188 |
| Kiaochow | Shandong | Qingdao | 1.253 | 122,000 | 798 | 63,609 | 5,315,954 | 773,321 |
| Kiukiang | Jiangxi | Jiujiang | 0.906 | 36,000 | 228 | 18,766 | 12,209,897 | 1,293,445 |
| Newchwang | Liaoning | Niuzhuang | 0.985 | 50,000 | 2,004 | 26,938 | 10,356,791 | 6,444,678 |
| Ningpo | Zhejiang | Ningbo | 0.942 | 260,000 | 266 | 134,818 | 7,918,607 | 3,093,938 |
| Shanghai | Jiangsu | Shanghai | 0.942 | 651,000 | 19,294 | 347,212 | 28,289,319 | 90,527,891 |
| Swatow | Guangdong | Shantou | 1.136 | 48,000 | 596 | 25,173 | 8,660,620 | 15,100,431 |
| Tientsin | Zhili | Tianjin | 1.036 | 750,000 | 4,542 | 390,852 | 12,809,691 | 15,837,388 |
| Wuhu | Anhui | Wuhu | 0.919 | 122,000 | 151 | 63,274 | 13,267,612 | 1,634,844 |

*Source:* Selection from "List of Treaty Ports, Etc., in Chronological Order" in Inspector General's Circulars, 1893 to 1910, "Documents Illustrative of the Origin, Development, and Activities of the Chinese Maritime Customs Service", Volume 2. Wage see Appendix A; Chinese population CMC (2001a), varous volumes; Foreign population as average for years 1901 and 1911, from CMC (2001b); labor force is 51.8% of population (Liu and Yeh 1965); total exports and imports (excluding purchases from self) for year 1904 from CMC (2001a), vol. 39 and 40.


Figure 4. The 15 Treaty Ports in the Analysis.

*Source:* Authors' map.

### *A. Trade data*

Two types of trade data are employed in the analysis: first, commodity-level multilateral trade at each of the fifteen regions, and second, the aggregate bilateral trade between the regions. Our analysis focuses on imports and exports of Chinese products, referred to in the Maritime statistics as "native goods". The commodity-level trade data is employed to estimate local prices, defined as the unit value of a range of goods at each port. The price difference for a given good between two regions provides an upper bound for the trade costs between these two regions. Before we turn to that, the following discusses aggregate bilateral trade of our regions (see Figure 5).

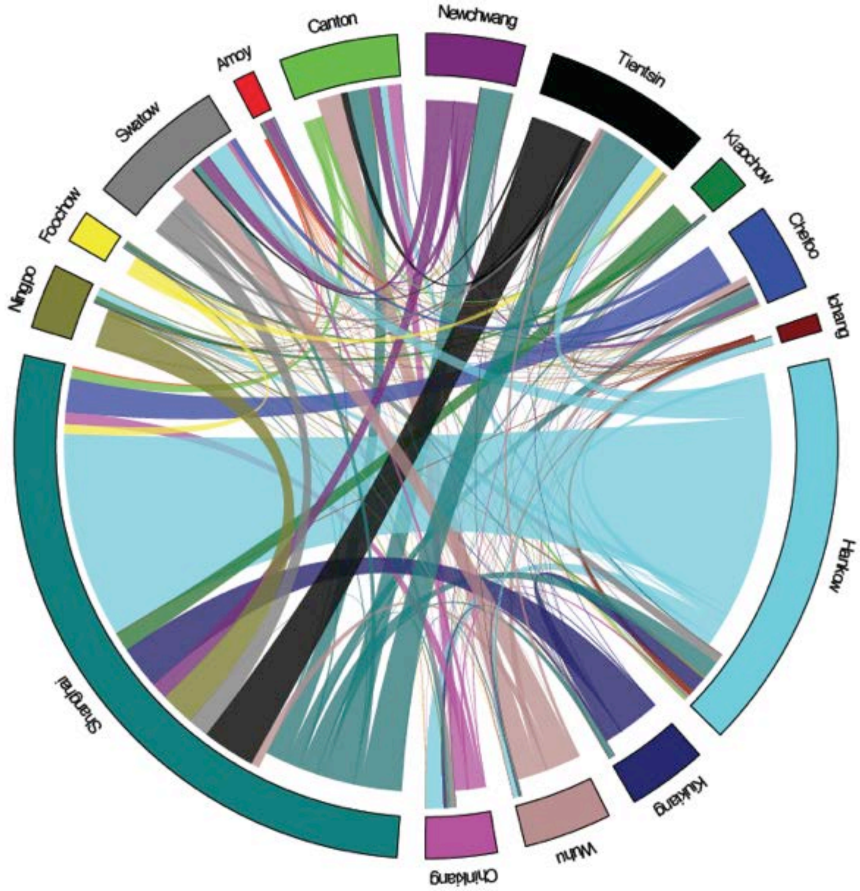



Figure 5. Bilateral Trade between Regions

*Source:* Calculated from CMC trade data.

This figure shows the matrix of bilateral trade, with the thickness of each line proportional to the size of the flow. Exports are shown in the color of the region itself and are offset towards the center of the figure. Hankow exports a large amount of its production to Shanghai, for example, while Tientsin's imports from Hankow are smaller than Tientsin's imports from Shanghai.

Importantly, the trade volumes shown in Figure 5 are locally produced in each of the fifteen regions. The Maritime Trade statistics are exceptional in that they provide information on re-export trade separately from local-origin trade.

Shanghai, in particular, re-exports goods from other Chinese regions at a level that exceeds its exports of local origin. If each region would export to every other region, Figure 5 would show 15 x 14 trade flows; however, 22% are equal to zero.[11] Also note that this trade is not balanced in the year 1904; we do not examine issues of intertemporal trade in the model.

The final step in our discussion of aggregate trade data concerns the trade of region $i$ with itself. Because we do not have information on production in region $i$, we cannot follow the usual approach of obtaining region $i$'s purchases from itself as its production minus total exports. Instead, we first run a gravity equation using all bilateral data on trade between regions $i$ and $j$. With the coefficient on distance on hand, the purchase of region $i$ from itself could be estimated by the predicted value of trade given a zero value of distance. Following the empirical gravity literature, however, we modify this approach to account for the size of region $i$ (which is not zero) as its internal distance (see Appendix C).

Turning to the commodity-level trade data, Figure 6 provides some detail on the most important commodities in four regions, as well as a comparison between the size of domestic and foreign trade at the commodity level. With the exception of Silk piece goods out of Canton and Raw cotton from Shanghai, domestic trade is larger than foreign trade. Furthermore, it is clear that foreign trade is less important than domestic trade in ports other than Shanghai.

The commodity-level trade data in this paper is employed to estimate the key parameter $\theta$ from examining price differences across ports. For this purpose we picked 26 commodities that are traded between virtually all fifteen regions. These commodities include coal, matches, rice, cotton, leather, silk pieces, among other goods. In Table 2 we show the average price difference in each region versus all other regions. With the exception of Tianjin, the average price differences are not far from zero. This is consistent with the hypothesis that at least across these 26

[11] In the estimation we add one before taking logs; using Poisson-type estimation models does not change our main results.

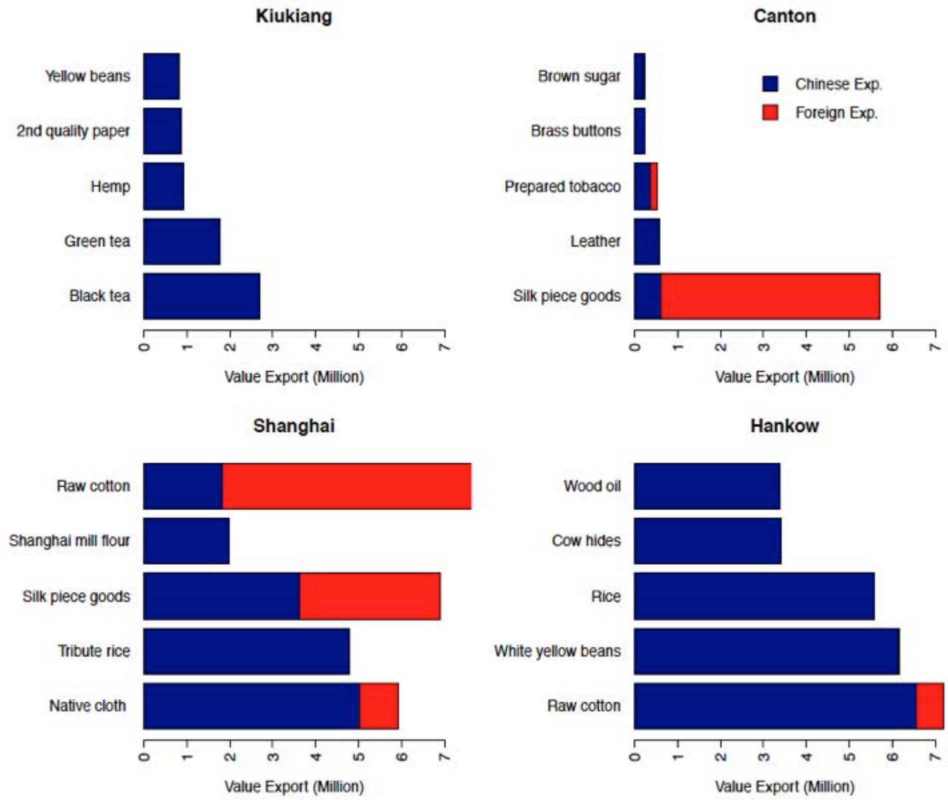



Figure 6. Five Key Commodities, by Region

*Source:* Chinese Maritime Customs' *Decennial Reports*, CMC (2001b).

commodities, most regions are low-cost for some and high-cost for other products.

### *B. Wages*

We obtain information on wages paid in the treaty ports from the Chinese Maritime Customs' *Decennial Reports*, CMC (2001b). These sources cover our fifteen regions over years 1892 to 1921; the director of the customs station in each port was asked to report about typical wages for particular occupations paid in his district. Occupations include both more and less skilled jobs such as painters, coolies, silk weavers, and manual laborers. The most frequent records are available for carpenters. Given the relatively small number of observations (n = 294),

Table 2—Bilateral Price Differences on 26 Commodities

| Region | Avg. Percent Difference | Region | Avg. Percent Difference |
|---|---|---|---|
| Amoy | 2.4 | Kiukiang | 8.7 |
| Canton | -0.2 | Newchwang | 0.1 |
| Chefoo | -0.4 | Ningpo | 1.9 |
| Chinkiang | -1.3 | Shanghai | 1.4 |
| Foochow | -1.6 | Swatow | 9.9 |
| Hankow | -0.1 | Tientsin | 24.5 |
| Ichang | 1.3 | Wuhu | -0.5 |
| Kiaochow | -4.3 | | |

*Source:* Chinese Maritime Customs' *Decennial Reports*, CMC (2001b).

we have estimated a region's wage from a hedonic regression across all ports (including occupation and year fixed effects). This is discussed further in Appendix A.

Wages across China around 1900 varied to some degree; the lowest wage $w_i$ is obtained for Chinkiang at 0.85, the highest for Canton at 1.5; the units for these figures is payment for a day's work of a carpenter in silver *taels*. We have also examined the robustness of our findings using alternative regional wages estimated from a subset of the *Decennial Reports* wage data together with a polynomial in longitude and latitude, finding similar results.

### *C. Labor Force and Gross Product*

We estimate the labor force in each region, $L_i$, by applying estimates of the labor force participation in China from Liu and Yeh (1959) to figures on the Chinese and foreign population living in each region, from CMC (2001a,b). Our GDP estimates are equal to the wage bill in each region, estimated as $w_i L_i$, plus the contribution from land, which is estimated based on Perkins (1969).[12] See Appendix B for details.

[12]We employ Perkins' (1969) estimates of the value of provinvial agricultural production across thirteen products, and use data on the fraction of people living in each region i relative to total provincial population to apportion a fraction of provincial land income to each region.

## IV. Parameter Estimation

In this section we present the empirical strategy to estimate the parameters of the model. In the first step, we estimate the value of the comparative advantage parameter, $\theta$. Then, given the latter, we estimate the parameters that capture each region's state of technology, $T_i$, and bilateral geographic barriers, $d_{ni}$.

### *A. Comparative Advantage*

The model described above provides a simple way of estimating the comparative advantage parameter, $\theta$. Dividing equation (9) by the equivalent expression for destination region $i$, using the price index (7), and taking logarithms, one can show that:

$$\ln\left(\frac{X_{ni}/X_n}{X_{ii}/X_i}\right) = -\theta \ln\left(\frac{p_i d_{ni}}{p_n}\right) \tag{17}$$

We use data on aggregate bilateral trade flows and relative prices for each region pair to recover a simple method-of-moments estimate of $\theta$.[13] The left-hand side of (17) is the (log of) the share of region $n$'s expenditure on region $i$'s goods (normalized by region $i$'s share).[14] The bilateral trade flows data provide a measure of that dependent variable.

The right-hand-side of (17) requires more discusssion. The logarithmic term, which is not directly observable, depends on the relative price indices of regions $n$ and $i$, and the size of geographic barriers between the two regions, $d_{ni}$. We construct a proxy for that term, $D_{ni}$, based on the prices of individual commodities mentioned above:

$$D_{ni} = max2_j \left\{ r_{ni}(j) \right\} - \sum_{j=1}^{J} \frac{r_{ni}(j)}{J} \tag{18}$$

[13]The method-of-moments estimation procedure constitutes Eaton and Kortum (2002)'s preferred specification. We also provide an OLS estimate of the comparative advantage parameter, see below.

[14]We only use region pairs where $n \neq i$. For the case $n = i$, equation (17) is an identity. With data on 15 regions, we end up with a total of 210 observations.

where $max2_j$ indicates the second highest value across all $J$ commodities and $r_{ni} \equiv \ln p_n(j) - \ln p_i(j)$. The intuition behind the first term is provided by the theoretical model: a buyer from region $n$ can always purchase any good $j$ from region $i$ at the effective price $p_i(j)d_{ni}$. Thus, $p_n(j)$ cannot be higher than that effective price, making $d_{ni}$ the upper bound (max) of the relative price between regions $n$ and $i$. The second term in (18) captures the relative price indices part in (17). We use the second highest value across all goods to avoid the potential bias from measurement error for the prices of certain commodities.

Using the proxy given in (18), the method-of-moments estimation procedure yields a value of the comparative advantage parameter of $\theta = 18.7$.[15] That value is higher than the preferred estimate of 8.28 of Eaton and Kortum (2002) for OECD countries in 1990, from a range of estimates between 3.60 and 12.86. Alternatively, one can add an error to (17) and estimate $\theta$ with an OLS regression; using this approach we obtain $\theta = 13.9$.[16] Overall this suggests that China's regional diversity in productivity across goods around the year 1900 was relatively small compared to other settings. This will be important for our analysis of welfare gains from trade, since the source of those gains in our framework is precisely comparative advantage.

### B. *Technology and Geography Parameters*

Armed with an estimate of the comparative advantage parameter $\theta$, we proceed to estimate the remaining parameters of the model, namely the parameters that capture regional states of technology, $T_i$, and geographic barriers, $d_{ni}$. As in Eaton and Kortum (2002), the model implies that

$$\ln \frac{X'_{ni}}{X'_{nn}} = S_i - S_n - \theta \ln d_{ni} \tag{19}$$

[15] We have examined how this estimate varies given our set of commodities, finding that it is quite robust to dropping individual items from our list of 26 commodities.

[16] Donaldson (2015) estimates $\theta = 5.2$ across 85 commodities in colonial India.

where

$$\ln X'_{ni} \equiv \ln X_{ni} - [(1-\beta)/\beta] \ln (X_i/X_{ii}) \tag{20}$$

and

$$S_i \equiv \frac{1}{\beta} \ln T_i - \theta \ln w_i \tag{21}$$

Equation (21) provides a measure of a region's competitiveness, $S_i$, defined as its state of technology adjusted for labor costs. As for the geographic barriers in (19), they are modeled as follows:

$$\ln d_{ni} = \sum_{b=1}^{6} d_b DIST_b + m_n + \delta^1_{ni} + \delta^2_{ni} \tag{22}$$

where $DIST_b$ takes the value 1 if the distance between regions $n$ and $i$ lies in the interval $b = 1...6$, and takes the value zero otherwise, and $m_n$ captures destination effects.[17] The last two terms in (22) capture all other unobserved geographic barriers between regions $n$ and $i$ affecting one-way ($\delta^1_{ni}$) and two-way ($\delta^2_{ni}$) trade. Combining (19) and (22) yields:

$$\ln \frac{X'_{ni}}{X'_{nn}} = S_i - S_n - \theta m_n - \sum_{b=1}^{6} \theta d_b DIST_b - \theta \delta^1_{ni} - \theta \delta^2_{ni} \tag{23}$$

Adding a regression error, equation (23) is our estimation equation. The dependent variable is based on aggregate bilateral trade data between the ports, and we assume that $\beta$, the cost share of labor, is 0.36. From equation (23), the competitiveness measures are estimated as region-specific dummies. The one-way and two-way unobserved barriers introduce heteroskedasticity and correlation be-

[17]The distance intervals (in miles) we use are as follows: [0,200); [200,400); [400,600), [600,800); [800,1000); [1000, maximum]. We also explore other specifications with polynomials of the log of distance instead of the distance dummies, finding similar results.

tween the errors of different region-pair observations (i.e., the error terms of the equations for the pairs $(n, i)$ and $(i, n)$ have non-zero correlation). Thus, we estimate this regression by generalized least squares.

Note that the coefficients on the distance dummies and destination effects are not separately identified from the comparative advantage parameter, $\theta$. However, given our estimate of the latter from above, we can identify those coefficients to obtain the geographic barriers parameters, $d_{ni}$. Finally, with data on wages and the estimated values of each region's competitiveness, $S_i$, we can use (21) to recover the technology parameters, $T_i$.

Table 3 presents the estimation results for the competitiveness measure and the implied values of the technology parameters. The table shows that Shanghai is the most competitive of the 15 regions, with the second highest state of technology, only surpassed by Swatow that, due to its relatively higher wages, loses part of its technological competitiveness. The result that Shanghai is highly competitive conforms well with its export level, which is twice that of Tianjin even though the two ports are roughly equal in size (see Table 1). Also interesting is the case of Canton (Guangzhou); while the port is third in terms of technology, it ranks 10th in terms of competitiveness due to the high wages in that region.

Table 4 presents the estimation results for the distance and destination dummies in (23), as well as the implied percentage effect of each particular barrier on costs. As can be seen in the table, costs increase with distance, although not in a monotonic way. In the lower part of the table, we see that exporting to Shanghai costs 48% less than exporting to the average region, while exporting to Ichang increases costs by 112% relative to the average region.

With these parameter estimates in hand, we are now ready to perform a number of counterfactual analyses.

Table 3—State of Technology and Competitiveness

| | Competitiveness | Technology |
|---|---|---|
| Shanghai | 7.38*** | 1.00 |
| Swatow | 5.98*** | 2.13 |
| Chefoo | 3.64** | 0.14 |
| Ningbo | 3.20* | 0.22 |
| Newchwang | 2.59 | 0.24 |
| Hankow | 2.37 | 0.23 |
| Tientsin | 1.92 | 0.27 |
| Amoy | -0.55 | 0.09 |
| Kiaochow | -0.79 | 0.36 |
| Canton | -2.02 | 0.90 |
| Foochow | -2.33 | 0.02 |
| Wuhu | -2.97* | 0.02 |
| Chinkiang | -3.67** | 0.01 |
| Kiukiang | -7.21*** | 0.00 |
| Ichang | -7.54*** | 0.02 |

*Note:* Ports ordered in terms of their estimated competitiveness. Statistical significance at 1%, 5%, and 10% indicated by ***, **, or *, respectively. The technology parameters are computed using wages and the estimated competitiveness measures, by solving for $T_i$ in (21) and using the method-of moments estimated value of $\theta = 18.7$.
*Source:* Authors' calculations.

### C. *Counterfactuals*

In this section we simulate counterfactuals involving changes in some of the model parameters. In particular, we explore the welfare effects of: 1) increases in the state of technology of specific ports; and 2) lower geographic barriers across the board. In all cases, our measure of welfare is real GDP, defined in equation (16).

Table 5 presents the results from changes in the state of technology of specific ports, $T_i$. We start with an increase of 20% in the state of technology of the biggest port, Shanghai, holding everything else in the model constant. An increase of 20% is reasonable given that the operation of customs by the CMC brought with it a wide range of improvements, such as dredging of the harbor, new lighthouses, increased protection from pirates, and the customs process itself. The first column

Table 4—Geographic Barriers

| Distance | Geography parameters | Percentage effect on cost |
|---|---|---|
| [0,200) | -2.76 | 15.9 |
| [200,400) | -3.84*** | 22.8 |
| [400,600) | -7.04*** | 45.71 |
| [600,800) | -7.75*** | 51.35 |
| [800,1000) | -6.94*** | 44.94 |
| [1000,maximum] | -5.69*** | 35.56 |
| DESTINATION | | |
| Amoy | -3.38 | 19.81 |
| Canton | -0.69 | 3.76 |
| Chefoo | 3.66 | -17.78 |
| Chinkiang | -3.00 | 17.40 |
| Foochow | -1.54 | 8.58 |
| Hankow | 7.59*** | -33.36 |
| Ichang | -14.05*** | 111.98 |
| Kiaochow | -4.6* | 27.89 |
| Kiukiang | -4.54* | 27.48 |
| Newchang | -0.69 | 3.76 |
| Ningbo | 4.21 | -20.16 |
| Swatow | 3.91 | -18.87 |
| Tientsin | 3.58 | -17.42 |
| Wuhu | -2.82 | 16.28 |
| Shanghai | 12.35*** | -48.34 |

*Note:* Estimated parameters for distance dummies and destination effects. Statistical significance at 1%, 5%, and 10% indicated by ***, **, or *, respectively. The implied percentage effect on cost for each parameter $d$ is calculated as $100 \times exp(-d/\theta - 1)$, using the method-of moments estimated value of $\theta = 18.7$.
*Source:* Authors' calculations.

reports the percentage change in welfare at each port derived from this increase in Shanghai's technology. The second column normalizes Shanghai's welfare change to 100. The improvement in Shanghai's productivity leads to a welfare change in this region of about 1.5%. Importantly, the welfare gains are not confined to this port. Because of domestic trade, other ports in the vicinity of Shanghai, such as Ningbo, Chinkiang, and Wuhu also experience significant welfare gains. Even Swatow, at 1,300 km from Shanghai, experiences around 13% of the welfare increase of Shanghai. Also noteworthy is the fact that not all regions benefit from Shanghai's technology improvement. Because factor costs, income, and

Table 5—Port-Specific Technology and Welfare

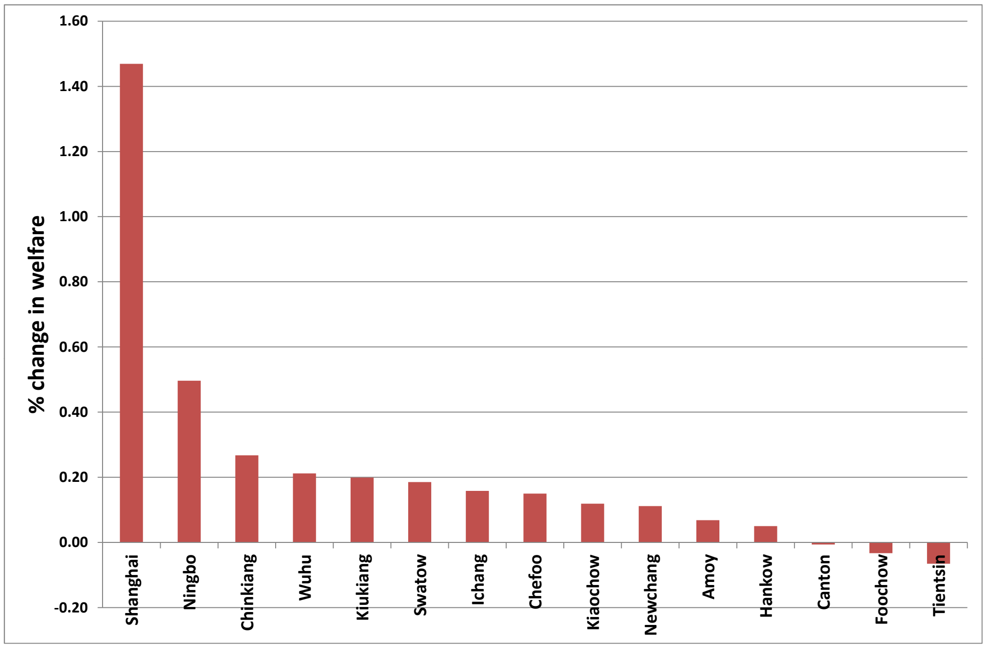
| | Technology Shanghai up 20% | | Technology Hankow up 20% | |
|---|---|---|---|---|
| | Welfare % Δ | % Δ /Shanghai | Welfare % Δ | % Δ /Hankow |
| Amoy | 0.07 | 4.64 | 0.06 | 3.94 |
| Canton | -0.01 | -0.44 | -0.01 | -1.03 |
| Chefoo | 0.15 | 10.19 | 0.13 | 8.86 |
| Chinkiang | 0.27 | 18.19 | 0.10 | 7.08 |
| Foochow | -0.03 | -2.25 | -0.03 | -1.97 |
| Hankow | 0.05 | 3.41 | 1.45 | 100 |
| Ichang | 0.16 | 10.78 | 0.16 | 10.87 |
| Kiaochow | 0.12 | 8.09 | 0.06 | 3.89 |
| Kiukiang | 0.20 | 13.55 | 0.21 | 14.49 |
| Newchwang | 0.11 | 7.59 | 0.10 | 6.60 |
| Ningbo | 0.50 | 33.78 | -0.23 | -16.11 |
| Swatow | 0.19 | 12.62 | 0.18 | 12.35 |
| Tientsin | -0.07 | -4.44 | 0.01 | 0.68 |
| Wuhu | 0.21 | 14.42 | 0.13 | 9.15 |
| Shanghai | 1.47 | 100 | -0.01 | -0.96 |
| Average | 0.226 | | 0.154 | |

production patterns respond endogenously to this change, welfare actually falls in some ports like the distant Tientsin.

The last two columns present the results of a similar experiment with Hankow's technology. The welfare gains in Hankow are similar to those for Shanghai in the previous experiment. Welfare gains spread to other regions, especially the ones close to Hankow, but with lower magnitudes than in the case of Shanghai's productivity improvement. This is evident by comparing Figures 7 and 8.

In Table 6 we present the results of two experiments involving changes in geographic barriers across the board, keeping all regions' technology fixed. We start by lowering trade impediments to half of the original levels underlying Table 4. This is a drastic reduction of trade barriers which however could be plausible given the introduction of steam ships during the late 19th century. We see that trade increases by 13% as a result of the lower barriers. Welfare gains, however, are unevenly distributed across ports, and some regions, in particular Shanghai

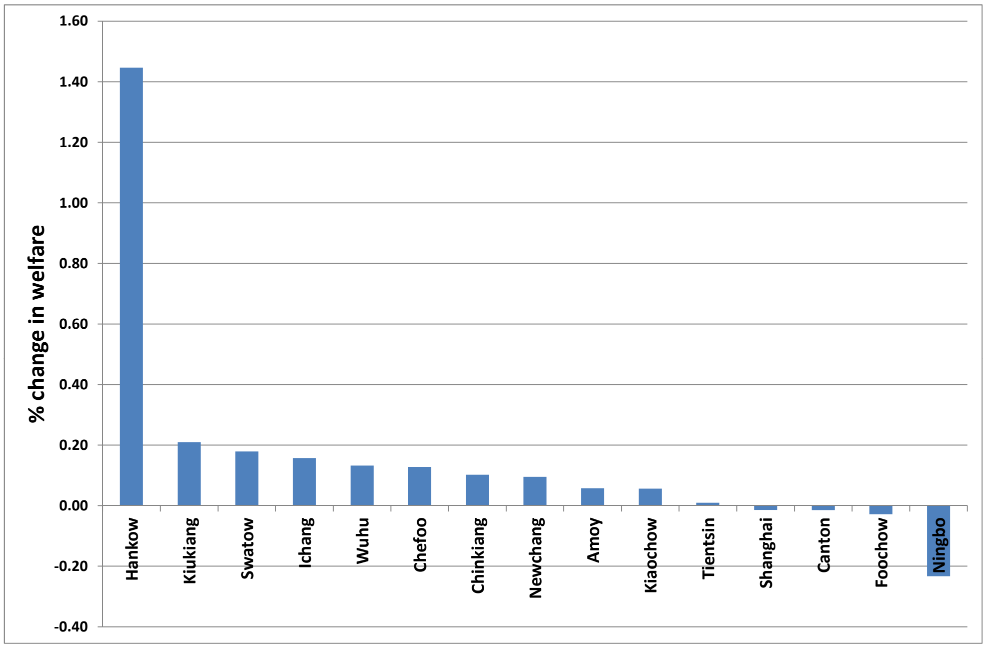
Figure 7. Welfare Effects of Higher Technology in Shanghai




and Ningbo, experience welfare losses. One can show that the share a region buys from itself is a sufficient statistic for the welfare effect of a change in trade costs: if this share goes up, welfare falls, and vice versa (see Costinot and Rodriguez-Clare 2013). In our case, the share that Shanghai and Ningbo consumers buy from their own region increases as a consequence of the 50% reduction in trade costs.

The reason for this lies in the reallocation of production and trade predicted by our general-equilibrium model. The intuition is that lower trade barriers across the board diminish the advantage that Shanghai has based on its technology. More generally, notice that the four regions with the lowest welfare gains due to lower trade barriers are Shanghai, Ningbo, Chefoo, and Swatow, which are the four regions with the highest level of labor-cost adjusted technology (or competitiveness, see Table 3). For all competitive exporters, lower trade barriers means that they might not be any longer the low-cost source of supply for some importing regions,

Figure 8. Welfare Effects of Higher Technology in Hankow




relative to slightly less competitive regions that are located geographically closer. If a competitive exporter ceases to serve a particular region, this is a movement in the direction of autarky, and welfare falls.

The difference between the more strongly negative welfare effects in Shanghai and Ningbo, compared to Swatow and Chefoo, can be explained by their different geographic location. Shanghai and Ningbo are centrally located close to the Yangzi Delta. This means that before the reduction of trade barriers, given their high level of competitiveness they exported to many other locations, and the reduction in trade barriers has the potential that they lose their status of low-cost supplier in many importing regions. In contrast, Chefoo and Swatow are located in geographically more remote parts of China, North and South, respectively. They lose some markets as the result of the lower trade barriers, while they hold on to others due to their geographic remoteness. As a consequence, Chefoo and Swatow lose less than Shanghai and Ningbo.

In the second half of Table 6 we experiment with a more extreme reduction in geographic barriers from the baseline to zero-gravity (setting all iceberg coefficients to virtually $d_{ni} = 1$). As a result, overall trade increases more than in the previous case, although the increase remains, with 54%, relatively modest. The distribution of welfare gains presents the same pattern as before, although with higher magnitudes.

Table 6—Lower Geographic Barriers and Welfare

| | Trade barriers down 50% % change relative to baseline | | | Trade barriers down to zero % change relative to baseline | | |
|---|---|---|---|---|---|---|
| | Welfare | Prices | Wages | Welfare | Prices | Wages |
| Amoy | 2.58 | -7.15 | -2.07 | 22.03 | -35.69 | 16.35 |
| Canton | 1.67 | -0.03 | 3.24 | 10.18 | -17.51 | 4.25 |
| Chefoo | 0.17 | 4.25 | 9.36 | 5.79 | -6.35 | 12.64 |
| Chinkiang | 0.75 | -2.90 | -3.53 | 13.68 | -27.00 | 7.91 |
| Foochow | 2.15 | 0.05 | 4.02 | 17.21 | -21.23 | 13.61 |
| Hankow | 2.01 | 10.23 | 10.30 | 2.49 | 6.95 | 8.74 |
| Ichang | 8.90 | -26.89 | -24.80 | 37.89 | -92.07 | -31.31 |
| Kiaochow | 1.95 | -6.13 | -2.79 | 19.84 | -35.08 | 11.90 |
| Kiukiang | 3.51 | -8.00 | -2.26 | 18.98 | -39.09 | 16.31 |
| Newchwang | 4.22 | -3.48 | 9.96 | 19.79 | -25.86 | 28.25 |
| Ningbo | -31.41 | 15.12 | -32.25 | -35.40 | 9.79 | -41.17 |
| Swatow | 0.27 | 3.22 | 14.44 | 5.45 | -7.19 | 17.69 |
| Tientsin | 3.43 | 4.25 | 8.95 | 10.55 | -6.54 | 12.51 |
| Wuhu | 2.38 | -4.59 | 1.77 | 15.37 | -28.89 | 13.12 |
| Shanghai | -17.29 | 23.73 | -7.76 | -32.62 | 31.00 | -22.50 |

| % change in overall trade | % change in overall trade |
|---|---|
| 13.14 | 54.11 |

*Note:* The table shows the results of lowering geographic barriers by 50% (first half) or to virtually zero (0.001 of the baseline barriers; second half) from the baseline estimated values provided in Table 4 without changing states of technology (which are fixed at the estimated levels provided in Table 3). The comparative advantage parameter is fixed at its method-of-moments estimated value of 18.7.

## V. Concluding discussion

In this paper we provide estimates of a general-equilibrium trade model for China around the year 1900, employing a new, commodity-level dataset for fifteen major treaty ports. We show that the welfare effects of internal trade depend critically on each port's productivity, China's economic geography via trade costs, and the degree of regional diversity in production.

There are two main findings. First, we find that a change in productivity for any of the ports has ripple effects throughout China. Specifically, a 20% increase in Shanghai's productivity raises welfare in Shanghai by about 1.5%; because of trade, however, welfare increases not only in Shanghai but also in other regions. For example, the welfare increase at a 1,300 kilometers distance away from Shanghai, in Swatow, is still 13% of the welfare increase due to the improvement in technology in Shanghai. Since trade diminishes smoothly over geographic space, whether between two treaty ports or between treaty port and hinterland, these results suggest that the foreign opening had a sizable positive welfare effect on large portions of China. Furthermore, because factor costs, income, and production patterns respond endogenously, welfare in some ports can actually fall, as it does in the relatively distant Tianjin. The endogenous reallocations of production and trade also explain the negative welfare effects we find for some ports like Shanghai and Ningbo when trade impediments are reduced across the board.

Second, we find evidence of relatively small regional diversity in productivity across goods for China during the treaty port era, at least in comparison with that found in high-income countries of the late 20th century. This provides a rationale for the aggregate size of welfare gains from internal trade we find for China in this historical period, since differences in productivity across goods – comparative advantage – is the source of the gains from trade in our framework.

How confident can we be about the magnitudes of the estimated welfare effects? Clearly, the foreign opening brought many consecutive changes in technology, not only one, to one region, as in our counterfactual. Furthermore, trade barriers fell unevenly across regions, and in several steps over time. In principle, assuming we had reliable estimates of the relevant port-level changes, our counterfactual analyses could be extended to incorporate such effects. The analysis of other potential gains from openness, such as the availability of new goods, learning, and increased innovation require a more substantial extension that is left to future work. In summary, the high rate of development since 1978 is consistent with China's catch-up to her long-run trajectory, suggesting that more work on the legacy of China's 19th century opening will help our understanding of the sources of economic growth.

## REFERENCES


[1] Brandt, L., D. Ma., and T. G. Rawski (2014), "From Divergence to Convergence: Reevaluating the History behind China's Economic Boom." *Journal of Economic Literature*, 52(1): 45-123.

[2] Broadberry, S., H. Guan, and D. Li (2014), "China, Europe, and the Great Divergence: A Study in Historical National Accounting, 980-1850", London School of Economics working paper, July.

[3] Cassel, P. K. (2012), *Grounds of Judgment. Extraterritoriality and Imperial Power in Nineteenth-Century China and Japan*, Oxford University Press.

[4] Chang, J. (1969), *Industrial Development in Pre-Communist China: A Quantitative Analysis.* Chicago: Aldine.

[5] CMC (2001a), *Returns of Trade and Trade Reports, China, Imperial Maritime Customs*, (The Maritime Customs after 1910), Statistical Department of the Inspectorate General of Customs, Shanghai, various years.

[6] CMC (2001b), *Decennial Reports, China, Imperial Maritime Customs*, (The Maritime Customs after 1910), Vol. 1 (1882-1891), Vol. 2 (1892-1901), Vol.3 (1902-1911), and Vol. 4 (1912-1921), Statistical Department of the Inspectorate General of Customs, Shanghai, various years.

[7] Costinot, A., and A. Rodriguez-Clare (2013), "Trade Theory with Numbers: Quantifying the Consequences of Globalization", manuscript, March.

[8] Dernberger, R. F. (1975), The Role of the Foreigner in China's Economic Development", in D. H. Perkins (ed.), *China's Modern Economy in Historical Perspective* (Stanford, CA: Stanford University Press.

[9] Donaldson, D. (2015), "The Railroads of the Raj", *American Economic Review*, forthcoming.

[10] Eaton, J., and S. Kortum (2002), "Technology, Geography, and Trade", *Econometrica* 70: 1741-1779.

[11] Fairbank, J. K. (1978), "The Creation of the Treaty System", in D. Twitchett and J. K. Fairbank (eds.), *The Cambridge History of China*, Vol. 10 Late Ch'ing, 1800-1911, Part I (Cambridge: Cambridge University Press).

[12] Fajgelbaum, P., and S. Redding (2014), "External Integration, Structural Transformation and Economic Development: Evidence from Argentina 1870-1914", NBER Working Paper # 20217, June.

[13] Findlay, R., and O'Rourke, K. (2007), *Power and Plenty: Trade, War, and the World Economy in the Second Millennium,* Princeton University Press.

[14] Helliwell, J. and G. Verdier (2001), "Measuring internal trade distances: A new method applied to estimate provincial border effects in Canada," *Canadian Journal of Economics* 34 (4):1024-1041.

[15] Head, Keith and Thierry Mayer (2001), "Increasing returns versus national product differentiation as an explanation for the pattern of US-Canada trade," *American Economic Review* 91 (4):858-876.

[16] Head, K., & Mayer, T. (2002). *Illusory Border Effects: Distance mismeasurement inflates estimates of home bias in trade* (Vol. 1). Paris: CEPII.w 55(1): 131-168.

[17] Hsiao, L.-L. (1974), *China's Foreign Trade Statistics, 1864-1949* (Cambridge, MA: Harvard University Press.

[18] Jia, R. (2014), "The Legacies of Forced Freedom: China's Treaty Ports", *Review of Economics and Statistics*, vol. 96, 596-608.

[19] Keller, W., B. Li, and C. H. Shiue (2013), "Shanghai's Trade, China's Growth: Continuity, Recovery, and Change since the Opium Wars", *IMF Economic Review* Vol. 61(2): 336-378.

[20] Keller, W., B. Li, and C. H. Shiue (2012), "The evolution of domestic trade flows when foreign trade is liberalized: Evidence from the Chinese Maritime Customs Service", in *Institutions and Comparative Economic Development*, M. Aoki, T. Kuran, and G. Roland (eds.), Palgrave Macmillan.

[21] Keller, W., B. Li, and C. H. Shiue (2011), "China's Foreign Trade: Perspectives From the Past 150 Years", *World Economy*: 853 – 892.

[22] Keller, W., and C. H. Shiue (2015), "Capital Markets and Colonial Institutions in China", paper presented at the China Economic Summer Institute conference, Beijing, August 2015.

[23] Kose, H. (2005), "Foreign Trade, Internal Trade, and Industrialization: A Statistical Analysis of Regional Commodity Trade Flows in China, 1914-1931, in K. Sugihara (ed.), *Japan, China, and the Growth of the International Asian Economy, 1850 – 1949* (New York: Oxford University Press), 198-214.

[24] Kose, H. (1994), "Chinese Merchants and Chinese Inter-port Trade", in *Japanese Industrialization and the Asian Economy*, A. J. H. Latham and H. Kawakatsu (eds.), New York: Routledge.

[25] Liu, Ta-Chung, and Kung-Chia Yeh (1965), *The Economy of the Chinese Mainland: National Income and Economic Development, 1933-1959*, Princeton, New Jersey: Princeton University Press.

[26] Lyons, T. (2003), *China Maritime Customs and China's Trade Statistics, 1859-1948*, Willow Creek Publisher.

[27] Mitchener, K. J., and S. Yan (2014), "Globalization, trade, and wages: What does history tell us about China?", *International Economic Review* 55(1): 131-168.

[28] Morse H. (1926), *The Chronicles of the East India Trading Company, 1634-1834*, Vols 1-5, Oxford: Clarendon Press.

[29] O'Rourke, K., J. Williamson (1999), *Globalization and History. The Evolution of a Nineteenth-Century Atlantic Economy*, MIT Press.

[30] O'Rourke, K., J. Williamson (1994), "Late 19th Century Anglo-American Factor Price Convergence: Were Heckscher and Ohlin Right?", *Journal of Economic History* 54: 892-916.

[31] Perkins, D. H. (1969), *Agricultural Development in China 1368-1968,* Aldine.

[32] Redding, S. and A. Venables (2000), "Economic geography and inequality," mimeo London School of Economics.

[33] Richardson, P. (1999), *Economic Change in China, c. 1800-1950.* Cambridge University Press.

[34] So, B. K. L., and R. H. Myers, eds., (2011), *The Treaty Port Economy in Modern China: Empirical Studies of Institutional Change and Economic Performance*, China Research Monograph 65, Institute for East Asian Studies, University of California, Berkeley.

[35] Tinbergen, J. (1962), *Shaping the World Economy: Suggestions for an International Economic Policy.* New York: Twentieth Century Fund.

[36] Wei, S. J. (1996), "Intra-national versus international trade: How stubborn are nations in global integration?" National Bureau of Economic Research Working Paper no. 5531.

[37] Wolf, H. (1997), "Patterns of intra- and inter-state trade." National Bureau of Economic Research Working Paper no. 5939.

[38] Wolf, H. (2000), "Intranational home bias in trade," *Review of Economics and Statistics* 824 (4): 555-563.

## Appendix A: Wage Data

Wages are obtained as a mean residual, by port, from an OLS regression on occupation fixed effects, year fixed effects, length of work time fixed effects (hour, month, year), currency fixed effects. The wage for Hankow and Foochow is estimated as the prediction from a regression of observed wages on latitude and longitude. The following Table A1 shows the different occupations that are available from the *Decennial Reports.*

Table A1—Wage Data from the Decennial Reports

| Region | Obs. | Occupation | Obs. |
|---|---|---|---|
| Amoy | 1 | General, skilled (e.g. mechanic) | 21 |
| Canton | 29 | General, unskilled | 19 |
| Chefoo | 30 | Carpenter | 62 |
| Chinkiang | 91 | Stonemason | 57 |
| Foochow | n/a | Painter | 4 |
| Hankow | n/a | Blacksmith | 34 |
| Ichang | 15 | Coolie | 19 |
| Kiaochow | 12 | General, manual | 24 |
| Kiukiang | 8 | Servant | 23 |
| Newchwang | 2 | Cotton/silk weaver | 9 |
| Ningpo | 8 | Matchmaker | 1 |
| Swatow | 10 | Tailor | 26 |
| Shanghai | 12 | Farmhand | 4 |
| Tientsin | 69 | | |
| Wuhu | 7 | | |
| Total | 294 | | |

*Note:* Notes: Data from CMC (2001b), Decennial Reports, various volumes; number of observations for 1901-1911: n = 56, 1912-1921: n = 105, and 1922-1931: n = 144.

## Appendix B: Labor force and gross product data

To obtain figures for the labor force of each region, we employ the average of the population estimates of the *Decennial Reports* (CMC 2001b) for 1901 and 1911; there are separate estimates for the Chinese and the foreign population, which we add together. We apply Liu and Yeh's estimate of national labor force participation in 1933 of 51.8% to obtain regional labor forces, $L_i$ (Liu and Yeh 1965, p. 182). The wage estimates from Appendix A times these labor forces yield a region's wage income, $w_i L_i$.

Recall that our regions are defined on the basis of the customs districts of the treaty ports. While the ports were of central importance, it would be an overstatement to treat the customs districts as exclusively urban areas. In order to capture the large contribution of agriculture to China's gross product at this time, we estimate the gross product of each region by augmenting the wage income $w_i L_i$ with an estimate of the region's agricultural production, based on Perkins (1969).

The value of agricultural production in each province is estimated for the years 1914-1918 from data on acreage for barley, corn, cotton, fiber (including jute, hemp, ramie, and flax), millet, peanuts, rice, sesame, sorghum, soybeans, sugarcane, tobacco, and wheat (Perkins 1969, Appendix C); yield data for these crops, see Perkins 1969, Appendix D, and crop prices given in Perkins (1969, Table D.31). Given the value of agricultural production in each province, $p_i Q_i$, we estimate each region $i$'s agricultural production, $p_i Q_i$, as $p_i Q_i = s_i \times p_p Q_p$ , where $s_i$ is the fraction of region $i$'s population of the population in the province in which region $i$ is located. The gross product of region $i$, $Y_i = w_i L_i + \lambda \times p_i Q_i$ , with $\lambda = 1.1$ in the baseline analysis. We have confirmed that our main findings are not sensitive to choosing other reasonable values for $\lambda$ (results available upon request).

## Appendix C: Purchases-from-self

The expenditures of region $i$ on production of $i$ are not observed. We therefore estimate a gravity equation regression of bilateral trade flows on a set of standard gravity covariates to predict the value of each port's consumption of its own goods. These covariates include bilateral distance, the origin and destination ports' respective population sizes, and a dummy variable indicating the destination port's location on the Yangtze River. Values for each of these variables are for 1904; however, estimates are also produced including additionally data for the years 1895 through 1899. For these estimates which employ multiple years' worth of data, a time fixed effect is included. To preserve zero trade flows and maintain a sufficiently high sample size after taking logarithms, each trade flow value is increased by one.

Several flexible versions of the gravity equation are employed, including the standard log-linear gravity equation, a Poisson pseudo-maximum likelihood (PPML) estimator of the gravity relationship, and a PPML estimator possessing squared and cubed logarithms of distance. Because of the out-of-sample nature of the predictions, the preferred specifications are ones that are able to most closely fit the relation between bilateral trade flows and distance between ports, i.e., those specifications for which the (joint) significance of the coefficient(s) on distance is suitably high. Finally, each specification is either estimated by pooling the data across all 15 ports, or individually for each port. To capture a realistic measure of internal distance within treaty ports $d_{ii}$, five alternative measures of internal distance from the literature are used for the predictions for purchases-from-self. These include (with $d_{ij}$ denoting the distance between ports i and j):

1) Wei (1996): $d_{ii} = 0.25 \text{ min}_j d_{ij}$,

2) Wolf (1997, 2000): $d_{ii} = 0.50 \text{ mean } (d_{ij})$,

3) Redding and Venables (2000): $d_{ii} = 0.33\sqrt{area_i/\pi}$ ,

4) Head and Mayer (2000): $d_{ii} = 0.67\sqrt{area_i/\pi}$,

5) Helliwell and Verdier (2001): $d_{ii} = 0.52\sqrt{area_i}$ ,

where $area_i$ denotes the area of the prefecture in which the treaty port $i$ is located. In total, the various specifications and internal distance measures generate 2 x 3 x 2 x 5 = 60 candidate estimates for purchases-from-self for each of the 15 treaty ports. The preferred estimates are chosen along three dimensions. First, by comparing the correlation between predicted bilateral trade flows $\hat{x}_{ij}$ and observed trade flows $x_{ij}$. Estimates with a high correlation do a relatively good job of predicting actual purchases from other ports. For the second and third dimensions, two empirical regularities are exploited: the fact that modern large economies (which in turn tend to be larger exporters) generally have larger magnitudes of consumption of their own goods than smaller economies in absolute terms, and that the ratio of exports to purchases-from-self tends to run from around 0.10 for smaller, isolated countries like Australia, to around 0.25 for the U.S., to 0.35 for large countries such as Germany with many close, large trading partners. We therefore consider as the second dimension the correlation between total trade, $\sum_j x_{ij}$, and predicted self-purchases $\hat{x}_{ii}$, and the third dimension as the ratio of total trade to predicted purchases-from-self, $\sum_j x_{ij}/\hat{x}_{ii}$. Estimates that perform well in the second and third dimensions, by having, respectively, a high correlation and a "reasonable" ratio, perform comparatively well in predicting the relative magnitude of trade-with-self.

Of the 60 estimates for purchases-from-self, the four best candidate estimates are chosen upon evincing a high degree of performance in each dimension and after fitting the distance variable(s) well: when pooling the data across all ports, they are: i) PPML with a cubic expansion of log distance using Wolf's (1994) internal distance and data for 1904, ii) PPML of standard gravity using Helliwell and Verdier's (2001) internal distance and data for all six years, iii) PPML of standard gravity using Head and Mayer's (2001) internal distance and data for 1904, and with port-level regressions, iv) PPML of standard gravity using Wolf's (1994) distance and data for 1904.