Trade Openness, Geography and Products Heterogeneity: Price Convergence and Market Integration in Late Qing China

Linhui Yu

University of Hong Kong

Abstract:
The research investigates the evolution of market integration in late Qing China. Utilizing a panel containing yearly average market prices of 14 foreign products imported into China's 23 treaty ports during the period 1864-1900, I find that The Law of One Price holds for the vast majority of products examined, which implies that China's commodity markets were well integrated during that period. Further evidences show that trade openness significantly contributed to the enhancement of market integration through competition effects between treaty ports and age effects of local commodity markets since trade openness. In addition, it took differentiated goods longer time to converge to the LOP than homogeneous goods. Besides, geographic factors also had some impacts on the evolution of market integration. This research, on the one hand, contributes to the literature on economic history and economic geography of China. On the other hand, it provides further empirical evidences for identifying a casual relationship between trade openness and economic growth.

1. Introduction

It is well recognized by economists that market integration is essential for long-run economic growth. The rationale behind is obvious: it allows free flow of resources across regions, thus greatly improves the efficiency of market in allocating resources. **The Law of One Price (LOP)**, the central issue of market integration, requires that in a free market prices of the same products be equalized in different regions. The basic assumption is that arbitrage activities will appear to fill price gaps across regions at low costs in an efficient market. Therefore, in economic researches LOP is widely employed as a benchmark for measuring how well a market is integrated comparing to the ideal scenario.

This research, using a panel containing the market prices of foreign products imported into China during the period between 1864 and 1900, is dedicated to investigating the evolution of China's regional commodity markets in late Qing dynasty. By conducting this research, I attempt to answer the following questions: How did the commodities markets evolve in the late Qing dynasty after China opened its doors to foreign trade? Does openness of treaty ports contribute to the enhancement of market integration? How do factors like geography and products heterogeneity affect the integration of markets?

Different from the existing studies that mostly use grain prices to measure market integration, this research expands the price data pool to 14 commodities under 6 categories--Opium, Cotton goods, Woolen goods, Metals, Energy and Sundries. It allows us to present the broader picture of China's markets during that period than previous studies. In addition, some newly developed econometrical methods like nonlinear ESTAR model (Granger and Terasvirta, 1993), etc., are employed in this research to consolidate my findings.

This research contributes to the existing literature in three aspects. Firstly, it provides further evidences for identifying the effect of trade openness on market integration and even long-run economic growth, which is central to the very foundation of economics. According to economic theory, the most immediate impact of trade on economy lies in that it helps to narrow down price gap between regions, thus enhancing market integration which is essential for the long-run economic growth (Lillian M. Li, 2000). But empirically testing this theory is difficult because the data needed is usually unavailable. Fortunately, the trade openness of China in the 19th century offers us a precious *Natural Experimental Environment* for testing this theory. Using Chinese data, the simultaneity problem between trade openness and economic growth, which is most concerned by economic scholars, will be greatly relieved due to the contingency of passiveness of China's trade openness in the 19th century.

Secondly, findings of this research are helpful for people to better understand the historical role of treaty ports in the modernization of China. In traditional views, China's falling behind in the 20th century is regarded more or less as the results of its wretched history in the 19th century. China's treaty ports, which were forced open by western powers, actually acted as bases for foreign countries to dump cheap industrial products in China.[1] Therefore, the existence of treaty ports greatly depresses the growth of China's national industries at their embryo stages. However, some contemporary scholars also emphasize treaty ports' contribution to the progress of China in the long run. They argued that treaty ports served as windows for Chinese people to learn and even interact with outer world. Moreover, capitalistic production modes, advanced technologies and the latest thoughts were introduced into China via these treaty ports, which are absolutely beneficial to the modernization of China (Wu, Chengming, 1985a, 1985b; Zheng, Youkui, 1991).

Thirdly, this research also sheds light on the studies on economy of contemporary China. Actually, it is quite interesting that China's openness since 1978 surprisingly resembles its

[1] These ports were forced to open according to some treaties between China and western forces, so they are called treaty ports.

history of trade openness in the late 19th century. Both these two openness underwent a gradual process, and also spread from China coastal areas to inland areas. Since history always repeated itself, learning more from the past experiences will surely help us better develop China's economy today.

2. Literature Review

Two strands of literature are closely related to this paper. The first one is on the measurement of market integration through identification of price dispersion. The second one is on the determinants of market integration.

The Law of One Price (LOP) is widely used by economists to evaluate the competitiveness and efficiency of a market. According to Gibson and Smout (1995), the essential elements for market integration are information transmission, transportation infrastructures and coinage. Thus, LOP implies that that prices of the same commodity should be same in all regions after transport costs are considered. Perfect satisfying of LOP is almost impossible due to the existence of all kinds of boundaries. So, economic researchers only use it as a benchmark to quantify to what extent a market approximates to the ideal scenario of market integration.

Purchasing Power Parity (PPP), which is LOP across countries with different currencies, is most concerned by researchers who study international or cross-country markets. According to PPP theory, exchange rates should be determined by the aggregate price levels in corresponding countries, so that the real purchasing powers of two different currencies should be equalized strictly following their exchange rates (Taylor and Taylor, 2004). This theory is derived from the basic assumption of the LOP which emphasizes the importance of arbitrage across countries in the formation of real exchange rates. A lot of researches have been done to empirically test this theory. Engel and Rogers (1996) investigated the commodity prices in US and Canadian cities and found that there exist persistent price differentials between cities crossing US-Canada boundary. They referred to this phenomenon as "border effect". Since tariffs, exchange rate policies and the extent of trade protectionism are very different in some countries, moreover, it is also very difficult to select a basket of perfectly identical commodities for all countries, existing evidences of absolute PPP is very rare. But the relative PPP, which requires that the percentage change of the exchange rates of currencies offset their corresponding differences in inflation rates over a given period of time, has been proved to easily hold according to the findings of previous studies. Frankel (1986) detected the mean-reversion of the dollar-sterling real exchange rates during 1869-1984. Frankel and Rose (1996) found that the real exchange rates of 150 countries in 45 years after World War II were approaching to PPP at a relatively slow speed—the half-life was about 4 years. Taylor and Taylor (2004), using CPIs and PPIs of US and UK from 1820 to 2001, tested the absolute and relative PPP. Their findings also showed that PPP holds quite well in the long-run. Similar researches include Edison (1987), Glen (1992), Lothian and Taylor (1996), Taylor (2002), etc. In addition, Some newly developed econometric methods, e.g., panel unit root test (Maddala and Wu, 1999), non-linear stationarity test (Granger and Terasvirta, 1993; Terasvirta, 1994), etc., were also adopted by some researchers for testing PPP. These works include Benninga and Protopapadakis (1998), Dumas (1992), Taylor (2001), Michael, Nobay and Peel (1997), Baum, Barkoulas and Caglayan (2001), Taylor, Peel, and Sarno (2001), etc.

Compared to cross-country studies, prices within a country or an economic union like EU is exempt from exchange rates fluctuation, but still suffer from implicit trade protectionism. A lot of works have been done to test LOP in OECD countries and developing nations.[2] These works include Parsley and Wei (1996), Engel and Rogers (2001), Rogers (2001), Cecchetti, Mark, and Sonora (2002), Ceglowski (2003), and Goldberg and Verboven (2005), Fan and Wei (2006), Young (2000), De Masi and Koen

[2] There are 30 member countries of the OECD at present, which are Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, the Netherland, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, and the United States.

(1996), Berkowitz and DeJong (2001), Jha, Murthy, and Sharma (2005), Conway (1999), etc. Parsley and Wei (1996), using a panel containing the prices of 51 commodities and services in 48 U.S cities, estimated the market integration of the US. Their findings showed that in spite of holding of the LOP in US market non-tradable goods usually have lower speed of price convergence than tradable goods. The half-lives of the former are about 15 quarters, while the latter are only 4-5 quarters. Engel and Rogers (2001) explored the determinants of price differentials across US cities and found substantial contributions of nominal price stickiness on generating price gaps between cities. Ceglowski (2003) found that price gaps between Canadian cities are smaller than those between cities across the US-Canada border estimated by Engel and Rogers (1996). Goldberg and Verboven (2005) examined car prices in European countries. Their finding suggested that car prices dispersion originally existing in European countries were narrowing after EU founded. Berkowitz and Dejong (2001) examined the commodity prices in Russia during 1994-1999. Jha and Sharma (2005) investigated the market integration of India by analyzing the rice prices in 55 Indian regional markets between 1970 and 1999. A common finding of the above researches is that market integration of developed countries is usually better than developing countries, which can be reflected by different speed of price convergence between them.

A surge of literature has examined the market integration in China. Young (2000) found price dispersion of some agricultural and industrial products in China during 1986-1993. So, she argued that China was suffering serious market fragmentation. In contrast, Fan and Wei (2006) challenged Young's findings by showing that the vast majority of commodities and services they examined, including 49 industrial products, 33 agricultural products, 18 consumer goods and 18 services, conformed to LOP during 1990-2003. In addition, some researchers have examined the market integration in China at ancient times. Carol H. Shiue (2002) examined the grain markets of the most developed regions of China in Qing dynasty during 1742-1795. She found that grain markets in regions that do not have easy access to waterway are much more integrated than expected because they depended on storage instead of trade to smooth local supply shock, and she called this phenomenon "inter-temporal market integration". Similar works include Lillian Li (2000), which studied the grain markets in North China in the 18th and 19th centuries, Wang (1998), which examined the rice prices in 6 Yangtze Delta cities in China during 1738-1739, and Perdue (1992), which focused grain markets in Gansu province.

The other strand of literature related to this research is trade openness and economic growth. What people concerned is whether foreign trade plays propulsive roles in driving economic growth. Economic literature stresses the important roles of free trade in increasing labor productivity and driving economic growth, thus it is known as the "engine of growth". Previous works supporting trade-lead growth include Michaely (1977), Balssa (1978), Tyler (1981), Kavoussi (1984), Feder (1982), Greenway and Nam (1988), Esfahani (1991), Harrison (1996), Frankel and Romer (1999), Irwin and Tervio (2002), etc. However, some works such as Jung and Marshall (1985), Bahmani et al (1991) and Darrat (1986), etc., argued that the existing evidences were not sufficient to prove that theory. A more recent work by Acemoglu, Johnson and Robinson (2005) further shed light on this issue. They investigated the unprecedented economic growth of west Europe during the period 1500-1800 and established a close linkage between Atlantic trade and the First Great Divergence.[3] They finally documented that the growth path of Western Europe during the First Great Divergence can be mostly accounted for by the quick rise of the nations that have access to the Atlantic Ocean and also involved in Atlantic trade.

Actually, one of the difficulties facing this research is how to measure trade openness. A basic indicator is the share of trade volume (including import and export) in GDP. Harrison (1996), using this method found significantly positive impacts of trade openness on economic growth. Another method is measurement of trade barriers and non-tariff barriers. Researchers who have used this method reported mixed empirical results. Lee (1993) and Edwards (1998) both established a significant and negative relationship

---

[3] First Great Divergence means the sustained divergence during the period between 16th century and 19th century in income per capita across different regions of the world, which makes Western Europe substantially richer than Asia and Eastern Europe.

between tariffs and economic growth. By contrast, Edwards (1992), Sala-I-Martin (1997), and Clemens and Williamson (2001) showed very weak evidence of such relationship. Other methods of measuring trade openness include nominal exchange rate, bilateral payments arrangements, etc.

3. A Brief Description of Historical Background

Qing (1644-1911) was the last imperial dynasty in the history of China. During the reign of Qing dynasty, China was almost an autarky and rarely involved in foreign trade until the Sino-British Opium War breaking out in 1840.[4] Defeated in the Opium War, Qing government, according to the Sino-British Treaty of Nanking, was forced to open 5 coastal ports in the south-east of China for foreigners to do business there. Since then, more and more "treaty ports" (洋关) became open in China subject to some treaties between Qing government and foreign countries. Most of these treaty ports are along China's coasts or Yangtze River, and the rest are located in some inland areas.

The first 5 treaty ports—Canton, Ningpo, Shanghai, Foochow and Amoy, became open in 1842. The second batch of 9 ports—Tientsin, Newchuang, Chefoo, Chinkiang, Hankow, Kiukiang, Swatow, Takow and Tamsui, opened in 1861 following the Arrow War in 1860. The third batch, Kiuangchow, Pakhoi, Wuhu, Ichang and Wenchow, become open in 1876 according to the Treaties of Chefoo. Afterwards, Kowloon, Lappa, Longchow, Mengtsz and Chungking were open during 1887 and 1890. By the end of 1911, there were more than 80 treaty ports in China. I plot all the treaty ports opened before 1900 on the map in Appendix 1.

Since the appearance of treaty ports, they were managed by foreigners who were hired by Qing government under a centralized bureau named "Inspectorate General of Customs". The head of this bureau is titled "Inspector General of Customs". For almost half-century

[4] Canton is the only port permitted by Qing government to import and export before Opium War.

since this bureau was established, it was presided by Robert Hart, a Northern Irish man, who was also honored high-rank official by Qing's government. The main function of the branches of Inspectorate General of Customs (IGC) in each treaty ports were in charge of collecting tariffs and tonnages on imports of foreign produces and exports of native produces. Besides, they also took some roles in social services. They recorded local weathers and big events, dredged rivers, and even run postal services in China. Actually, officials from (IGC) could even exert considerable influences on local government in some affairs (Chen Shiqi, 2002). For such reasons, the impacts of treaty ports on the development of China are still under controversy till now. On the one hand, treaty port is the testimony of hegemony of westerners, which at least weakened China's sovereignty in terms of economic invasion. On the other hand, these ports actually acted as windows for Chinese people to learn from the western world. Some big treaty ports like Shanghai, Tiensien, Canton and Hankow even played important roles in the modernization of imperial China. Much experience is accumulated by China in foreign trade, commerce, finance, construction, urban planning and modern management, which is absolutely beneficial to the economic and social development of modern China (Zheng, Youkui, 1991).

4. Data

Data employed in this research is derived from the statistical archives originally published by the Inspectorate General of Customs.[5] The statistical series were written mostly in English and recognized as highly reliable by modern scholars for the objectivity of Inspectorate General of Customs in compiling them (Yan Zhongping et al, 1955; Yao Xiangao, 1962). This statistical archive covers very detailed information of foreign trade in each treaty port during the period 1856-1948, including yearly statistics of imports, exports and re-exports listed by commodities, yearly statistics of vessels clearance in each port, yearly statistics of tariffs and revenues of each port, etc. Since the trade volume and

[5] The edition we have is actually photocopied from original archives and compiled by The Second Historical Archives of China (2004).

the market value of each commodity are reported in each port on a yearly basis, we are able to obtain the average market price of each commodity per year by dividing the market value by the trade volume.[6] Our prices data consists of the market prices of 14 foreign goods imported in China. It spans 37 years from 1865 to 1900, and there are totally 23 treaty ports included. It is an unbalanced panel due to missing observations. The total number of observations is 7,324.

Regarding the selection of commodities, I employ the following criterions. Firstly, they have large trade volumes and are popular in foreign trade in all treaty ports. Secondly, they should be comprehensive and sufficiently representative. So, the 14 goods cover all categories of trade foreign goods including Opium, Cotton goods, Woolen goods, Metal, energy and Sundries. I also ensure that the names of these foreign goods are consistent in each treaty port for all the years. More details of description of the commodities are in Appendix 2.

Table 1 shows the summary statistics of the data set. Table 2 shows the Coefficient of Variance (CV) of the market prices of 14 goods on all treaty ports during the periods 1864-1875, 1864-1887 and 1888-1900. I distinguish three periods because another two batches of treaty ports became open in 1876 and 1887 respectively. The CVs of 8/14 goods during 1864-1886 get smaller comparing with theirs during 1864-1875. In addition, CVs of 10/14 and 11/14 during the period 1864-1900 become smaller comparing with theirs during 1864-1876 and 1864-1886 respectively. This suggests that price dispersions of these goods were gradually getting smaller over years, which can be regarded as the preliminary evidence of price converge to the LOP.

[6] Haikwan Tael is the currency used to state the market value and customs revenue in the book

Table 1. Summary Statistics of Prices of 14 Foreign Goods (unit:Hk.tls)*

Name of Goods	Unit	N	Mean	Std. Dev	Min	Max
Camlets	Piece	656	11.77	2.89	6.24	28.00
Coal	Ton	428	7.38	2.40	3.29	16.32
Cotton, raw	Picul	220	12.92	3.31	7.55	25.50
Drills	Piece	625	3.06	1.01	1.26	8.39
Iron, nail-rod	Picul	571	2.48	0.62	1.18	5.21
Lasting	Piece	650	9.85	2.38	5.36	24.24
Lead, in pigs	Picul	605	4.89	1.08	2.92	8.99
Matches	Gross	549	0.44	0.28	0.15	1.75
Oil, kerosene	Gallon	503	0.17	0.11	0.07	1.32
Opium, malwa	Picul	547	515.84	94.28	304.35	849.22
Rice	Picul	241	1.80	0.51	0.98	3.90
Shirtings, grey, plain	Piece	668	2.09	0.62	1.07	4.57
Sugar, white	Picul	455	5.59	1.00	3.40	10.04
Yarn, cotton	Picul	502	24.12	8.77	12.00	79.73

* Outliers are excluded. See appendices for detailed description of these goods.

Table 2. Coefficient of Variance (CV) of the Market Prices of 14 Products

	Opium	Cotton Goods			Woolen Goods		Metals		Energy		Sundries			
Years	Malwa	Grey Shirting	Drill	Cotton Yarn	Camlet	Lasting	Iron	Lead	Coal	Kerosene	Raw Cotton	Match	White Sugar	Rice
1864-1876	12.6	15.3	19.8	21.8	18.6	18.8	21.5	19.0	22.0	29.1	11.8	26.8	17.5	19.8
1864-1886	10.9	16.0	18.4	20.7	15.3	16.2	22.8	16.4	23.4	24.0	11.7	29.6	18.1	20.7
1864-1900	10.5	15.4	16.7	18.4	14.8	16.4	20.6	15.5	23.0	20.6	13.8	30.3	16.6	19.1

5. Hypotheses

5.1 Hypotheses related to the Law of One Price (LOP)

H1: LOP holds in China's foreign commodity markets in the late 19th century

I make this hypothesis for two reasons. Firstly, trade openness is supposed to have positive effect on the market integration according to economics theories. When more and more treat ports became open in China, its market integration should be improved and price convergence of products should be observed. Secondly, the trade tariffs were fixed during the period I examined, which is favorable for the holding of the LOP. The import tariffs remained 5% at that time for all the goods. Besides, an extra tariff named Zikou half-Tariff（子口半税）needs to be paid when foreign goods are transported or re-exported to another ports across provinces (Zheng, Youkui, 1939). Thus, the total tariff was between 5% and 7.5% for foreign goods from 1840s to the end of Qing dynasty. To test this hypothesis, I expect the following results:

1) The price differentials of commodities get smaller over time.
2) The price series of commodities revert to their mean eventually.

H2: Relative Convergence to LOP prevails as the result of substantial trade costs

Relative convergence to LOP implies that the price series will eventually revert to a constant other than the mean. Otherwise, it is defined as absolute convergence to LOP. I make this assumption because various forms of trade costs, different for goods in certain cities, may hinder the holding of absolute LOP. Trade costs may arise from higher transportation costs in some regions due to special geographic environments. Besides, different products are quite distinct in their characteristics. So, extra costs may occur for some commodities during storage and shipping. In addition, chaos caused by wars and rebellions broken out frequently in China in the 19th century, say, Tai-Ping-Tian-Guo rebellion, may also seriously destroy the market integration of some regions. Considering these factors, I assume that convergence to LOP should be mainly in relative form instead of absolute one during the period examined.

H3: It is easier for homogenous products to converge to the LOP than for heterogeneous products.

Previous literature has documented the impacts of products heterogeneity on price convergence (Parsley and Wei, 1996, 2001; Fan and Wei, 2006). Generally, nonperishable goods converge to the LOP more quickly than perishable goods and services. The 14 products in data pool are all nonperishable goods since it is impossible for perishable goods to be traded across oceans nearly 100 years ago. According to Feenstra and Hanson (2004), Hong Kong traders usually obtain higher markups from re-exporting differentiated products than from homogenous goods. I extend their findings to price convergence of different products and come up with this hypothesis, that is, homogenous products can easily converge to the LOP than differentiated goods. Homogenous products usually have very few varieties. Besides, it is easy for buyers and sellers to identify their quality and they are suitable for large-volume trade in exchange. These goods include e.g., rice, metals, coal, etc. By contrast, differentiated products have more varieties than homogeneous products. Costs of identifying their quality are relatively high. Customers' evaluation may differ substantially. Such products include toys, cloth, garments, etc. According to this hypothesis, I expect to see that homogenous goods such as oil, metal and rice converge to the LOP more quickly than those differentiated goods in our research

5.2 Hypotheses on the determinants of price convergence

H4: Trade openness significantly contributes to the enhancement of market integration in China's foreign commodities markets in the 19th century

This hypothesis aims to verify the classical economic theory relating the relationship between trade and economic growth. It emphasizes the positive roles of trade in reducing price differentials, enhancing market integration and driving economic growth. This hypothesis can be tested through the following two propositions:

P4.1: Market integration of existing treaty ports will be improved when one ore more treaty ports became open beside them

When several treaty ports locate closely, same products traded in both ports will flow between them if price gaps are sufficient to cover arbitrage costs. This is the so-called competition effect between treaty ports. As the arbitrage costs are prohibitively high between two ports located very far away, I only consider competition effects for city pairs within 300 miles. I list the shipping distance (in miles) between every two treaty ports In Table 5. I also underline the figures where competition effect between the corresponding two ports is considered.

P4.2: The Longer time a treaty port become open, the more integrated its local market is.

First of all, once a treaty port becomes open to foreign trade, its local markets turns prosperous spontaneously. In addition, with the increase of local demand and the intensity of competition, local business environment tends to be mature than before. This should to some extent reduce the trade costs of importing commodities. Besides, transaction costs in the local market should also decrease as a result of appearance of widespread distribution network, easier access to trade credit, improved management skills, etc. Therefore, the market prices of foreign products in the port city should become lower and gradually converge to the country average prices.

H5: Geography impacts on the evolution of market integration of China in late 19th century

In late 19th century China, some advanced transportation facilities, say, railways and steamships, have not been widely used.[7] The cheapest means of goods transportation at that time is shipping along big inland waterways, especially along Yangtze River. So, markets should be more integrated in port cities along Yangtze River than in other areas. Actually, contrasting to the cheap price of sea transportation today, transportation by sea

[7] According to Zhu Yingui (2001), before 1895, the total length of railway in China is only 364 KM and the civil capacity of steamboat were only 32708 tons.

is quite expensive at that time because commercial steamship transport business is not developed in the 19^{th} century. In addition, shipping by sea often suffers from high risks of goods damage or loss from storms or pirates. So, I expect to see different patterns of market evolution in different types of ports.

6. Methodology

6.1 Methodology for testing Hypothesis 1, 2 and 3

A lot of methods have been used in previous works to test the LOP. A fundamental and straightforward one is Coefficient of Variance (CV). I used this method and presented a rough picture of price deviation in Table 2. The following are some other methods.

a. Price deviation regression

Developed by Young (2000), this method is used to examine the trend of price deviation. The regression model is as follows:

$$p_{jt} = \alpha_{jt} + \sum_t \beta_t year_t + \sum_j \gamma_j good_j + \varepsilon_{jt} \qquad (1)$$

Where, p_{jt} is $\ln[sd(\ln g_{ijt})]$, the logarithm of the standard deviation of logorithmized raw price of product j in port i at year t. If the estimates of β_t is significantly negative, it means the price deviation in year t is smaller than the base year. If we see the declining estimates of β_t, it implies that prices are heading to convergence.

b. Linear stationarity test

ADF test (Augmented Dick-Fuller test) is the most popular method for linear stationarity test. Following literature, I use the relative prices of each product instead of raw prices when performing this method. Let us define $P_{ij,t} = \ln(g_{ij,t} / \overline{g}_{j,t})$ as the relative price, where $g_{ij,t}$ denotes the raw price of good j in port i at year t, and $\overline{g}_{j,t}$ denotes the mean price of good j over all ports. I usually perform ADF test to examine whether there is a unit root in the relative price series. If this hypothesis is rejected, the relative price series is supposed to eventually converge to a constant. Otherwise, it follows a random walk and heads to divergence in the long run.

Since there are 23 ports and 14 products in our data set, I should perform ADF test for totally 322 relative price series. The basic equation of ADF test takes the following form.

$$\Delta P_{ij,t} = c_{ij} + \alpha_{ij} P_{ij,t-1} + \sum_{h=1}^{p-1} \beta_{ijh} \Delta P_{ij,t-h} + \varepsilon_{ij,t} \qquad (2)$$

Where, p is the autoregressive order decided by Akaiki information criterion (AIC) case by case.[8] Mckinnon p-value (Pr<Tau) is used to judge whether the Null Hypothesis of unit root should be rejected or not.

The half-life of each stationary relative price series is also calculated. Half-life refers to the time needed for a substance undergoing decay to decrease by half. This method is originally used to describe a characteristic of unstable atoms (radioactive decay), and afterwards applied by statistician to measure how fast a stationary time series converge to its mean level. Therefore, Half-life in this research refers to the time needed for a data point (log price differential) at any period t to reduce by half. Here the half-life h can be derived from $\rho^h = 1/2$, where $\rho = \alpha_{ij} + 1$ and α_{ij} is the estimated coefficient of $P_{ij,t-1}$. The equation of Half-life is:

$$h = Ln(1/2)/Ln\rho \qquad (3)$$

Finally, for a stationary price series, if its estimate of c_{ij} is significantly not equal to 0, this price series conforms to the relative LOP. That means it will converge to a nonzero constant in the long run. The long-run differential is derived from the following equation:

$$c^* = c_{ij}(1+\rho+\ldots+\rho^t) \rightarrow \frac{c_{ij}}{1-\rho} = \frac{c_{ij}}{-\alpha_{ij}} \qquad (4)$$

8 The one with the smallest AIC value will be chosen.

c. Nonlinear stationarity test

Some relative price series may fail to pass ADF test and appears unstationary in linear form. But it doesn't mean that they will diverge eventually. Under the circumstances, some nonlinear time series models can be applied to explore the possible convergence of these price series. These models include EAR, TAR, STAR, ESTAR, LSTAR, etc.[9] (Granger and Terasvirta, 1993; Terasvirta, 1994)

I consider nonlinear stationarity of relative prices series forms in this research because I mentioned in the Hypothesis 2 that substantial trade costs may exist during the transportation and transaction of products. These trade costs may cause price movement more complicated than expected. Following Fan and Wei (2006), ESTAR model will be employed in this research. Compared to ADF test, ESTAR model is more relaxed in judging unit root by add a threshold term into the model. The steps of conducting ESTAR nonlinear stationarity test are as follows.

Step 1: test H0: $\pi_{ijh}=0$ $\theta_{ijh}=0$ (the price series conforms to linear specification)

$$p_{ij,t} = r_{ij} + \sum_{h=1}^{p}(\eta_{ijh} p_{ij,t-h} + \pi_{ijh} p_{ij,t-h} p_{ij,t-d} + \theta_{ijh} p_{ij,t-h} p^2{}_{ij,t-d}) + \varepsilon_{ij,t} \qquad (5)$$

If H0 is rejected, then go to step 2.

Step 2: test H1: $\lambda_{ij} < 0$ and H2: $\lambda_{ij} + \lambda_{ij}^* < 0$

$$\Delta p_{ij,t} = b_{ij} + \lambda_{ij} p_{ij,t-1} + \sum_{h=1}^{m-1} \phi_{ijh} \Delta p_{ij,t-h} + (b_{ij}{}^* + \lambda_{ij}{}^* p_{ij,t-1} + \sum_{h=1}^{m-1} \phi^*{}_{ijh} \Delta p_{ij,t-h}) F(p_{ij,t-d}) + \varepsilon_{ij,t} \qquad (6)$$

Where,

$$F(p_{ij,t-d}) = 1 - \exp[-\gamma(p_{ij,t-d} - a^*)] \qquad (7)$$

Nonlinear stationarity is only accepted when one of the following conditions holds,

[9] EAR, TAR, STAR, ESTAR, LSTAR denote exponential autoregressive, threshold autoregressive, smooth transition autoregressive, exponential STAR and logistic STAR respectively.

1. $\lambda_{ij} < 0$;

2. $\lambda_{ij} > 0$ and $\lambda_{ij} + \lambda_{ij}^{*} < 0$

Similar with ADF test, the half-life of convergence for nonlinear stationary price series can be calculated by:

$$h = Ln(1/2)/Ln\rho \tag{8}$$

Where,

$\rho = \lambda_{ij} + 1$ if $\lambda_{ij} < 0$;

$\rho = \lambda_{ij} + \lambda_{ij}^{*} + 1$ if $\lambda_{ij} > 0$ and $\lambda_{ij} + \lambda_{ij}^{*} < 0$;

The long-run price differential: $c^{*} = \dfrac{b_{ij} + b_{ij}^{*}}{-(\lambda_{ij} + \lambda_{ij}^{*})}$

6.2 Methodology for testing Hypothesis 4

I am also interested in measuring the impacts of ports openness on the evolution of market integration. As has addressed in Hypothesis 3, when new ports become open, their neighboring ports have to face competition in the supply and pricing of the same products. Additionally, the older of a treaty port, the more mature of its local markets, which is favorable for the holding of the LOP. So, I consider the above two factors to capture the effects of port openness on price convergence. Besides, some other factors that may also impact market integration are also controlled, including geographic position of the port, how far away is it from shanghai, China's trade hub in 19th century, and so on. The regression specification is as follows:

$$D_{ijt} = \rho_0 + \rho_1 COMP_{it} + \rho_2 OPEN_{it} + \rho_4 DFSH_i + \rho_4 COA_i + \rho_5 N_i + \rho_6 S_i + \phi Z_{ijt} + \varepsilon_{ijt} \quad (9)$$

The dependent variable $D_{ijt} = \dfrac{\log g_{ijt} - \log \overline{g}_{jt}}{\log \overline{g}_{jt}}$ measures port i' price deviation of good j from the mean price (volume-weighted) of all ports in year t. $COMP_{it}$, number of neighboring ports within the radius of 300 sea miles of port i, is used to capture the competition effects on price deviation. $OPEN_{it}$, number of years since opened till year t, is used to measure age effects on price deviation. Control variables include: (1) $DFSH_i$, log distance of port i from Shanghai, the treaty port with the largest trade volume. (2) COA_i, dummy variables indicating if port i locates in coastal areas. (3) N_i, dummies indicating whether port i locates in North China. (4) S_i, dummies indicating whether port i locates in South China. (5) Z_{ijt}, a vector of goods dummies.

6.3 Methodology for testing Hypothesis 5

Transportation costs should account for a considerable part of price differences between regions. Geographic factors may also affect the evolution of market integration and the realization of the LOP. Let us first define the relative price gap between port i and j: $Q_{ij,h,t} = \ln g_{i,h,t} - \ln g_{j,h,t}$, where $g_{i,h,t}$ and $g_{j,h,t}$ denote the market price of good h at port i and port j in year t. Then, I define dependent variable $q_{ij,h,t} = Q_{ij,h,t} - Q^{*}_{h,t}$, where $Q^{*}_{h,t}$ is the mean of $Q_{ij,h,t}$ over all port pairs. This variable is used to measure the deviation of the price gaps between ports. I regress $q_{ij,h,t}$ on: (1) time trend T and its squared term, (2) the log distance between port i and port j, D_{ij}, and (3) two dummy variables C_{ij} and R_{ij} indicating if port i and j are both locates in coastal areas and both along Yangtze River. So, the regression model examining the geography's roles in market integration is as follows:

$$q_{ij,h,t} = \rho_0 + \rho_1 T + \rho_2 T^2 + \rho_3 D_{ij} + \rho_4 C_{ij} + \rho_5 R_{ij} + \varepsilon_{ij,t} \tag{10}$$

7. Results

7.1 Test Results of Hypothesis 1

I firstly run the regression of equation (1), and plot the estimates of year dummies in Figure 1 (relative to 1864). As is shown in the upper part of Figure 1, except for a substantial shock in 1868 and 1869 and a slight fluctuation around 1883, the estimates are slowly decreasing during the whole period of examination, implying a decline trend of price dispersion over time. The t-statistics of the estimates are listed in the lower part of Figure 1. It can be seen that most of these estimates are significant statistically, showing that the results are quite robust.

Then, more rigorous methods--linear stationarity test (ADF test) and nonlinear stationarity test (ESTAR model) are employed to judge the LOP. I start by performing ADF test for every price series to examine their possibility of linear stationarity. Totally 267 relative price series are examined.[10] Next, I try nonlinear stationarity test for those price series that appear linearly nonstationary in ADF test. All the results of stationarity tests are shown in Table 3. I list all 14 products in columns and all 23 ports in rows. For each product, “L”, “NL” and “S” represents the linear stationarity test, nonlinear stationarity test and either. If a relative price series passes the linear or nonlinear test, then I mark a “Y” in the corresponding cell, else I mark “N”. When a price series passes linear test, no further nonlinear test is conducted, I mark a “-” in column NL. If a price series is unavailable for the linear test due to missing or few observations, it implies that nonlinear test is also unavailable, so I mark “-” in all three columns of that products. If a price series is proved to be stationary either linearly or nonlinearly, I mark a “Y” in column S. At the bottom of Table 3, I show by product the proportion (PROP) of the price series in all ports which are only linearly stationary and stationary in either form. We can see that, for each of 14 products examined, the majority of price series in ports are stationary, either linearly or nonlinearly. I also present by port the proportion of price series for all products

[10] During to missing observations, 55 relative price series are not available for ADF test.

in the last column of Table 3. Obviously, the vast majority of price series are stationary in each port. Overall, the results of stationarity shows that the LOP holds for the vast majority of products and ports. These finding well support Hypothesis 1, implying that the market integration of China in the 19th century is fairly good.

7.2 Test Results of Hypothesis 2

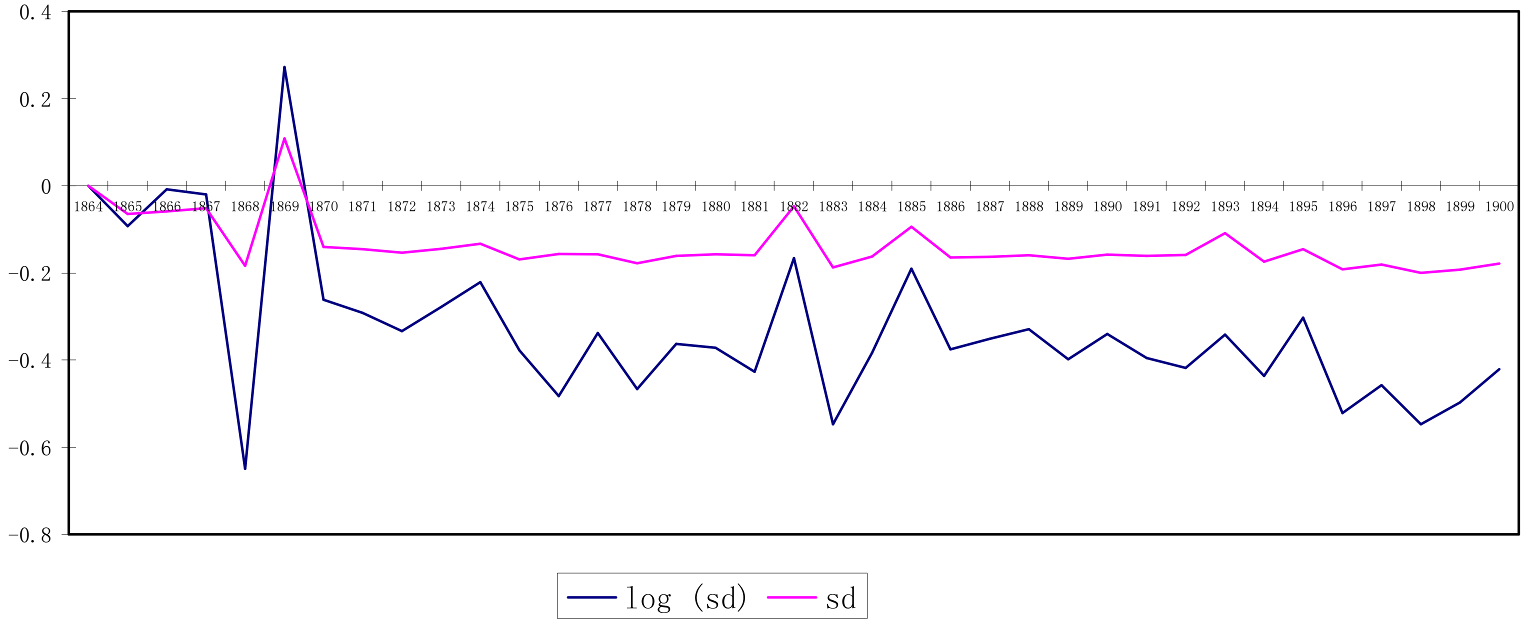
Now I turn to look at the results showing the speed of convergence to LOP in Table 4. Figures in the table are the half-lives of the stationary price series. Note that the figures underlined denote convergence to the relative LOP, which means that these relative price series will eventually converge to a nonzero constant. Actually, I find such cases are popular. Industrial raw materials such as lead, iron and raw cotton seem more likely to conform to the relative LOP. By contrast, most consumer products tend to converge to the absolute LOP. This finding shows that industrial raw materials may have higher trade costs than consumer products, but I still need further evidence to prove it. In addition, I find more cases of convergence to the relative LOP in Canton, Kowloon, Shanghai, Ningpo, Chinkiang and Chungking. Most of these treaty ports actually involved actively in foreign trade according to statistics, especially the port of Shanghai, the busiest hub port in foreign trade in the late 19th century China. So, trade costs may not be convincing to explain why there exist price differentials in their long-run price convergence. An alternative interpretation may be that import prices in these ports are highly volatile as a response to the frequent price fluctuations in international markets. "Divg" in the table denotes price divergence, and "N/A" denotes unavailable for calculating half-life due to missing or too few observations.

7.3 Test Results of Hypothesis 3

The last row of Table 4 shows the average half-life of each product in all ports. I find that camlet, lasting and drill have relatively lower speed of convergence compared to the other products. Their half-lives range from 0.84 to 1.28 years. By contrast, products like rice, sugar, iron, lead, coal, kerosene, raw cotton and cotton yarn are faster in price convergence, with their half-lives ranging from 0.56 to 0.76. It is not hard to find that the products like camlet, lasting and drills are typical differentiated goods, which have many varieties in colors, patterns, qualities or even styles. But this kind of information is unavailable from the statistical archive which lists all the varieties of these kind of products. So, it is not surprising that their prices vary greater than other products. As an exception, shirting is also a kind of differentiated product, but it is classified in details in the statistical archives. I only choose the grey and plain shirting for examination. It is seen that its prices converge relatively faster than other differentiated products. Besides, Opium (Malwa) is found to have a high speed of price convergence because it is actually homogeneous products according to the literature.

7.4 Test Results of Hypothesis 4

Table 5 lists the matrix of distance between any other treaty ports examined. As has mentioned in the methodology part, the number of the neighboring ports of a port within the radius of 300 sea miles is regarded as the direct competitors of this port. I underline the figure to show the competition effect between port pairs in Table 5. Table 6 shows the estimation results of regression equation (9). Since Shanghai is a coastal port and along Yangtze River, I have it covered in the dummy variable "Coastal", and exclude it in dummy variables "Northern Coastal" and "Southern Coastal". Then, I add them one by one into the regression model to control for the geographic factors. As we can see in both columns of table 4, the number of competitors and the age of ports both have significant effects in reducing price deviations in ports given I have controlled for the geographic reasons. These results are perfectly in line with our assumptions made in Hypothesis 4.



Year	1865	1866	1867	1868	1869	1870	1871	1872	1873	1874	1875	1876	1877	1878	1879	1880	1881	1882
t-statistic	-0.59	-0.05	-0.13	-4.16	1.74	-1.67	-1.87	-2.13	-1.78	-1.42	-2.42	-3.09	-2.16	-2.98	-2.32	-2.38	-2.73	-1.06
Year	1883	1884	1885	1886	1887	1888	1889	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899	1900
t-statistic	-3.5	-2.46	-1.22	-2.4	-2.25	-2.11	-2.55	-2.18	-2.53	-2.57	-2.19	-2.79	-1.94	-3.34	-2.93	-3.5	-3.18	-2.69

Figure 1. Estimates of Year-dummies in Price Deviation Regression

Table 3. Results of Linear and Nonlinear Stationarity Test

	Opium (1)			Shirting (2)			Drill (3)			Yarn (4)			Camlet (5)			Lasting (6)			Iron (7)			Lead (8)			Coal (9)			Cotton (10)			Match (11)			Oil (12)			Rice (13)			Sugar (14)			Prop
Ports	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	L	NL	S	
Amoy	Y	-	Y	N	N	N	N	Y	Y	Y	-	Y	N	Y	Y	N	Y	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	13/14
Canton	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	14/14
Chefoo	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	-	-	-	N	Y	Y	Y	-	Y	N	Y	Y	Y	-	Y	13/13
Chinkiang	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	-	-	-	N	Y	Y	Y	-	Y	-	-	-	Y	-	Y	12/12
Chungking	-	-	-	Y	-	Y	N	Y	Y	N	N	N	Y	-	Y	Y	-	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	N	Y	Y	-	-	-	-	-	-	5/6
Foochow	N	Y	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	Y	-	Y	N	Y	Y	N	N	N	12/13
Hankow	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	12/12
Ichang	-	-	-	N	Y	Y	N	Y	Y	Y	-	Y	N	Y	Y	Y	-	Y	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	N	Y	Y	-	-	-	N	Y	Y	7/7
Kiukiang	Y	-	Y	N	Y	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	-	-	-	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	12/12
Kiungchow	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	N	N	N	Y	Y	Y	-	Y	N	Y	Y	Y	-	Y	-	-	-	12/13
Kowloon	N	N	N	N	Y	Y	Y	-	Y	N	Y	Y	N	Y	Y	N	N	N	Y	-	Y	N	N	N	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	N	Y	Y	Y	-	Y	11/14
Lappa	-	-	-	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	N	Y	Y	13/13
Mengtsz	-	-	-	N	Y	Y	-	-	-	N	Y	Y	N	Y	Y	-	-	-	-	-	-	-	-	-	-	-	-	N	Y	Y	N	Y	Y	N	Y	Y	-	-	-	-	-	-	6/6
Newchwang	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	N	N	N	N	Y	Y	Y	-	Y	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	11/12
Ningpo	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	N	Y	Y	-	-	-	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	13/13
Pakhoi	-	-	-	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	N	Y	Y	-	-	-	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	-	-	-	11/11
Shanghai	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	N	Y	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	14/14
Swatow	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	14/14
Takow	-	-	-	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	-	-	-	N	Y	Y	N	Y	Y	-	-	-	Y	-	Y	10/10
Tamsui	-	-	-	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	-	-	-	-	-	-	N	Y	Y	N	N	N	-	-	-	-	-	-	8/9
Tientsin	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	12/12
Wenchow	N	Y	Y	N	Y	Y	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	N	N	N	Y	-	Y	-	-	-	-	-	-	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	10/11
Wuhu	Y	-	Y	Y	-	Y	N	Y	Y	Y	-	Y	Y	-	Y	N	Y	Y	N	Y	Y	Y	-	Y	Y	-	Y	-	-	-	Y	-	Y	N	-	Y	-	-	-	N	Y	Y	12/12
Prop	13/16		15/16	17/23		22/23	17/22		22/22	17/22		21/22	17/23		22/23	13/22		21/22	15/20		19/20	16/20		19/20	15/20		19/20	5/9		9/9	13/21		20/20	16/22		22/23	6/11		11/11	14/18		17/18	

L: linear stationary; NL: nonlinear stationary; S: stationary (either linearly or nonlinearly); Y: stationary; N: unstationary; -: N/A

Table 4. Half-life Speed of Convergence (years)

Ports	Opium	Shirting	Drills	Yarn	Camlet	Lasting	Iron	Lead	Coal	Cotton	Match	Kerosene	Rice	Sugar	**Average**
Amoy	0.39	Divg	1.80	1.32	2.68	1.01	0.58	0.29	0.85	0.71	0.64	0.88	0.71	0.77	1.02
Canton	0.84	0.23	0.54	0.55	0.62	1.70	1.00	0.37	0.68	0.26	0.66	0.80	0.65	1.57	0.74
Chefoo	0.55	0.49	1.47	0.39	0.28	0.22	0.27	0.76	1.67	N/A	1.87	0.30	0.30	0.78	0.74
Chinkiang	0.17	1.39	1.26	0.61	0.93	1.01	0.49	0.29	0.65	N/A	1.07	0.44	N/A	0.84	0.82
Chungking	N/A	0.16	1.22	Divg	0.33	0.73	N/A	N/A	N/A	N/A	N/A	0.23	N/A	N/A	0.54
Foochow	2.05	0.69	1.14	0.74	1.37	0.73	0.41	0.64	0.64	N/A	0.20	1.11	0.59	Divg	0.75
Hankow	0.20	0.64	0.47	0.92	1.36	3.88	1.04	0.91	0.80	N/A	0.25	0.81	N/A	0.50	1.05
Ichang	N/A	1.30	0.97	0.39	0.62	0.75	N/A	N/A	N/A	N/A	N/A	0.94	N/A	1.06	0.86
Kiukiang	1.05	1.67	1.03	0.38	0.76	1.04	0.54	0.70	1.61	N/A	0.39	0.51	N/A	0.30	0.81
Kiungchow	0.53	0.37	0.44	0.86	3.36	1.34	2.06	2.02	Divg	0.85	0.83	1.89	0.19	N/A	1.29
Kowloon	Divg	1.02	0.36	1.64	0.78	Divg	0.83	Divg	0.76	0.36	0.58	0.28	0.71	0.27	0.69
Lappa	N/A	0.41	0.65	1.27	1.16	1.12	0.27	0.65	0.36	0.53	1.13	1.22	0.31	0.43	0.73
Mengtsz	N/A	0.70	N/A	0.54	2.06	N/A	N/A	N/A	N/A	0.64	1.03	0.91	N/A	N/A	0.98
Newchwang	0.63	1.00	0.94	2.01	Divg	2.44	1.06	0.59	0.49	N/A	1.76	0.47	N/A	0.46	1.12
Ningpo	0.40	1.03	1.07	0.92	1.75	0.59	1.84	1.13	0.38	N/A	0.44	0.65	0.67	1.03	0.96
Pakhoi	N/A	0.51	0.17	0.21	0.39	1.87	0.69	0.53	N/A	0.91	0.60	1.01	0.97	N/A	0.71
Shanghai	1.16	0.39	0.50	0.22	0.65	0.83	0.28	0.66	0.37	0.27	0.44	0.31	0.65	0.66	0.48
Swatow	0.83	0.39	1.07	0.20	1.25	1.31	0.15	0.29	0.74	0.91	1.04	0.76	0.35	0.88	0.72
Takow	N/A	0.98	0.24	N/A	0.32	0.52	1.29	0.45	0.63	N/A	0.70	0.58	N/A	0.29	0.60
Tamsui	N/A	0.41	0.51	0.28	0.77	0.57	0.31	0.89	N/A	N/A	0.92	Divg	N/A	N/A	0.58
Tientsin	0.16	0.69	0.44	0.31	0.76	1.45	0.38	0.53	0.29	N/A	2.38	0.39	N/A	0.31	0.72
Wenchow	1.83	1.72	0.58	0.55	2.51	1.23	Divg	0.86	N/A	N/A	0.87	0.87	N/A	0.19	1.04
Wuhu	0.75	0.17	1.51	0.30	0.52	2.45	0.86	0.32	0.40	N/A	0.54	1.17	N/A	1.42	0.88
Average	0.77	0.74	0.84	0.70	1.15	1.28	0.76	0.68	0.71	0.61	0.87	0.75	0.56	0.69	0.81

Notes: figures underlined denote relative convergence to LOP, and else absolute convergence to LOP. N/A means insufficient observations for stationarity test. Divg means divergence.

Table 5. Distance between China's Treaty Ports (sea miles)

Amoy	0																					
Canton	385	0																				
Chefoo	1031	1355	0																			
Chinkiang	805	1122	719	0																		
Chungking	2005	2322	1919	1200	0																	
Foochow	250	553	880	630	1830	0																
Hankow	1258	1575	1172	453	747	1083	0															
Ichang	1625	1942	1539	820	380	1450	367	0														
Kiukiang	1113	1430	1028	308	892	938	145	512	0													
Kiungchow	552	307	1521	1276	2476	719	1729	2096	1584	0												
Kowloon	292	87	1277	1030	2230	459	1483	1850	1338	272	0											
Lappa	319	69	1304	1057	2257	486	1510	1877	1365	252	39	0										
Newchwang	1221	1502	209	867	2067	1019	1320	1687	1175	1669	1435	1462	0									
Ningpo	540	828	610	291	1491	351	744	1111	599	995	735	763	807	0								
Pakhoi	669	426	1602	1400	2600	836	1853	2220	1708	128	388	371	1786	1112	0							
Shanghai	640	957	554	165	1365	465	618	985	473	1111	865	892	702	126	1235	0						
Swatow	128	283	1076	863	2063	310	1316	1683	1171	447	187	214	1260	586	564	698	0					
Takow	165	435	1045	765	1965	243	1218	1585	1073	1711	342	369	1192	518	708	600	214	0				
Tamsui	222	568	857	1105	2305	149	1558	1925	1413	735	475	502	1005	331	852	418	326	229	0			
Tientsin	1198	1495	189	860	2060	1020	1313	1680	1168	1661	1417	1444	286	789	1778	695	1252	1185	997	0		
Wenchow	401	657	684	467	1667	204	920	1287	775	824	564	591	867	219	942	302	415	350	169	860	0	
Wuhu	914	1231	828	99	1031	739	344	682	199	1385	1139	1166	976	400	1509	274	972	874	692	969	576	0
Miles (1.853km)	Amoy	Canton	Chefoo	Chingkiang	Chngkiang	Foochow	Hankow	Ichang	Kiukiang	Kiungchow	Kowloon	Lappa	Newchwang	Ningpo	Pakhoi	Shanghai	Swatow	Takow	Tamsui	Tientsin	Wenchow	Wuhu

(Figures underlined (also in shadow) refer to competition effects between corresponding treaty ports)

Table 6. Impact of Trade Openness on Price Deviation

(Dependent variable: price deviation from volume-weighted mean price)

Independent variables	1	2
Age of port	-0.0047***	-0.0057***
	(0.0012)	(0.0014)
Number of competitors	-0.0242*	-0.0749***
	(0.0135)	(0.0199)
Distance from Shanghai	-0.0421*	-0.1880***
	(0.0230)	(0.0453)
Coastal (include SH)	0.0797**	
	(0.0354)	
Northern coastal (exclude SH)		0.1058*
		(0.0405)
Southern coastal (exclude SH)		0.3200***
		(0.0758)
Good dummies	Yes	Yes
Sample size	6773	6773
Adjusted R^2	0.0713	0.0744

Note: *, **, and *** denotes significance at 1%, 5% and 10% level. Robust standard errors are in parenthesis.

7.5 Test Results of Hypothesis 5

Table 7 and Table 8 show the regression results of equation (10). In Table 7, I list the results when all the goods are pooled together in the regression. Columns (1)-(3) show the results of adding year dummies instead of Trend terms into regression. Column (4)-(7) show the results when Trend terms are added into the regression one by one. To show the robustness of our findings, I also add coastal and Yangtze River dummies one by one into the regression. The results in table 7 show that variable "log distance" are significantly positive in all columns, implying that distance well explain the price gaps between two ports, that is, more distance between two ports, the higher price gaps between them. This is completely in line with our knowledge that price gap will get wider due to higher costs of long distance transportation. In addition, estimates of coastal dummy are positive and significant and estimates of Yangtze River dummies are mostly negative and significant, which means that if two ports are both located in coastal areas, their price gaps tent to be larger than those of the other port pairs. By contrast, if two ports are both located along Yangtze River, their price gaps are significantly smaller than those of other port pairs. The estimates of "trend" are negative when its square term is not added into the regressions, which indicates that price gaps are declining with time. After the square term is included, the estimates of square terms become negative and significant. This implies that the decline trend appears to follow nonlinear form instead linearly form. I further run regressions for each product and present the results in Table 8. Overall, the results from individual product regressions are consistent with the findings shown in Table 7. Actually, I also control some geographic factors in the regression showed in Table 6. The result shows that the farther a port away from Shanghai, the largest hub in foreign trade at that time, the larger deviation of its prices from the average level. In addition, coastal ports have much larger price fluctuations than the other ports, especially Yangtze River ports.

Table 7. Impacts of Geography on Price Gaps (All 14 goods)

Independent Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Log distance	0.0227***	0.0145***	0.0223***	0.0227***	0.0227***	0.0145***	0.0145***
	(0.0010)	(0.0010)	(0.0011)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
Coastal	0.0283***		0.0277***	0.0283***	0.0283***		
	(0.0015)		(0. 0017)	(0.0015)	(0.0015)		
Yangtze River		-0.0252***	-0.0026			-0.0252***	-0.0251***
		(0. 0023	(0. 0026)			(0.0023)	(0.0023)
Trend				-0.0004***	0.0006	-0.0005***	0.0005
				(0.0001)	(0.0003)	(0.0001)	(0.0003)
$Trend^2$					-0.00003***		-0.00002***
					(0.0000)		(0.0000)
Year dummies	Yes	Yes	Yes	No	No	No	No
Good dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Sample size	54193	54193	54193	54193	54193	54193	54193
Adjusted R^2	0.0211	0.016	0.0211	0.020	0.020	0.015	0.015

Notes: Robust standard errors are in parentheses, and *,**, and *** denote significance at 10%, 5% and 1% levels.

Interestingly, some of our results is quite different from the findings of Fan and Wei (2006) and Parsley and Wei (2003), who focus on the LOP in China and U.S in recently years and find more integrated markets in coastal cities than in inland cities. Their findings indicate that sea transportation in the past century have experienced rapid growth and become much more convenient than it was in the 19th century.

Table 8. Impacts of Geography on Price Gaps (Individual goods)

(Dependent variable: $q_{ij,h,t} = Q_{ij,h,t} - Q^{*}_{h,t}$, $Q_{ij,h,t}$, log of relative price between port i and j)

Independent variables	Opium	Shirting	Drill	Yarn	Camlet	Lasting	Iron	Lead	Coal	Cotton	Match	Oil	Rice	Sugar
log distance	0.0023	0.0132***	-0.0008	0.0162***	0.0200***	0.0103***	0.0113***	0.0001	0.0025	0.0263 **	0.1383 ***	0.0217***	0.0638***	0.0111***
	(0.0029)	(0.0028)	(0.0031)	(0.0035)	(0.0028)	(0.0029)	(0.0039)	(0.0029)	(0.0062)	(0.0060)	(0.0064)	(0.0035)	(0.0072)	(0.0037)
coastal	0.0272***	0.0202***	0.0228***	-0.0353***	0.0337***	0.0219***	0.0055	0.0051	0.0214**	0.0071	0.1456***	0.0097*	-0.0146	0.0291***
	(0.0034)	(0.0043)	(0.0045)	(0.0056)	(0.0042)	(0.0043)	(0.0061)	(0.0046)	(0.0093)	(0.0173)	(0.0107)	(0.0054)	(0.0742)	(0.0055)
Yangtze River	-0.0243***	0.0149*	-0.0248***	-0.0244***	0.0044	-0.0094	0.0070	-0.0011	-0.0436***	0.0672	0.0632***	-0.0399***	-0.1331**	-0.0120
	(0.0059)	(0.0075)	(0.0068)	(0.0086)	(0.0065)	(0.0077)	(0.0114)	(0.0097)	(0.0162)	(0.0398)	(0.0159)	(0.0081)	(0.0563)	(0.0081)
constant	-0.0279	-0.0993	-0.0070	-0.1619	-0.1510	-0.0788	-0.0766*	-0.0037	-0.0280	-0.1429	-1.0181***	-0.1591***	-0.3721***	-0.0940***
	(0.0209)	(0.0216)	(0.0330)	(0.1725)	(0.0252)	(0.0522)	(0.0327)	(0.0306)	(0.0502)	(0.0900)	(0.0790)	(0.0271)	(0.1131)	(0.0352)
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
sample size	3890	5703	5222	3725	5509	5488	4453	4896	2641	635	4462	4069	755	2925
Adjusted R^2	0.0306	0.0076	0.0123	0.0417	0.0194	0.0113	0.0039	0.0006	0.0125	0.1516	0.1085	0.1086	0.1144	0.0239

Note: t-statistic in parenthesis. ** denotes significance at 5% level* denotes significance at 10% level

8. Conclusions

In this research, I investigate the evolution of market integration in late Qing China during the period 1864-1900. There are several main findings of this research. Firstly, The Law of One Price holds for the majority foreign commodities examined in most port cities, which implies that commodity markets in China are well integrated during that period. Secondly, I find that it takes differentiated goods longer time to converge to the LOP than homogeneous goods. Thirdly, trade openness significantly contributes to the integration of markets in terms of competition effects between treaty ports and age effects of local markets after trade openness. Fourthly, geographic factors impact the LOP and market integration. To be specific, the longer distance between a port and Shanghai--the largest trade hub in China at that time, the larger deviation of its prices from average level. In addition, price fluctuations in coastal ports are much larger than in ports located along Yangtze River or in inland areas. On the contrary, price gaps within port pairs both along the Yangtze River are significantly smaller than port pairs of other types.

The findings of this research certainly shed light on the studies of economic history and economic geography of China. Meanwhile, it also provides further empirical evidences for the identification of causal relationship between trade openness and economic growth.

9. References

Acemoglu,D.,S.Johnson and J.A.Robinson (2005), The Rise of Europe, Atlantic Trade, Institutional Change and Growth, American Economic Review, 95 (3), pp.546- 579.

Alan M. Taylor and Mark P. Taylor (2004), the Purchasing Power Parity Debate, Journal of Economic Perspective, 18(4), pp.135-158

Bahmani, Oskooee M., Mohtadi H., and Shabsigh G.. (1991), Exports, Growth and Causality in LDCs: a Re-examination, Journal of Development Economics, 36, pp.405–15.

Bai, Chong-En, Yingjuan Du, Zhigang Tao and Sarah Tong (2004), Local Protectionism and Regional Concentration: Evidence for Chinese Industries, Journal of International Economics, 63, pp.397–417.

Balassa, B. (1978), Exports and Economic Growth: Further Evidence, Journal of Development Economics, 5, pp.181–89.

Baum, Christopher F., John T. Barkoulas, and Mustafa Caglayan (2001), Nonlinear Adjustment to Purchasing Power Parity in the Post-Bretton Woods Era, Journal of International Money and Finance, 20(3), 379–399.

Benninga, Simon and Aris A. Protopapadakis (1998), The Equilibrium Pricing of Exchange Rates and Assets when Trade Takes Time, Journal of International Economics, 7,pp. 129–149.

Berkowitz, Daniel and Dejong N. David (2001), The Evolution of Market Integration in Russia, Economics of Transition, 9 (1), pp. 87-104.

Carol, H. Shiue (2002), Transport Costs and the Geography of Arbitrage in Eighteenth-century China, The American Economic Review, 92(5), pp.1406-1419.

Cecchetti, Stephen G., Nelson C. Mark, and Robert J. Sonora (2002), Price Index Convergence among United States Cities, International Economic Review, 43(4), pp.1081-99.

Ceglowski, Janet (2003), The Law of One Price: Intranational Evidence for Canada, Canadian Journal of Economics, 36(2), pp.373-400.

Chen, Shiqi (2002), Modern History of Chinese Customs (in Chinese), Renmin Press, Beijing.

Clemens and Williamson (2001), A Tariff-growth Paradox? Protection's Impact the world around 1875–1997, NBER Working Paper Series, No. 8549.

Conway, Patrick (1999), Privatization and Price Convergence: Evidence from Four Markets in Kyiv, Journal of Comparative Economics, 27(2), pp.231-57.

Darrat, A. (1986), Trade and development: the Asian experience, Cato Journal, 6, pp.695–99.

De Masi, Paula and Vincent Koen (1996), Relative Price Convergence in Russia, International Monetary Fund Staff Papers, 43(1), pp. 97-122.

Edwards (1992), Trade Orientation, Distortions and Growth in Developing Countries, Journal of Development Economics, 39, pp. 31–57.

Edwards (1998), Openness, Productivity and Growth: What Do We Really Know? Economic Journal 108, pp. 383–398.

Engel, Charles and John H. Rogers (1996), How Wide is the Border, American Economic Review, 86, pp.1112-1125.

Engel, Charles and John H. Rogers (2001), Violating the Law of One Price: Should We Make a Federal Case Out of It?, Journal of Money, Credit, and Banking, 33(1), pp.1-15.

Esfahani, H.S (1991), Exports, Imports, and Economic Growth in Semi-industrialized Countries, Journal of Development Economics, 35, pp.93–116

Fan, C. Simon and Xiangdong Wei (2006), The Law of One Price: Evidence from the Transitional Economy of China, The Review of Economics and Statistics, 88(4), pp. 682-697.

Feder, G. (1982), On Exports and Economic Growth, Journal of Development Economics, 12, pp. 59–73.

Feenstra, Robert and Gordan H. Hanson (2004), Intermediaries in Entrepôt Trade: Hong Kong Re-Exports of Chinese Goods, Journal of Economics and Management Strategy, 13(2004), pp. 3-36.

Fisher, Ronald Aylmer (1970), Statistical Methods for Research Workers, Edinburgh: Oliver and Boyd. Edition 14th ed., revised and enlarged.

Frankel and Romer (1999), Does Trade Cause Growth? American Economic Review, 89(3), pp. 379–399.

Frankel, Jeffrey A. and Andrew K. Rose (1996), A Panel Project on Purchasing Power Parity: Mean Reversion within and between Countries, Journal of International Economics, 40(1-2), pp.209-224.

Froot, Kenneth A. and Kenneth Rogoff (1995), Perspectives on PPP and Long-Run Real Exchange Rates, in Grossman, Gene M. and Rogoff, Kenneth, eds. Handbook of International Economics, 3, pp. 1647-88, Amsterdam: Elsevier, North-Holland.

Gibson, A.J.S. and Smout, T.C. (1995), Prices, Food, and Wages in Scotland 1550-1780, Cambridge: Cambridge University Press.

Goldberg and Verboven (2005), Market Integration and Convergence to the Law of One Price: Evidence from the European Car Market, Journal of International Economics, 65, pp.49-73.

Greenway, D. and Chong Hyun Nam (1988), Industralization and Macroeconomic Performance in Developing Countries and Alternative Trade Strategies, Kyklos, 41, pp. 419–35.

Harrison (1996), Openness and Growth: A Time Series, Cross-country Analysis for Developing Countries. Journal of Development Economics, 48, pp. 419–447.

Im, Kyung-So, M. Hashem Pesaran, and Yongcheol Shin (2003), Testing for Unit Roots in Heterogeneous Panels, Journal of Econometrics, 115(1), pp. 53-74.

Irwin and Tervio (2002), Does Trade Raise Income? Evidence from the Twentieth Century, Journal of International Economics, 58, pp. 1–18.

Jha, Murthy and Sharma (2005), Market Integration in Wholesale Rice Markets in India, ASARC working paper, 200503.

Kavoussi, R. (1984), Export Expansion and Economic Growth: Further Empirical Evidence, Journal of Development Economics, 14, pp.241–50.

Lau, Lawrence J., Yingyi Qian, and Gerard Roland (2000), Reform without Losers: An Interpretation of China's Dual-Track Approach to Transition, Journal of Political Economy, 108(1), pp.120-143.

Lee J.W (1993), International Trade, Distortions, and Long-run Economic Growth, IMF Staff Papers, 40(2), pp. 299–328.

Levin, Andrew and C. Lin (1992), Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties, unpublished manuscript, University of California, San Diego Discussion Paper, pp.92-23.

Lillian M. Li (2000), Integration and Disintegration in North China's Grain Market 1738-1911, The Journal of Economic History, 60(3), pp.665-699.

Maddala, G. S. and Shaowen Wu (1999), Comparative Study of Unit Root Tests with Panel Data and a New Simple Test, Oxford Bulletin of Economics and Statistics, 61(0), pp.631-652.

Michael, Panos, A. Robert Nobay, and David A. Peel (1997), "Transactions Costs and Nonlinear Adjustment in Real Exchange Rates: An Empirical Investigation," Journal of Political Economy, 105(4), pp.862–879.

Michaely, M. (1977), Exports and Growth: An Empirical Investigation, Journal of Development Economics, 4, pp.49–53.

Murphy, Kevin M., Andrei Shleifer, and Robert W. Vishny (1992), The Transition to a Market Economy: Pitfalls of Partial Reform, Quarterly Journal of Economics, 107(3), pp.889-906.

Naughton, Barry (1995), Growing out of the Plan: Chinese Economic Reform, 1978-1993. New York: Cambridge University Press.

O'Connell, Paul G. J. and Shang-Jin Wei (2002), The Bigger They Are, the Harder They Fall: Retail Price Differences across US Cities, Journal of International Economics, 56(1), pp.21-53.

Parsley, David and Shang-Jin Wei (1996), Convergence to the Law of One Price without Trade Barriers or Currency Fluctuations, Quarterly Journal of Economics, 111(4), pp.1211-1236.

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

Perdue and Peter (1992), the Qing State and the Gansu Grain Market, in T.Rawski and L.Li, eds, Chinese History in Economic Perspective, Berkeley: University of California Press.

Rodrik, Dani (2000), How Far Will International Economic Integration Go? Journal of Economic Perspectives, 14(1), pp.177-186.

Rogers, John (2001), Price Level Convergence, Relative Prices, and Inflation in Europe, International Finance Discussion Paper, Board of Governors of the Federal Reserve System.

Sala-i-Martin (1997), I Just Ran Two Million Regressions, American Economic Review, 87, pp.178–183.

Taylor, Alan M. (2001), Potential Pitfalls for the Purchasing-Power-Parity Puzzle? Sampling and Specification Biases in Mean-Reversion Tests of the Law of One Price, Econometrica, 69(2), pp.473-498.

Taylor, Mark P., David A. Peel, and Lucio Sarno (2001), Nonlinear Mean-Reversion in Real Exchange Rates: Toward a Solution to the Purchasing Power Parity Puzzles, International Economic Review 42(4), pp.1015–1042.

The Second Historical Archives of China (2004), Old China Customs Statistical Archives: 1859-1948, 1-170, Jinghua press, Beijng.

Tyler, W. (1981), Growth and Export Expansion in Developing Countries: Some Empirical Evidence, Journal of Development Economics, 9, pp.121–30.

Wang, Yeh-chien (1992), Secular Trends in Rice Prices in the Yangtze Delta, 1638-1935, in T.Rawski and L.Li, eds, Chinese History in Economic Perspective, Berkeley: University of California Press.

Wei, Shang-Jin (1997), Gradualism versus Big Bang: Speed and Sustainability of Reforms, Canadian Journal of Economics, 30(4), pp.1234-1247.

Wu, Chengming (1985a), Modernization of China: Market and Society (in Chinese), China Social Science press, Beijing.

Wu, Chengming (1985b), China's Capitalism and Domestic Market (in Chinese), China Social Science Press, Beijing.

Yan, Zhongping et al (1955), Selection of Modern China's Economic History Statistics (in Chinese), Science Press, Beijing.

Yao, Xiangao (1962), Foreign Trade Historical Statistics of Modern China: 1840-1895 (in Chinese), 1-3, Zhonghua Shuju Press, Beijing.

Young, Alwyn (2000), The Razor's Edge: Distortions and Incremental Reform in the People's Republic of China, Quarterly Journal of Economics, 115(4), pp.1091-1135.

Zheng, Youkui (1939), Transition of Import Tariffs after China Regaining the Authority to Decide Custom Duties (in Chinese), Shangwu Press, Shanghai.

Zheng, Youkui (1991), Studies of Modern China's Economic Foreign Relationship (in Chinese), Shanghai Social Science Press, Shanghai.

Zhou, Zhihua (1971), China's Important Commodities (in Chinese), Taiwan Xuesheng Shuju Press, Taipei.

10. Appendices

Appendix I. Distribution of Treaty Ports in China

Year of openness:

Shanghai	1842
Canton	1842
Ningpo	1843
Foochow	1844
Amoy	1844
Swatow	1860
Tientsin	1861
Chefoo	1861
Chinkiang	1861
Hankow	1861
Kiukiang	1861
Takow	1861
Tamsui	1861
Newchwang	1861
Kiungchow	1876
Pakhoi	1876
Wuhu	1876
Ichang	1876
Wenchow	1876
Kowloon	1887
Lappa	1887
Longchow	1887
Mengtsz	1887
Chungking	1890
Shasi	1896
Soochow	1896
Hangchow	1896
Wuchow	1897
Samshui	1897
Yochow	1898
Santuao	1898
Kiaochow	1898
Nanking	1899

Appendix II. Description of 14 Foreign Goods

Name	Name in Chinese	Category	classifier	Source	Description of Goods
Opium,Malwa	鴉片、洋藥、白皮土	Opium	Piculs(擔)	India	A kind of opium produced in Malwa (IAST: Māḷawā), a region in west-central northern India
Shirtings, Grey, Plain	平灰布、原色布	Cotton Goods	Pieces(疋)	Britain	A kind of plain and grey fabric produced in Britian which is suitable for making shirts
Drills	斜紋布	Cotton Goods	Pieces(疋)	Britain, America	Durable cotton or linen twill of varying weights, generally used for work clothes or a hard-wearing cotton cloth, used for uniforms
Cotton Yarn	棉紗	Cotton Goods	Piculs(擔)	India, Britain	A continuous strand of twisted threads of cotton, used in weaving or knitting
Camlets	羽紗	Woollen Goods	Pieces(疋)	Britain	A rich cloth of Asian origin, supposed originally to have been made of camel's hair and silk and later made of goat's hair and silk or other combinations.
Lastings, Plain	斜紋呢	Woollen Goods	Pieces(疋)	America, Britain	A sturdy twilled fabric
Iron, Nail-rod	盤條（釘桿）	Metals	Piculs(擔)	Britain	A kind of iron wire rods, usually suitable for making nails
Lead, in pigs	錫錠、生錫	Metals	Piculs(擔)	Britain, America	A crude block of lead, poured from a smelting furnace
Coal	煤炭	Energy	Tons(噸)	Japan, Britain	A natural dark brown to black graphite-like material used as a fuel
Oil, Kerosene	煤油	Energy	Gallons(加侖)	America	Light-colored oil that is a mixture of hydrocarbons derived from petroleum, which is used as a fuel in lamps and home heaters and furnaces.
Cotton, Raw	生棉	Sundries	Piculs(擔)	India	Non-processed natural and raw cotton
Matches	洋火	Sundries	Gross(羅)	Europe, Japan	A thin strip of wood or cardboard tipped with a chemical that ignites when scraped against a rough or specially treated surface
Sugar, White	白糖	Sundries	Piculs(擔)	South East Asia	A sweet carbohydrate, in the form of white crystals, which is found in many plants and is used to sweeten food and drinks
Rice	大米	Sundries	Piculs(擔)	South East Asia	Fruits of a plant, grown in well-watered ground in tropical countries, whose seeds are used as food

Appendix III. Units of Measurement/Classifiers Used in this Research

1. Value Measure：

1 Hk.Tls. (海關兩, Haikwan Tael) = value of a Tael of silver (a kind of currency in China)
= Approximate 5s.2(1/4)d in 1880s

2. Weight Measure:

1 Picul (擔) = 100 Catties (舊市斤)
1 Picul (擔) = 133.3 Pounds
1 Picul (擔) = 60.453 Kilograms
1 Catty (舊市斤) = 16 Taels (舊市兩)
1 Catty = 1.33 Pounds
1 Catty = 0.60453 Kilogram
1 Tael = 1.33 Ounces
1 Tael = 37.783 Grams

3. Volume Measure:

1 Gallon (British) = 4.546 Liter

4. Length Measure:

1 Piece (疋) = 40 Chi (市尺) = 12.44 Meters

5. Quantity Measure:

1 Gross = 12 Dozens