The Decline of China's Intraregional Market Integration in Qing Dynasty*

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Abstract

This chapter shows that China's intraregional market integration was on the decline during the Industrial Revolution era when Western Europe went through an increasing market integration, based upon econometric analysis. We present a unified theoretical framework which can help understand the concept of market integration more clearly. Beyond traditional measures, we propose and apply a new method to estimate the market integration intensity: the arbitrage cost between two prefectures, and the associated arbitrage probability. All empirical results are consistent with the conclusion of a decreasing intraregional market integration in Qing China.

Keywords: Market Integration, China, Qing Dynasty

JEL Classification: N15, N75, O47

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1 Introduction

For a long time, the Great Divergence has been one of the most controversial issues in economic history. The debate focuses on when and why the Great Divergence arose, that is, around what time and for what reasons Western Europe went ahead of other parts of the world economically. One influential view, called Western Centrism, argues that Western Europe's "exceptional" path of economic development is rooted in its unique characteristics, which could have been shaped centuries earlier than the Industrial Revolution: scientific culture and Christian tradition that led to technological progress (Landes, 2006); better institutions (North and Thomas, 1973); better structure of class relations which led to a free labor market (Brenner, 1976); and better demographic patterns (Clark, 2005, 2008). As a result, Western Europe's economic progress outperformed that of the rest of the world.

However, a different view based on the California School's works, represented by Pomeranz's The Great Divergence (2000), has got attention in recent years.[1] According to the California School, the rise of Western Europe occurred just before and during the Industrial Revolution and depended very much on a relatively sudden shift out of the traditional Malthus Trap. Since then, Western Europe took off and followed a sustained development route which made up the West's current supremacy. In contrast, Asian economies were trapped in the Malthus cycle and were constrained by the negligible productivity growth together with a growing population. They argue that, East Asia—particularly China, is comparable to the Western Europe on the eve of Industrial Revolution in terms of economic performance, measured by various indicators; it was exogenous shocks like coal usage and colonial exploitation, rather than endogenous factors that brought luck to the Western Europe.

Both the Western Centrism supporters and the California School scholars attach great importance to the role that market integration plays in the economic growth and social development. In general, market integration facilitates specialization and technology dif-

[1] See also Wong (1997) and Frank (1998).

fusion, and helps reduce the production cost. Unger (1983) and Allen and Unger (1990) argue that market integration is helpful in optimizing resource allocation and in promoting economic development. Many works point out that a better-functioning market or more integrated markets, in association with a set of institutions, e.g. non-distortionary pricing system, efficient legal framework, and clear property rights, would lead to more efficient resource uses and would provide greater incentives for investments, which are vital for raising income per capita for any economy. It is the well-functioning markets that distinguish the West from the rest of the world, induce the Industrial Revolution, and give rise to the Great Divergence (North and Thomas, 1973; North, 1981; North and Weingast, 1989). Moreover, various scholars examine how the market integration helped different countries or regions develop during the Industrial Revolution era, based on historical data and archives. For instance, Rothenberg (1992) analyzes the commodity, financial, and labor market integrations in Massachusetts in 1750–1850, Mora-Sitja (2007) investigates the labor market integration in Catalonia in 1772–1816, and Ronsijn (2014) studies the commodity market integration in Flanders in 1780–1850.

In an influential paper, Shiue and Keller (2007) provide econometric evidence to support California School's revisionist view. They compare the degree of grain market integration in Western Europe and China, two most advanced regions in the preindustrial era, but who would start to industrialize about 150 years apart, and find that the market integrations in China and in Western Europe were overall comparable in the late eighteenth century. Their finding has helped the revisionist view gain popularity in academia significantly. The above test, however, is static. Bernhofen et al. (2017) conduct a dynamic analysis using Shiue and Keller (2007)'s method, and find a secular decrease in the market integration in China in late 18th century and early 19th century. In contrast, they show that the market integration was stable or improved in Belgium and England at the same time.

For China's case, there seems to be a consensus and scholars generally emphasize the disintegration between regions: They argue that local markets in China were vibrant, but commercial connections between regions were weak and hence the diminishing interregional trade (Rawski, 1972; Pomeranz, 2000). In this chapter, we use rigorous econometric analysis to show that China's market integration was on the decline even within a region during Western Europe's Industrial Revolution era. Thus our research complements the early argument by showing that both the interregional and the intraregional market integrations were weakened in Qing China, which deepens our understanding of Shiue and Keller (2007) and Bernhofen et al. (2017)'s findings.

More generally, our analysis also sheds light on the fundamentals underlying market integration. How do we understand market integration under a theoretical framework? The market, itself a fairly complicated object, is determined by interactions of numerous factors. Market integration, an indicator of economic performance of a set of spatially independent markets, could conceptually be more complex. Current literature basically interprets market integration in pragmatic ways. For instance, Studer (2008), Shiue and Keller (2007), Yan and Liu (2011) and Bernhofen et al. (2017), do correlation and cointegration analyses, which can detect linear relationships between prices of different markets. Although price correlations and cointegration statistics are probably the most widely used measures of market integration, it is difficult to understand, intuitively, the market integration intensity in terms of price correlations and cointegration statistics. We do not know exactly what mechanism induces larger or smaller price correlations or cointegration statistics. In this chapter, we propose a unified theoretical framework which helps us understand the market integration in a clearer way. Specifically, we follow Spiller and Huang (1986) and Sexton et al. (1991) and emphasize the efficiency of arbitrage of agricultural products in different locations. Moreover, traditional measures can also find their own positions under our framework, and bear clearer economic meanings.

In our framework, the two key elements are the arbitrage cost and the arbitrage probability. For a homogeneous good, two locations are in a consolidated market, or equivalently, markets of these two locations are integrated if the prices in the two markets differ by exactly the arbitrage cost from one location to another. That is, two markets are integrated if the Law of One Price holds. Applying a method that is widely used in agricultural economics, our research directly estimates the arbitrage cost between two markets and the associated arbitrage probability. Obtaining the arbitrage costs and the corresponding arbitrage probabilities of the pre- and post-Industrial Revolution periods, we can identify the secular trend clearly.

This chapter is organized as follows. Section II discusses data, time, and why we focus on the Yangzi Delta. Section III proposes a unified theoretical framework of market integration. Section IV explains the empirical strategy in detail. Importantly, based on the proposed framework, we introduce a new methodology which can be used to directly estimate the arbitrage cost and the arbitrage probability between two local markets. The conventional measures also become more understandable in our framework. We present the empirical results in section V. Section VI turns to robustness checks. And Section VII concludes.

2 Data, Yangzi Delta and Time Range

Throughout the chapter we shall focus on China's Yangzi Delta, which refers to the area of southern part of Jiangsu province, northern part of Zhejiang province, and the Shanghai city. More specifically, it consists of the following 17 prefectures: Changzhou, Hai, Jiangning, Songjiang, Suzhou, Taicang, Tong, Yangzhou, Zhenjiang, Hangzhou, Huzhou, Jiaxing, Jinhua, Quzhou, Ningbo, Shaoxing, and Taizhou. Yangzi Delta was the most prosperous region in China during the Qing Dynasty (1644–1912). And it was a reasonablly comparable region in agricultural, commercial, and proto-industrial developments to the Western Europe on the eve of the Industrial Revolution (Shiue and Keller, 2007; Li, 2010). Therefore, had the Industrial Revolution occurred anywhere in China, Yangzi Delta would have been the region that embraced it and witnessed a rising intraregional market integration. If on the other hand we observe a declining intraregional market integration in the Yangzi Delta, it would not be surprising to see that have happened elsewhere in Qing China.

It should be noted that the Yangzi Delta is more meaningful economically than administratively. Skinner (1964) suggests that the traditional Chinese society is a mixed system of a centrally hierarchical structure combined with a host of paralleling locally hierarchical subsystems. He also proposes eight macro-regions as the units for analyzing various factors that impact China's dynastic development. The Yangzi Delta is one of these eight macro-regions. Skinner stresses the importance of analysis units and argues that they are largely neglected in historical scholarship and that a topic cannot be thoroughly understood unless the proper analysis units are fully analyzed.

We use the prefecture-level rice price data here, which is the monthly average price of mid-quality rice. Rice is the most important product traded in the Qing Dynasty, and its market can be regarded as competitive (Wu, 2007). The Qing government established a set of special institutions to document grain prices in the local markets. The local officials were required to report prices of major grains, further categorized by different grades, on a routine basis with the minimum frequency of once per month. The prices recorded were retail prices of grains in each prefecture, in the standard accounting units of taels (silver currency) per bushel. Such documentation comprises the first-hand resources of the database we use.

The database is constructed and maintained by Dr. Yeh-Chien Wang, and it is released for public use since 2008. The data come from the Grain Price Lists in the Palace Archives of the Number One Historical Archives in Beijing (Gongzhong liangjiadan) from 1736 to 1911. The database covers 21 provinces and 331 prefectures. There are 42 grains included and for each kind, a high price and a low price are reported. The time span differs across regions and across grains. This systematic database is the most comprehensive one in its sort. More conveniently, all prices are expressed in the unified units and are thus comparable across time, and the time originally based on the Chinese lunar calendar is also converted according to the Western calendar system.

In this chapter, we focus on two periods: Jan. 1770–Dec. 1779 and Jan. 1810–Dec. 1819, when the data are of the highest quality. Moreover, the Industrial Revolution took place roughly between 1760 and 1830 in the Great Britain. So the time we choose are reasonablly good for comparison. Our second period is just before the Daoguang Depression to avoid business cycle complications. Under the reign of Emperor Daoguang (1820–1850), China experienced a depression. The grain price underwent an unusually low level from 1825 to 1850 (Kishimoto, 1997). In doing the robustness check, we also try some other time period and find no significant changes in the result.

3 Theoretical Framework

Based on Skinner (1964) and Shiue and Keller (2007), our research focuses on the Yangzi Delta and analyzes the price relationship between two rice markets in pairwise prefectures. Since arbitrage will affect price levels of two prefectures' rice markets, integrated markets tend to be associated with a unique price, after arbitrage cost being taken into account. Thus, testing price integration is equivalent to testing whether local prices adhere to the Law of One Price. If local markets are not integrated, there is no arbitrage between markets, and therefore the local prices are not systematically related. In contrast, if local markets are integrated, arbitrage occurs through trade between prefectures, and arbitrageurs will help prices to achieve their equilibrium levels.

Hypothetically, consider the "autarkic" rice prices of a pair of prefectures i and j at time t, P_t^{iA} and P_t^{jA}.[2] By the quotation marks on autarkic, we stress the idea that prefecture i does not engage in trade with prefecture j *only*. Conceptually, this is not autarkic for prefecture i in a strict sense, which requires prefecture i not to engage in trade with the rest of the world, because prefecture i may trade with a third prefecture, say prefecture l, and P_t^{iA} should have been influenced by this factor. A symmetric argument applies to prefecture j as well.[3] Let us denote the prefecture with the higher price j and the one with the lower price i.[4] For $k \in \{i, j\}$, a lot of factors might enter into the

[2] Throughout the chapter, we use prefecture i and market i interchangeably.

[3] Note that "autarkic" prices may not always be observable.

[4] Theoretically, we assume that the rice price is a continuous random variable and the probability of two prices being equal is zero. Empirically, in the rare case of two equal prices, we pick one of them randomly and add to it an arbitrarily small number to make it prefecture j.

determinant set of P_t^{kA}, e.g. consumer preferences, agricultural technology, market power, weather, so on and so forth.

Assume that there is a merchant who seeks the arbitrage opportunity between prefectures i and j. Correspondingly, there is an arbitrage cost C_t^{ij} between the two regions that follows the log-normal distribution,

$$C_t^{ij} = e^{V_t^{ij}},\ V_t^{ij} \sim N(b_t^{ij}, \delta_{ijt}^2).$$

The arbitrage cost includes, for instance, the transportation cost, the storage expense differential between locations, and the in-transit loss, etc. Sometimes, even though the geographic distance between two markets does not change, C_t^{ij} may decline due to, e.g. the improvement of transportation technology.

Now consider the observed rice prices in markets i and j at time t, P_t^i and P_t^j. If market i is not integrated with market j, then the prices in the two separated markets are independent of each other and there should be no systematic relationship between them. We would have $P_t^i = P_t^{iA}, P_t^j = P_t^{jA}$.

However, if the two markets in prefectures i and j are integrated, whenever there exists an arbitrage opportunity between the two regions, arbitrage would make the following equation hold.

$$P_t^j - P_t^i = e^{V_t^{ij}}. \tag{1}$$

In other words, P_t^i and P_t^j are systematically related to each other based upon the Law of One Price. Let us denote the probability for equation (1) to hold λ_t^{ij}. Many shocks could affect the arbitrage probability λ_t^{ij}. For instance, an increased population in prefecture j would likely lead to an increased demand for rice in market j, which would raise P_t^{jA} and thus λ_t^{ij}. Similarly, improved irrigation system in prefecture i would make the supply of rice go up in market i, which would probably lower P_t^{iA} and make λ_t^{ij} go up.

One point that we want to emphasize is, *market integration is not treated as "all or nothing" here.* When one looks at all the prefecture pairs at some point in time, then some are integrated and some are not, or, arbitrage is present between some pairs and absent between other pairs. From a probabilistic perspective, for a given prefecture pair at a given time, it follows some distribution of being integrated and not being integrated.

4 Empirical Strategy

4.1 Estimating Arbitrage Cost and Arbitrage Probability

Based on the above theoretical framework and following Spiller and Huang (1986) and Sexton et al. (1991), we propose a method which can be used to estimate the arbitrage cost and the probability of having an arbitrage opportunity. This method helps overcome a number of lingering problems in the existent models: (a) Arbitrage costs can be estimated within the model; (b) Market integration is not treated as "all or nothing" and it is assumed that local markets sometimes are linked by arbitrage while at other times are separated, depending upon the relevant factors discussed in the previous section.

Regime 1: Arbitrage. Because there is arbitrage, equation (1) holds. We take logs on both sides, and get

$$\log(P_t^j - P_t^i) = V_t^{ij}. \tag{2}$$

Since $V_t^{ij} \sim N(b_t^{ij}, \delta_{ijt}^2)$, we have $\log(P_t^j - P_t^i) \sim N(b_t^{ij}, \delta_{ijt}^2)$. Recall that the probability of a pair of markets being integrated, or the probability that equation (1) holds, is λ_t^{ij}.

Regime 2: No Arbitrage. If no arbitrage takes place, then the local markets are separated (not integrated). The probability of this event, or the probability that equation (1) does not hold, is $1 - \lambda_t^{ij}$.

Now we introduce a new random variable, U_t^{ij}, to capture the barriers to trade between prefectures i and j at time t, such that the following equation holds:

$$\log(P_t^j - P_t^i) = V_t^{ij} + U_t^{ij}. \tag{3}$$

We further assume $U_t^{ij} \sim N(a_t^{ij}, \sigma_{ijt}^2)$. No restriction is placed on a_t^{ij}: it could be positive, negative, or zero. Further more, V_t^{ij} and U_t^{ij} are assumed to be independently distributed. Therefore, we have $\log(P_t^j - P_t^i) \sim N(b_t^{ij} + a_t^{ij}, \delta_{ijt}^2 + \sigma_{ijt}^2)$.

Consider a switching regression model with the above two regimes: Arbitrage (A), and No Arbitrage (NA). To estimate the model, the likelihood function is formulated as follows:

$$L_T^{ij} = \prod_{t \in T} [\lambda_T^{ij} f_{ijt}^A + (1 - \lambda_T^{ij}) f_{ijt}^{NA}] \tag{4}$$

where T are two time sets: the first one is Jan. 1770–Dec. 1779 (denoted as period 1 or T_1), and the second one is Jan. 1810–Dec. 1819 (denoted as period 2 or T_2), that is $T \in \{T_1, T_2\}$; f_{ijt}^A and f_{ijt}^{NA} are density functions based on equation (2) and equation (3), respectively:

$$f_{ijt}^A = \frac{1}{\delta_{ijT}} \phi\left(\frac{\log(P_t^j - P_t^i) - b_T^{ij}}{\delta_{ijT}}\right) \tag{5}$$

$$f_{ijt}^{NA} = \frac{1}{\sqrt{\delta_{ijT}^2 + \sigma_{ijT}^2}} \phi\left(\frac{\log(P_t^j - P_t^i) - (b_T^{ij} + a_T^{ij})}{\sqrt{\delta_{ijT}^2 + \sigma_{ijT}^2}}\right) \tag{6}$$

where $\phi(.)$ denotes the standard normal density function. The maximum likelihood estimates of the parameters $b_T^{ij}, a_T^{ij}, \delta_{ijT}, \sigma_{ijT}$ and λ_T^{ij} can be obtained by maximizing the logarithmic function of equation (4).

For a given period T and for each pair of prefecture i and prefecture j, we focus on the arbitrage probability λ_T^{ij}, and the arbitrage cost b_T^{ij}. To get a clear picture, we graph them against the geographic distance d^{ij}. We do this for the period Jan. 1770–Dec. 1779 and the period Jan. 1810–Dec. 1819. By comparison and contrast, we can identify the trend of market integration in Qing China.

4.2 Price Correlation and ADF t-Statistic

Price correlation is the basic and probably the most-widely used measure of market integration. Correlation coefficient $Corr(P_T^i, P_T^j)$ is estimated for two time series of spot price for rice of prefectures i and j. If the two local markets are integrated, the Law of One Price prevails and the two time series should move in tandem. Empirically, the larger $Corr(P_T^i, P_T^j)$ is, to the higher degree the markets i and j are integrated.

It is even clearer if we examine the price correlation in our proposed framework. When it is in Regime 1 (with the probability λ_T^{ij}), $Corr(P_t^i, P_t^j)$ is positive.[5] When it is in Regime 2 (with the probability $1 - \lambda_T^{ij}$), $Corr(P_t^i, P_t^j)$ is zero. Intuitively, $Corr(P_T^i, P_T^j)$ can be thought of as a "weighted average" of Regime 1 and Regime 2.[6] It follows that the greater $Corr(P_T^i, P_T^j)$ is, the higher the probability of Regime 1 is, and therefore there is a higher integration of market i and market j.

Another popular approach to examining market integration is testing for cointegration among time series of prices for market pairs. In our research, generally, P_t^i and P_t^j are individually nonstationary.[7] To test whether there is a long-run equilibrium relationship between P_t^i and P_t^j, or whether the two price series are cointegrated, we follow Engle and Granger (1987) and estimate the following equation by OLS

$$P_t^j = \alpha_T^{ij} + \beta_T^{ij} P_t^i + e_t^{ij} \tag{7}$$

If P_t^i and P_t^j are cointegrated, there will be some parameters α_T^{ij} and β_T^{ij} such that $P_t^j - \alpha_T^{ij} - \beta_T^{ij} P_t^i = 0$ is satisfied in the long run.[8] To test for this, one needs to examine the time series property of e_t^{ij}. Because P_t^i and P_t^j are cointegrated if and only if e_t^{ij} is stationary, an augmented Dickey-Fuller test on $\hat{e}_t^{ij}$, the residual of the above equation, is

[5] The value is between zero and one. More specifically, the magnitude depends on the variances of P_t^i and C_t^{ij}, the total arbitrage cost: the larger is $Var(P_t^i)$ relative to $Var(C_t^{ij})$, the higher is $Corr(P_t^i, P_t^j)$.

[6] Strictly speaking, the correlation coefficient over a whole sample is not a linear function of the correlation coefficients over its constituent subsamples.

[7] The null hypothesis of a unit root cannot be rejected using the Augmented Dickey-Fuller test. The average p-value for the null of a unit root is 0.42.

[8] In general, there are three functional forms for equation (7). Aside from the one presented here, the other two are: α_T^{ij} is omitted from the right hand side; a deterministic trend term $\gamma_T^{ij} t$ is added to the right hand side.

employed

$$\Delta \hat{e}_t^{ij} = \theta_T^{ij} \hat{e}_{t-1}^{ij} + \sum_{k=1}^{n} \psi_{Tk}^{ij} \Delta \hat{e}_{t-k}^{ij} + u_t^{ij} \tag{8}$$

where the lagged $\Delta \hat{e}_t^{ij}$'s are added as regressors to reduce the serial correlation problem. Under the null hypothesis that e_t^{ij} is nonstationary, the parameter θ_T^{ij} is equal to zero. According to Shiue and Keller (2007), the stronger is the evidence that $\theta_T^{ij} < 0$, the more convincing is that P_t^i and P_t^j are cointegrated, or that local markets in prefecture i and in prefecture j are integrated. The measure they use is the t-statistic for θ_T^{ij}. A very negative t-statistic indicates a strong support for the cointegrating relationship between P_t^i and P_t^j.

Like the price correlation, it is very helpful to study the above t-statistic in our proposed framework. When it is in Regime 1 (with the probability λ_T^{ij}), P_t^i and P_t^j are cointegrated and thus the t-statistic is very negative. When it is in Regime 2 (with the probability $1-\lambda_T^{ij}$), P_t^i and P_t^j are not cointegrated and thus the t-statistic is close to zero. Again, the whole-sample t-statistic can be thought of as a "weighted average" of Regime 1 and Regime 2. Therefore, the more negative t-statistic is, the higher the probability of Regime 1 is, and consequently there is a higher integration of market i and market j.

5 Empirical Results

Our data cover 17 prefectures in the Yangzi Delta, an area of 133,080 square kilometers. The population of this region rose from 44.89 million in 1776 to 55.13 million in 1825. As discussed before, we focus our attention to two periods: Jan. 1770–Dec. 1779 (denoted as period 1), and Jan. 1810–Dec. 1819 (denoted as period 2). For each prefecture k, the monthly rice price data are used. To investigate local market integration, we first estimate the pairwise arbitrage cost and the corresponding arbitrage probability, utilizing the methodology proposed in the previous section, and then we calculate the conventional measures in the literature: the price correlation and the cointegration t-statistic. Through cross-time comparison, a time trend of market integration can be identified.

5.1 Arbitrage Cost and Arbitrage Probability

Applying the methodology detailed in Section 4.1, we obtain the maximum likelihood estimates (MLE) of interested parameters. In particular, for a given period T and for each pair of prefecture i and prefecture j, we focus on the arbitrage probability λ_T^{ij}, and the arbitrage cost b_T^{ij}, where T can be period 1 (Jan. 1770–Dec. 1779), or period 2 (Jan. 1810–Dec. 1819).

Figure 1a graphs the arbitrage cost b_T^{ij} against the distance between prefectures i and j. In the scatter plot, each point represents a point estimate of b_T^{ij}. To make things clearer, we also draw the lowess (Locally Weighted Scatterplot Smoothing) curves for period 1 and period 2. The lowess curves are generally upward sloping, indicating a positive relationship between the arbitrage cost and the physical distance. This is intuitive as the further two markets are lying from each other, the higher the transportation cost and the in-transit loss are. More importantly, period 2's lowess curve clearly lies above period 1's. That is, the arbitrage cost is generally higher in period 2 than in period 1. This pattern is further supported by the summary statistics of b_T^{ij}'s. For instance, its mean rises from 3.17 in period 1 to 3.78 in period 2; and at the same time, its median increases from 3.27 in period 1 to 3.87 in period 2.[9]

Similarly, Figure 1b graphs the arbitrage probability λ_T^{ij} against the distance between prefectures i and j. Again, each point represents a point estimate of λ_T^{ij} and the curves are the lowess functions of periods 1 and 2. Apparently, period 2's lowess curve is beneath period 1's in the graph, which implies that the arbitrage probability is generally lower in period 2 than in period 1. Summary statistics of λ_T^{ij}'s echo this pattern: its mean drops from 0.76 in period 1 to 0.61 in period 2; and meanwhile, its median declines from 0.80 in period 1 to 0.64 in period 2.

Overall, changes in the arbitrage cost and the arbitrage probability point to a same

[9]Note that in our model, the level of arbitrage cost is $e^{b_T^{ij}}$.

conclusion here: the market integration in the Yangzi Delta was weakened, rather than was strengthened, from the period of Jan. 1770–Dec. 1779 to the period of Jan. 1810–Dec. 1819. Such a Chinese phenomenon is in stark contrast to what had happened in the Western Europe at times before and after the Industrial Revolution.

5.2 Price Correlation and ADF t-Statistic

To be complete, we also use the conventional measures of price correlation coefficients and cointegration test statistics to check the local market integrations. Section 4.2 spells out the details of the methods, particularly, in the context of our proposed framework.

Figure 1c shows the scatter plots and lowess curves of the price correlation, $Corr(P_T^i, P_T^j)$ versus the geographic distance between a pair of prefectures, d^{ij}. As in Shiue and Keller (2007), the price correlation appears to be negatively related to the physical distance. It seems that distance is an obstacle for the Law of One Price to hold. More importantly, the lowess curve in period 2 lies beneath the one in period 1. As our theory suggests that a larger correlation indicates a higher degree of market integration, the graph shows that the market integration became weaker in period 2 than in period 1. It is also verified by changes in price correlation's summary statistics: the mean and the median drop from 0.74 and 0.81 in period 1, to 0.50 and 0.56 in period 2, respectively.

In Figure 1d, we plot the ADF t-statistic on Equation (7)'s θ_T^{ij} against the distance between prefectures i and j, and the associated lowess functions. From the scatter plot we see that most ADF t-statistics are very negative, implying that the cointegration relationship exists for P_t^i and P_t^j in a majority of times. More importantly, the lowess curve in period 2 lies above the one in period 1. According to our theory, a more negative ADF t-statistic implies a higher degree of market integration. Figure 1d tells us that the market integration became weaker in period 2 than in period 1. The changes in ADF t-statistics also verify this finding: the mean and the median rise from -3.39 and -3.33 in period 1, to -2.86 and -2.81 in period 2, respectively.

To sum up, both of the two conventional measures to quantifying market integration, the price correlation between local markets and the ADF t-statistic used to test the cointegrating relationship between local market prices, show that the market integration became weaker in the period of Jan. 1810–Dec. 1819 than in the period of Jan. 1770–Dec. 1779. This result is consistent with our conclusion based on the arbitrage cost and the arbitrage probability.

6 Robustness Check

In this section, we conduct two robustness checks. In particular, alternative time spans and geographical region are specified, one at a time. We investigate how sensitive our conclusion in the previous section is to the above changes.

6.1 Alternative Time Ranges

First, we examine whether the time spans we choose are critical for our results. We modify period 1 from Jan. 1770–Dec. 1779 to Jan. 1760–Dec. 1799, and period 2 from Jan. 1810–Dec. 1819 to Jan. 1800–Dec. 1839. That is, we extend each period from 10 years to 40 years. Figures 2a to 2d are the counterparts of Figures 1a to 1d, respectively. It is obvious that all the results still hold qualitatively, despite the change in time ranges.

6.2 Alternative Macro-Region: Middle Yangzi Region

Second, we want to see whether the decline of intraregional market integration is a special case occurring only to the Yangzi Delta. So we repeat our exercises using the rice price data of a different region, a macro-region called the Middle Yangzi Region (Skinner, 1964). This is a relatively prosperous area in then China, but less developed than the Yangzi Delta. Again, Figures 3a to 3d are the counterparts of Figures 1a to 1d, respectively. When we compare Figure 3b with Figure 1b, or when we compare Figure 3c with Figure 1c, we find that local markets integrated to a lesser degree in the Middle Yangzi Region than in the Yangzi Delta, in a cross section sense. Despite this difference between these two macro-regions, the weakening trend of intraregional market integration holds for both regions, no matter whichever measure is used. Therefore, the weakening of intraregional market integration is not specific to only the Yangzi Delta; it is rather a general phenomenon taking place in China in the Qing Dynasty.

In summary, our sensitive analysis based upon different time windows and macro-region indicates that results in the previous section are very robust. The intraregional market integration became weaker as time went by in China in the Qing Dynasty. This is a stylized fact supported by strong empirical evidence.

7 Conclusion

In this chapter, through econometric analysis we demonstrate that the intraregional market integration was on the decline during the Industrial Revolution era when Western European countries saw an increasing market integration. Our result echoes the findings of Bernhofen et al. (2017) who, however, apply a different approach and do not distinguish the intraregional and interregional market integrations.

This chapter also contributes to the literature by presenting a unified theoretical framework in which the notion of market integration can be understood with ease. Essentially it is based upon the Law of One Price, with stochastic factors taken into account. The key parameters include the arbitrage cost and the associated arbitrage probability. Our numerical exercises show that China went through a rise in the former and a decline in the latter in the late 18th century and the early 19th century. Finally, the traditional measures of market integration, the price correlation and the cointegration t-statistic, become more intuitive in the context of our framework.

Future research may extend our analysis along two lines. First, one can move one step further and explore the reasons why the arbitrage cost and the corresponding arbitrage probability within a region deteriorated in Qing China during the Industrial Revolution era. It would be helpful if we can pinpoint some major events or socioeconomic developments that underlie the observed changes. Second, our theoretical framework and the associated empirical methodology can be utilized to study the interregional market integration evolution in Qing China, to test whether Rawski (1972) and Pomeranz (2000)'s arguments hold, econometrically.

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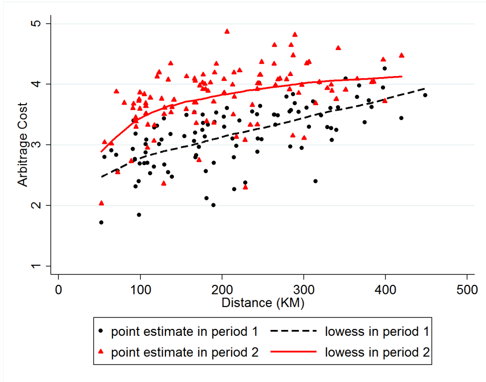
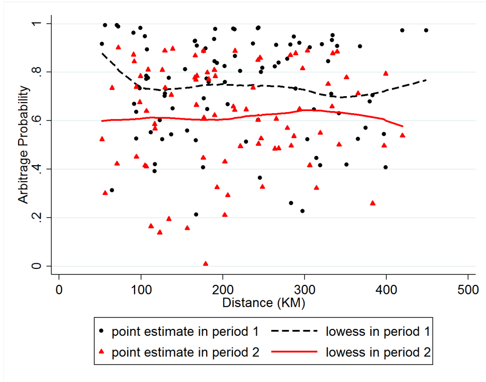
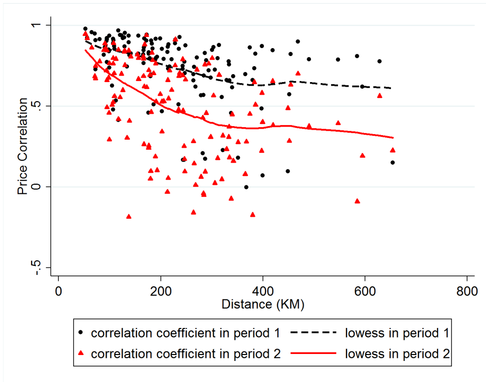


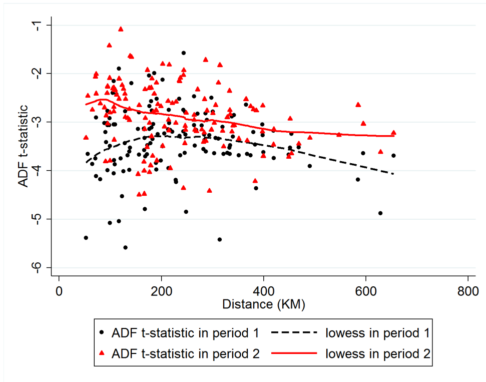
(a) Arbitrage Cost



(b) Arbitrage Probability

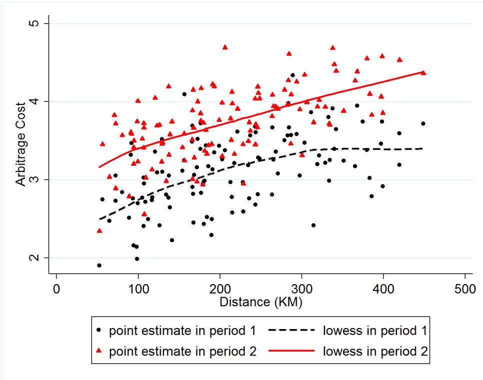


(c) Price Correlation

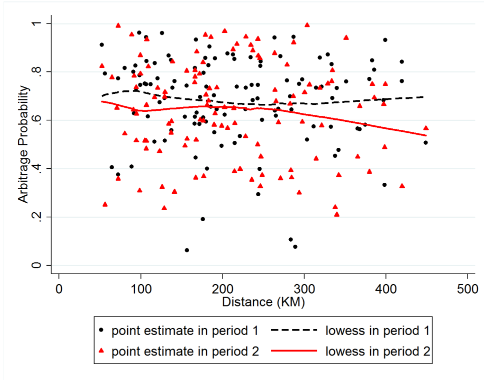


(d) Price Cointegration

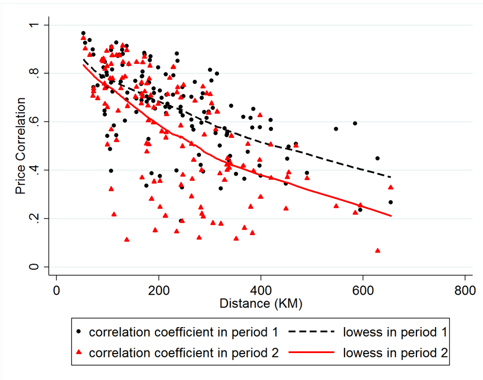
Figure 1: Baseline



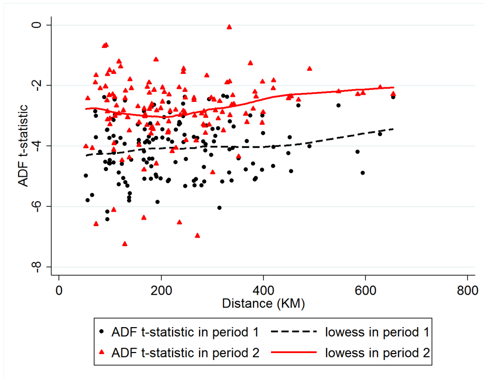
(a) Arbitrage Cost



(b) Arbitrage Probability

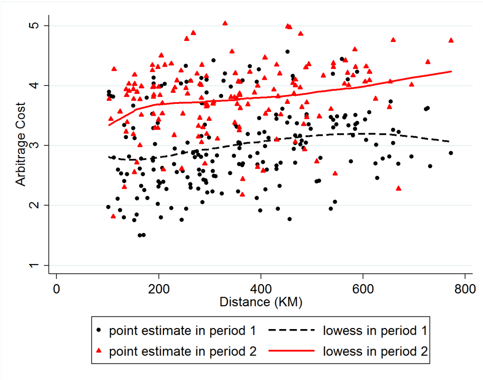


(c) Price Correlation

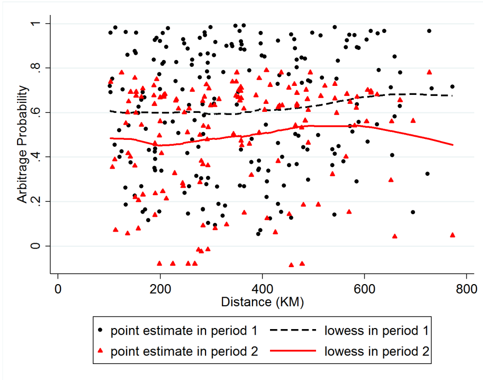


(d) Price Cointegration

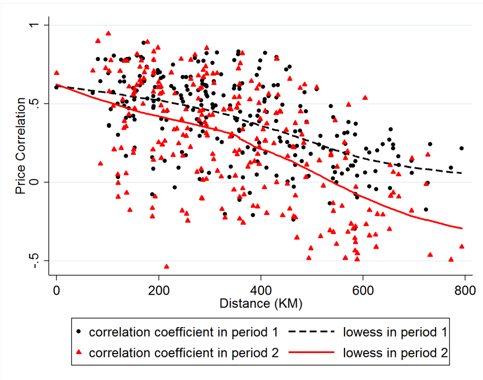
Figure 2: Alternative Times



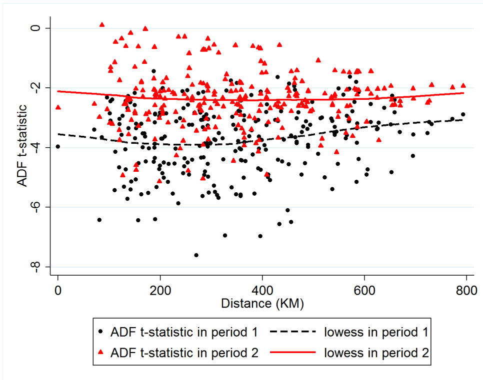
(a) Arbitrage Cost



(b) Arbitrage Probability



(c) Price Correlation



(d) Price Cointegration

Figure 3: Middle Yangzi Region