Grain Trade and Market Integration in China's Qing Dynasty

JIANAN LI, Msc.

Thesis submitted to The University of Nottingham for the degree of Doctor of Philosophy

DECEMBER 2014

Abstract

The paradox of China's failure to industrialize despite its thriving commercialization before the 19th century has been debated intensively, especially in terms of whether market efficiency is sufficient for industrialization in the pre-modern period. This thesis sheds light on this question using archival data on grain prices covering Qing China's most prosperous episode (1740-1820) to identify the determinants of market evolution as well as the true extent of market integration. My results suggest that China's market efficiency on the eve of Western industrialization has been grossly overstated, and further imply that China's market was heavily influenced by its bureaucratic structure. My analysis is based on a historical dataset of monthly grain prices (rice, wheat) in 211 prefectures across China and I match these with new data on the physical geography of the postal and river network and physiographic distribution. My analysis first confirms the close relationship between market integration and geographic proximity but shows that geographical influence is dominated by provincial boundaries. I then employ novel panel time series methods to account for the impact of local and global shocks and to investigate the evolving process of market integration over time. This analysis indicates that China experienced continuous market disintegration with fragmentation driven by political structure. These results support my hypothesis that Qing China's political system was not conducive to the development of the market mechanism since its primary concern was market regulation rather than revenue.

Acknowledgements

I would never been able to finish my dissertation without the guidance of my committee members, help from friends, and support from my family.

I would like to express my deepest gratitude to my supervisors, Prof. Daniel Bernhofen, Prof. Stephen Morgan, and Dr. Markus Eberhardt, for their excellent guidance, caring, patience, and providing me with an excellent atmosphere for doing research. I would also like to thank my parents and grand-parents. They were always supporting me and encouraging me with their best wishes. I also wish to thank all my fellow PhD students for their assistance and support.

For any errors or inadequacies that may remain in this work, of course, the responsibility is entirely my own.

Content

List of Figures

List of Tables

Weights, Measures, and Units of Currency

Note: the equivalents stated below refer to the official standards. Local variation was considerable.

Capacity: 1 *shi* = approximately 103.6 *liters*

***Weight**:* 1 *liang* = approximately 37.3 *grams*

***Area**:* 1 *mu* = approximately 0.0615 *hectare*

1 *qing* = 100 *mu* = 6.15 *hectares*

***Distance**:* 1 *li* = approximately 0.576 *kilometer*

Currency: The principal means of exchange in wholesale and other large transactions was silver, which circulated by weight. The *liang* (see above) of silver was the main unit of value. It was notionally supposed to exchange for a full "string" of 1,000 "copper" (actually brass) coins. In monetary contexts, *liang* is conventionally rendered "tael".

Chapter 1
Introduction

1.1 Background

Since the late 1970s, China witnessed unprecedented economic growth, which allowed it to re-emerge as a leading global economy. China's recent rise after a century or more of backwardness has been upheld as a "suitable" model of gradual reform, which would help developing countries escape poverty and sustain economic growth. Explaining China's economic "miracle" has spurred a huge literature. However, China's new found prominence in the world economy is not the first time it has been a global leader. For much of its history, China has been the world's largest and most powerful economy. China's last dynasty-Qing Dynasty (1644-1911) was the world's largest national economy before 1800. The Qing experienced a tripling of population with few signs of diminishing per capita income. Despite the past prosperity, from the early 19th century onward China was overtaken by Western Europe, rapidly falling behind in productivity, living standards, and technology. Many scholars have long sought to explain the origin of China's decline.

How to combine China's sudden decline in the 19th century with its sudden rise in the 20th within one unified framework pose a formidable challenge to economists and economic historians. Most existing literature attributed China's recent success to contemporary policies of market-oriented reforms and openness. However, this literature ignores the impact of China's past on its shifting trajectory of economic development. Brandt *et al.* (2014) systematically discuss the link between China's past and present, arguing that China's development continues to be shaped by its institutional "legacies". Keller and Shiue (2007b) find that China's market integration in the 1720s is highly correlated with per capita income in the 1990s. Appropriate explanation of China's economic success has to be built on a longer view of its economic dynamics. This thesis makes a contribution to such a task through combining unique historical grain price data with advanced empirical methods to investigate the determinants of market efficiency in Qing China in the 18th century, which provides new empirical evidence for future discussion that how China was shaped by it past.

1.2 Motivations

China's civilization and economy was built on agriculture, which sustained China's highly centralized empire from the Qin Dynasty (B.C.E 221) to the early 20th century. During the Qing Dynasty, the 18th century witnessed political unity, freedom from external influences and relative commercial prosperity. But from around the late 18th century there unfolded the 'Great Divergence'. China suffered the chaos of foreign domination and civil strife for almost a century whilst Western Europe industrialised to create global economic leaders. Incomes and productivity diverged sharply. Earlier explanations of Western economic success emphasised Western exceptionalism, such as religion and culture, political institutions or the role of colonialism. The recent revisionist scholars contested these arguments and argued the origin of the Great Divergence rested in resource endowments, the impact of

Western imperialism and historical path dependency associated with the presence of specific institutions. All the hypotheses about the origin of the Great Divergence to varying degrees share the view that institutions play an essential role in the shaping of modern economies.

There is a growing literature arguing that institutions dominated geography over the long-run (Acemoglu *et al.* 2001, 2002, 2004, 2005; Banerjee and Iyer, 2005; Dell, 2008; Fang and Zhao, 2011). The elegance of these empirical papers lies in their ability to show that institutions are an important channel through which the role of geography (e.g. large-scale plantations, mortality rate for colonizer) matters for income differences today, which reflects the relationship between history and current economic development.[1] Since the collapse of the Chinese Han dynasty and the Roman Empire, China and Europe have evolved distinct social structures to sustain cooperation, which subsequently led to different cultural and institutional evolution. In this process, Europe relied more on formal institutions while China relied more on informal institutions (Greifand and Tabellini, 2010; Rosenthal and Wong, 2011). Consequently, Europe evolved formal property right institutions for contract enforcement while China's merchants mostly enforced the contract through informal institutions like informal networks involving clans or place of origin.

The Industrial Revolution was the turning point in the process of the Great Divergence as it was the first time in human history that positive per capita growth rates were sustained over a long period. The sustained per capita growth of the

---

[1] However, Sachs (2003) insists that not all the impacts of geography on the long-term economic growth go through institutions, e.g. malaria transmission. Glaeser *at el.* (2004) argues that human capital is a more basic source of growth than are the institutions, and some of the instrumental variable techniques used in this literature are unsuitable for that purpose. Glaeser *at el.* (2004) even suggests that poor countries escape poverty through good policies often pursued by dictators.

Industrial Revolution allowed humans for the first time to escape the Malthusian trap. The argument behind the Great Divergence debate could be narrowed to the following specific questions. Why did Western Europe industrialize first? Alternatively, why did China not industrialize first? Social and economic historians have tried to tackle this issue by identifying potential sufficient conditions for industrialization. Since Adam Smith's *The Wealth of Nations,* market integration has been one of the popular explanations of economic growth. One candidate condition for industrialization has been the degree of market integration of an agricultural economy on the eve of industrialization, which provided sufficient incentives to invest into industrialization.

A well-functioning market is supposed to be supported with a set of institutions (e.g. non-distortionary pricing systems, common law, and property rights) that would lead to more efficient resource re-allocation and provide far greater incentives to make investment (North and Weingast, 1989; North, 1981; North and Thomas, 1973). Following this argument, well-functioning markets could only take root in Europe since European commerce trade was regulated by state-supported property rights institutions. The conventional wisdom holds that markets in Western Europe were more integrated than China, which led to the industrialization in Europe. By contrast, Pomeranz (2000) and others argued that the most advanced regions of China and Europe had institutional frameworks and demographic patterns that were equally favorable to growth. This view is supported by Shiue and Keller's (2007) finding that China and Europe had comparable market efficiency on the eve of industrialization. Following from this finding, Shiue and Keller conclude that market performance is not sufficient for industrialization.

This thesis uses historical grain price data to investigate whether China possessed a well-functioning market in the 18th century, and whether geography or institutions affected the market evolution. Grains, as the staples, were the most important commodities traded in an agricultural economy like Qing China. Studer (2008) asserts that grains are the most suitable goods to assess market integration in the pre-modern era as they provide a representative picture of trading capacities. In this thesis, I collected monthly rice and wheat prices for 211 prefectures across North and South China in the period between 1740 and 1820 to investigate market efficiency in these regions. In order to further disentangle the relative importance of the mode of transport in determining the extent of spatial market integration, I digitised the networks of grain rivers documented for grain trade in various archival records. Furthermore, I digitised the extensive imperial postal-route network, which according to Fan (1993) represented the primary land trading routes in Qing China.

1.3 Contributions

1.3.1 Grain Price Data, Waterway Network and Postal Route Network

The first contribution of this thesis is the grain prices I collated as well as detailed geographical variables I constructed for this research. To the best of my knowledge, this is the first study using such detailed historical information of the transport network and topographical distribution for the analysis of market integration.

The grain data is collated from sources documenting the nationwide grain price system in the Qing Dynasty. This elaborate grain price reporting system became a formal system at the start of the reign of Emperor Qianlong (1736-1795). The grain price data was based on monthly reports detailing the prevailing high and low prices for up to 20 commodities (not all grain were reported in every region) at the prefecture level, of which I collect monthly rice price of 131 prefectures in South China and monthly wheat price of 80 prefectures in North China in the years from 1740 to 1820. The reliability and comparability of this data have been confirmed by historians and economic historians (Chuan and Kraus, 1975; Wang, 1978, 1986, 1992; Marks, 1991). The geographical coverage of these data amounts to around two-thirds of China's administrative units and more than 80% of China's population in the mid-18th century.

Based on geographical information system (GIS) data from China Historical Geographic Information System (CHGIS) for 1820, I created two geographical datasets as trade cost proxy for (i) the postal route network at the county level, (ii) the grain trade waterway network, which are aggregated and matched to the grain price data at the prefecture level. In pre-modern China, postal routes acted as an "administrative traffic system", and were used as transportation highways for the movement of goods and people during the Qing Dynasty (Fan, 1993). In 1907 the Qing Dynasty produced the China Postal Almanac, which contains maps of the primary postal routes, railroads and telegraph lines in each province. These postal routes were for the most part the same as those used for many centuries. The postal route distance measure I derive from the postal network gives a better proxy for trade distance than the widely used direct distance because in practice the true trade route follows the topographical distribution of the land (e.g. valleys or navigable rivers), especially for heavy commodities such as grains. In the same period, waterway transport was far more economical and convenient than land transport. To construct a variable that captures the impact of the waterway network on market integration, I identify and digitize all the rivers that have been recorded for grain trade in gazetteers and archives reported in Deng (1994, 1995) as well as inland waterways reported in Wiens (1955), which form the river layer for the river data-set in CHGIS. The third geographic dataset I have applied in this thesis is the boundaries of nine "physiographic macroregions" introduced by William Skinner (1977a), who divide China into nine regions according to the mountain ranges, drainage basins of major rivers and other travel-constraining geomorphological features. Physiographic border can act as natural barriers to trade.

1.3.2 Geography, Institutions and Market Evolution

This thesis contributes to the argument contrasting the effects of institutions and geography on the long-run development, and provides results to support the "institutions hypothesis". Applying Engle-Granger cointegration and conventional cross-section method, my results indicate that Qing China's provincial border produced larger impact than waterway network and physiographic distribution on shaping the market evolution. Although I provide robust evidence to identify that Southern markets were more integrated than Northern markets, the role of river transport for the subtle differences between China's Southern and Northern regions is significant but not dominant. Applying novel panel time series methods and conventional cross-section method, I provide robust evidence for continuous market disintegration and fragmentation of China's grain market while the pattern and driving force of market fragmentation was determined by the provincial border rather than the physiographic determinants. All these results highlight two perspectives: i) Qing's bureaucratic intervention and influence, rather than geographical factors, determined Qing China's grain market performance; ii) the role of transport cost for the market integration has been overstated for pre-modern China. The strong provincial border effects coincided with the primary concern for food security of the Qing state. Under the integrated provincial bureaucratic hierarchy, Qing China's provincial governors were delegated political power as the head of province, and bore the responsibility of maximizing local grain storage, which encouraged and enable them to embargo the grain export.

My results contribute to the discussion of the Great Divergence. Combined the results from analysis on spatial and time dimension, I provide robust evidence that China's market disintegrated over time and was fragmented along its provincial borders, which strongly challenges previous hypotheses that China had an unified integrated market on the eve of industrialization. With these findings, firstly, we have to re-consider the role of market integration for further industrialization. And, we may go back to Smithian trade-led arguments to explain China's decline. Contrary to Shiue and Keller's (2007) conclusion that market efficiency is not sufficient for industrialization, China may have failed to industrialize due to its lack of well-functioning market or institutions supporting well-functioning market. Secondly, we may re-emphasize the importance of "good" institutions, especially property right institutions, for the long-run economic development, which was discussed in the seminal works of North and Thomas (1973), North and Weingast (1989) and North (1981, 1990). China's commercial prosperity in the Qing Dynasty relied on the informal rules in the form of family bylaws, lineage rules and guild regulations that overcame the commitment problem. My findings suggest that, despite informal institutions under the centralized regime was favourable to trade within the clan network, they were not favourable to inter-regional market integration therefore cannot lead to modern economic growth.

This thesis provides robust evidence of market decline in China during the 18th century, which trigger another essential question that Why China's market declined during its prosperous period. Based on a simple regression between population growth and market integration change at the prefectural level, I cannot find any significant statistical correlation to support that hypothesis that China's grain market decline was driven by its demographic change. In the short run analysis of the determinants of trade cost, I cannot find evidence to support the hypothesis that the deterioration of transport capacity of rivers determined the increasing trade cost. In addition, only 30% of trade cost can be explained by the provincial border while 50% of trade cost has to be attributed to the unknown distance-unrelated cost. Although there is no direct evidence, it is quite likely that these unknown distance-unrelated costs came from institutions. The Qing State paternalist interventions in the grain market intervention to maintain food security was its primary policy target. Under the stable centralized polity with large scope of geography, Qing State had no incentive to establish formal property right institutions to promote economic growth since its primary concern was social stability. The insecurity of property impeded the incentives for investment as well as the demand for financial loans, which eventually prevented the development of modern financial sector as well as the modern market mechanism in Qing China.

1.3.3 Structure of this Thesis

This thesis is divided into four core chapters. Chapter 2 explores the background of the Qing Dynasty and its political institutions, the Great Divergence debate and the development of Qing grain market. Chapter 3 describes the data on grain price, postal route network, grain waterway network as well as Skinner macroregions. In Chapter 4, I apply Engel-Granger cointegration method to identify and quantify the determinants of market integration spatially, based on the comparison between Southern rice prices and Northern Wheat prices. In Chapter 5, I apply one novel panel cointegration method (i.e. mean group estimator) to provide robust evidence that China experienced a process of market disintegration and fragmentation.

Chapter 2
Great Divergence, Qing Dynasty and its Grain Trade

2.1 Introduction

China's civilization was built on agriculture, the prosperity of which depends on the natural and geographical endowment (Wen, 2005). China has been for most periods a centralized empire since the Qin Dynasty (B.C. 221). Since the Tang Dynasty (618 – 907) China has had a market economy with a high degree of labour division and private-owned land, fairly free movement of labour, and relatively well-functioning factor and product markets (Lin, 1995). During the 18th century, the Qing Dynasty attained a high degree political stability and economic prosperity. Qing China saw increasing agricultural development, commercialization and urbanization driven by population growth, which spurred the expansion of interregional grain trade. However, food security was the primary concern of Qing's emperors. The Qing's officials intervened in the grain trade through the national-wide granary system, which had ambitious goals of grain storage to relieve periodic food shortages and price stabilization to ensure the livelihood of the people.

Despite the prosperity of China in the past, from the 19th century onward Western Europe rapidly overtook China with gains in productivity, living standard, and technology, which we identify with the Industrial Revolution. The process is often known as the "Great Divergence" or the "Rise of the West". The corollary of the West's new found economic and political power was the "fall of the China" and the rest of the world in relative terms. The timing of the divergence is hotly debated. Historians such as Pomeranz (2000), Parthasarathi (1998) and Frank (1998) have claimed that the Great Divergence between Europe and Asia occurred only after the start of the 19th century. Many scholars have long sought to explain the origin of Western economic success. The argument behind the Great Divergence debate could be narrowed to the following specific question: why was China unable to industrialize if China and Europe were comparable as recently as the 18th century. Can we identify a unified framework behind the "rise of the West" as well as the "fall of the China", which would help us to identify the proper economic mode producing the modern economic institutions and sustainable economic growth?

Earlier explanations of Western economic success emphasised Western exceptionalism, such as religion and culture, political institutions or the role of colonialism. Revisionist scholars contest these arguments, such as those associated with the California School including Andre Gunder Frank, James Z. Lee, Bozhong Li, R. Bin Wong and most well-known, Kenneth Pomeranz. They argue the origin of Great Divergence in terms of resource endowments, the impact of Western imperialism and historical path dependency associated with the presence of specific institutions.

One particular form of Western exceptionalism emphasises how European allocative institutions are both necessary and sufficient conditions for effective resource re-allocation and modern growth. Countries such as Britain and Netherlands developed well-functioning markets supported with a set of institutions (non-distortionary pricing system, common law, and property right institutions) (North, 1981). Western Europe's more integrated markets compared with China explained the West's industrialization. Pomeranz (2000) seriously challenged this view arguing that market efficiency and living standards were comparable with Europe on the eve of the Industrial Revolution. That Europe- in particular England- entered into sustained modern growth, according to Pomeranze, arose from the accident of plentiful energy (coal) near urban areas and the bounty of land-based resources (food and fibre) of the New World. Based on a study of rice prices in China and wheat prices in Europe, Shiue and Keller (2007) found some support for Pomeranz's conjectures. But their results imply integrated market were insufficient for industrialization. If so, why was China's thriving commerce unable to lay the foundation for industrialization?

A growing literature argues that "property right institutions" are a primary determinant of economic performance. Since China and Europe have evolved distinct social structures to sustain cooperation, I might find our answer in the Chinese use of informal contract arrangements compared with the Europeans reliance more on formal property right institutions to enforce trade contracts. Shiue and Keller's (2007) results imply that informal contracting institutions are substitutable for formal property right institutions at least in terms of market integration. However, my study questions whether Qing China's markets were "well-functioning". In Chapter 4 and 5 I show that Qing China's market integration has been exaggerated, and contrarily I suggest it experienced a process of disintegration and fragmentation because of the Chinese political structure.

This Chapter is organized as below. Section 2.2 introduces the golden period of Qing Dynasty before the Great Divergence. Section 2.3 discusses a variety of hypotheses to explain the Great Divergence. Section 2.4 suggests that the highly centralized regime in China held back institutional change favourable to the modern economic growth. Section 2.5 introduces the national-wide granary system, describes the prosperity of grain trade as well as the difference between rice and wheat markets. Section 2.6 discusses grain market integration as one acceptable measurement of market performance for Qing China. Conclusions are given in the final section.

2.2 Qing Dynasty and the Great Divergence

2.2.1 18th century: China's Golden Age

The Qing Dynasty (1644-1911) founded by the Manchus from northeast China, took over from the ethnic Han Ming Dynasty (1368-1644). Qing China became the largest consolidated Chinese empire. Between 1650 and 1850, China's population grew from less than 150 million to more than 400 million (Perkins, 1969), without any apparent drop in the average living standards before the mid-19th century (Baten *et al.*, 2010). China's economy as late as the 1820s was the largest economy in the world; GDP accounted for 32.4% of the world total (Maddison, 1998).

The Qing period before the first Opium War (1839-40) is usually divided into three sub-periods. The Early Qing was a period of military conquest and political consolidation that concluded in the 1680s. The second High Qing period, which saw social stability and expansion of interregional trade, is characterised as a golden age. The end of the High Qing was marked by the late 18th century large-scale uprising, the White Lotus Rebellion (1796-1804). The Late-Qing sub-period is one of rising monetary and economic instabilities. China's humiliating defeat by the British in the first Opium War ushered in a period of economic and political turmoil, including the outbreak of the Taiping Rebellion (1850-1864) and the second Opium War (1856-1860), which finally culminated in the collapse of the Qing state in the early 20th century. The High Qing 18th century was a prosperous period, especially the years of the emperor Qianlong (1736-1795). There were innovations in farm management and production technologies that enabled long-term growth in agricultural productivity, rural income and peasants' living standard (Hung, 2008; Li, 1998). Long distance trade flourished during the period (Wang, 1992). Increasing commercialization, urbanization and mobility was driven by population growth and political stability, which helped produce a society that was more differentiated, more integrated, more competitive and more complex than in the past (Naquin and Rawski, 1987).

Such economic development and prosperity trigger the question: why was China in the 18th century unable to take advantage of its thriving commercialization to modernize its economy through an Industrial Revolution? This is a broad question with at least three inter-related issues related to how an autocratic, managerial and interventionist state handled a) economic policies and economic development (Sng, 2014), b) institutions for the protection of property rights (Landes, 2006; North and Weingast, 1989), and c) the regulation of merchants (Dunstan, 2006). This thesis will explore all three channels through analysing empirically the determinants and extent of the grain market integration between 1740 and 1820, and discuss the role of the interaction between merchants and centralized political structures for the evolution of markets in pre-modern China.

A fundamental aspect of the Qing state is its unified political system. With the emperor at the centre of the unity state in Beijing, the central state relied on local officials at the provincial and sub-provincial level to implement its policies through a hierarchy of four administrative layers: the emperor, the governor-generals and governors (provincial level), the prefects (prefectural level), and the magistrates (county level). In this order, governors were the middlemen between local and central government, and between military and civilian authority (Guy, 2010). Shiue (2004) uses a principal-agent framework to explain that the principal (i.e. emperor and his central state in Beijing) lacked sufficient information to monitor the agent (i.e. local administrators). As a consequence, local governments may allocate public resources at their discretion and priority. Ma (2011) uses a similar principal-agent model but with three major actors: the emperor, the local officials and the people. Although an absolutist regime may move towards a path leading to low-taxation, high stability and extensive growth, Ma argues its centralized and hierarchical political structure would produce information asymmetry and incentive misalignment among the three actors. Consequently, the regime's fiscal and financial capacity was limited, which weakened capacity for institutional changes conducive to modern growth. These arguments imply that the understanding of China's institutional evolution may offer a deeper insight about why Qing China's commercial prosperity could not be transformed into modern economic growth (e.g., an industrial revolution) than other explanations, such as culture and geography.

Despite Qing China's prosperity, a widespread view is that the Song Dynasty – and the later period Southern Song Dynasty – was the most advanced dynasty with the best potential for an industrial take off (Lin. 1995). Elvin (1973) conceived the

Song achievements as a medieval economic revolution. Others have challenged such claims, such as Li (2000a), who argued that the cited high crop yields in the Southern Song period were based on biased and selective evidence. The cultivation of the rice, the diffusion of new agricultural tools and best practices, and the intensification of agriculture might have appeared in the Song Dynasty, but the adoption of the innovations were only diffused during the Ming and Qing dynasties (Ma, 2004).

2.2.2 Great Divergence

China and Europe were comparable in agriculture productivity, population dynamics, handicraft industry, and levels of income and consumption in the 18th century, but they experience divergent developmental paths in the 19th century. The Great Divergence is the process by which the Western Europe overcame pre-modern growth constraints to enable a sustained improvement in per capita standard of living. It is a contentious issue in economic history.

The Great Divergence attracts attention because it inspires one general but important question: what triggers the emergence of modern economic growth. In the 1990s the Eurocentric view of modern economic development was challenged by the California school revisionists, which included Andre Gunder Frank, James Z. Lee, Bozhong Li, R. Bin Wong and most well-known, Kenneth Pomeranz. Pomeranz and others argued that China’s most advanced region (the Lower Yangtze Region) and the most advanced regions of Europe (England) had institutional frameworks and demographic patterns that were equally favorable to growth. Similar trajectories of economic evolution, including comparable farming productivity, produced average standards of living that were roughly common; China might even have been ahead of Europe (Allen, 2009; Li, 2000a, Pomeranz, 2000). One key claim in Pomeranz (2000) is that it is difficult to identify any internal, socio-economic causes of or dispositions towards growth in the Britain, which did not equally apply to China.

Contrary to Pomeranz (2000), Brenner and Isett (2002) argue that between 1500 and 1750 the Lower Yangtze Region and England may have already had divergent developmental paths. While the peasant-based economy in the Lower Yangtze Region was descending into a Malthusian crisis, the capitalist economy of England had entered into self-sustaining growth. Broadberry and Gupta (2006) have shown that living standards in China were far lower than those of north-western Europe. Several studies have shown that by the start of the 19th century there was already a large gap between England and China in real wages and other measures of the standard of living, though the standard of living was comparable to southern Europe (Allen 2011 *et al.*; Baten 2010 *et al.*).

2.3 Main Hypotheses of the Great Divergence

Many different hypotheses intertwined to interpret the Great Divergence, but no single factor would have been enough on its own. All the hypotheses agree that (political and market) institutions are in one way or another essential for development, but their views differ on the specific mechanisms being linked.

2.3.1 Non-institution Hypotheses

Culture

Cultural factors are a popular explanation used to explain the divergence between China and Europe. The best known is Max Weber's association of Christianity with European economic prosperity in his famous work *The Protestant Ethic and the Spirit of Capitalism*. It argued that religious factors were crucial for spurring European economic growth. Weber's view centered on the subtle link between the teaching of Calvin and the Puritans, which encouraged savings, investments, and the relentless pursuit of profit with the unintentional consequences of capitalist behavior (Bai and Kung, 2013). Elvin (1973) mentions that an intellectual paradigm shift from Taoism to Confucianism in China moved the focus from natural science and mathematics fostered under Taoism to studies of morality and social philosophy under Confucianism, which changed the intellectual climate for scientific research. The role of the Protestant Christian churches in Europe was custodian of knowledge and school for technicians (Landes, 2006). On the other hand, the Confucianist orthodoxy upheld in China impelled the officials and gentry leaders to exercise paternalist, benevolent leadership and attention to their subjects' well-being (Hung, 2008).

Different religions predetermine different evolution of social cooperation, in Weber's and other culturalist's schema, which leads to different institutional evolution. China's predominated Confucianism considers moral obligations among kin as the basis of social order but Europe's Christianity discouraged practices that sustain kinship groups, such as adoption, polygamy, concubinage, marriage among distant kin, and marriage without the woman's consent (Greif and Tabellini, 2010). Cultural distinctions eventually determined modes of economic growth through shaping institutions.

Geography, Natural Resource and Colonialism

Advocates of "geography hypothesis" argue that time-invariant geographic factors such as ecology, climate, natural endowments, and the disease environment, are the primary drivers of long-run economic development. This view has been emphasized by a number of empirical studies that highlight the correlations between geographic characteristics and economic development, such as the climate (Kamarck, 1976), the disease environment (Sachs *et al.*, 2001; Sachs and Malaney, 2002), natural openness (Rappaport and Sachs, 2003), factor and resource endowments (Engerman and Sokoloff, 2000; Sachs and Warner, 2001). This literature mostly focuses on the countries in the America, Africa and the tropical zones.

Some historians looked to geographical explanations for the Great Divergence. Diamond (1997) suggests that environmental factors of particular geographies played a crucial role in the European take-off. Diamond argues that Europe was uniquely endowed with domesticable plants and animals such that the population was also more immune to diseases. These factors led to higher productivity and, crucially, higher population density, which eventually led to the development of institutions (e.g. cities, bureaucracies), and contributed to economic growth. Europeans' higher resistance to bacteria and virus also accelerated its colonialism since the germs they carried killed large number of native populations, particularly in the Americas and Australia. However, Clark's (2008) explanation is the opposite: the better-off segment of the population became steadily more competent and productive over successive generations because disease picked off Britain's poorer residents. Despite their unconformity, both of their hypotheses agree that geography pre-determined the long-run economic consequence through institutions.

Diamond (1997) also used the geographical characteristics to explain why China evolved into a centralized social organization but Europe was fragmented. First, China's geographical connectedness made it too easily unified under stultifying dictatorships, whereas Europe had just the right amount of geographical fragmentation to keep power divided.[2] Second, Chinese civilization over the past 2000 years was built increasingly on the irrigated agriculture. The establishment of a central social organization and hierarchy, founded upon the construction and maintenance of irrigation. European civilization, on the other hand, was founded upon the domestication of rainfall-dependent crops – wheat and barley, which will grow anywhere, as long as it rains for part of the year. This allowed farming communities, villages, towns and eventually cities to emerge autonomously in Europe. There was never any need for a central authority to control irrigation across the continent. Distinct political system shaped by geography determines dissimilar institutional evolution thereby lead to different economic mode.

[2] China is enclosed by a ring of insurmountable geographic obstacles – the ocean to the east, desert to the north, mountains to the south and sparsely populated desert and steppe regions beyond an enormous, man-made wall to the west. On the other hand, Europe was geographically segmented, ,with four mountain ranges, five peninsulas, dozens of rivers, islands, and proximity to the coast of north Africa (Diamond, 1997).

In Pomeranz (2000), access to natural resources pre-determined the Great Divergence. China was locked into a development path of ecologically efficient but highly labor-intensive agriculture and proto-industry, which offered limited room to shift labour into manufacturing for per capita growth. Pomeranz argues that Britain was able to break this limitation and evolve along an energy-intensive ecological trajectory because of the lucky geographical accident of its ready access to coal. However, Brenner and Isett (2002) and Huang (2002) argue that Pomeranz is too optimistic about China's resource constraints and over-estimates China's economic prosperity. Pomeranz (2000) considers the Middle Yangtze households' allocating female labour to domestic proto-industry in the 19th century was a sign of growing prosperity, while for Brenner and Isett (2002) and Huang (2002) it was an unavoidable response to downward pressures on living standards resulting from the decreasing returns to labour in agriculture. Huang (2002) criticized Pomeranz for failing to grasp the distinction between land productivity and labour productivity and between labour intensification per unit of land and capitalization per unit of labour, which he says lead Pomeranz to glide over China's agricultural stagnation after the 18th century.

Pomeranz also argues Britain obtained huge natural resource windfall from the discovery of the New World. Centuries of European colonialism following the 1492 landing of Christopher Columbus in America enabled Europe to pull in raw materials, bullion and labour resources, which had the effect of holding back the rest of the world. Blaut (1993) argues the rise of Europe for the 15th century stemmed directly from the wealth. Europeans acquired from colonizing on America, first in acquiring vast quantities of gold and silver, and later from the slave plantations and other colonial enterprises. This immense wealth inflow gave the Western European merchant community the power to seize political control over sizeable territories through buying off the landlord class, which in England eventually lead to the "Glorious Revolution" of 1688 that ushered in a raft of institutions innovations central to Britain's rise. However, although colonialism may explain the rise of Europe, it cannot explain why China's merchants have no interest on maritime trade even though China's maritime navigation technology was much advanced.[3]

2.3.2 Institution Hypotheses

Instead of culture, weather, geography or right policies, Acemoglu and Robinson (2012) argue that man-made political and economic institutions underlie economic success. Different patterns of institutions are deeply rooted in the past and they tend to persist with enduring influence on later socioeconomic organisation.

<u>Technology</u>

One key to the Industrial Revolution is interpreting the technological advance in the Europe. Mokyr (1990) articulated the view that the industrial revolution was the culmination of a millennium of technological creativity.[4] The historical evidence suggests that the watershed between the Malthusian and Post-Malthusian Regimes is

[3] Between 1405 and 1433, the Ming government sponsored seven naval expeditions. Zheng He was placed as the admiral in control of the huge fleet, and he commanded these seven expeditionary voyages to Southeast Asia, South Asia, the Middle East and East Africa.

[4] The debate about the causality between innovation and industrial revolution is still ongoing but ambiguous (Zhao, 2009).

the acceleration in the pace of technological progress (Galor and Weil, 2000). Before 1820s, the income differential between today's rich countries and poor countries existed but comparatively small. After 1820s, the rich countries have grown faster, and the divergence has increased. The immediate cause of this divergence was that the rich countries have invented and adopted technologies to raise labour productivity enormously (Allen, 2012; Clark and Feenstra, 2003). Prior to 1760 the average rate of efficiency[5] advance through technological change in the world through millennia was almost zero, whereas efficiency growth rates in England 1760-1860 was sustained as 0.5% per year for over 100 years (Clark, 2010). China's pre-modern achievements in science and technology were remarkable as documented in the monumental works of Joseph Needham and his collaborators (Lin, 1995). One famous questions asked by Needham in 1940s, which is well known as "The Needham Question", which asks why was China overtaken by the West despite its earlier successes in science and technology. This question foreshadowed the Great Divergence debate by several decades.

Landes (2006) attributes the absence of technical progress in China to the lack of free market and institutionalized property rights. The Chinese state was always stepping in to interfere with private enterprise by a desire to reserve labour to agriculture for stabilizing the agricultural output or to control important resources for fiscal expansion, such as salt and iron. Shiue and Keller (2007) argue that China failed to industrialization may due to its lack of institutions supporting technical progress rather than market institutions. However, the Malthusian model also implies that countries with superior technology will have denser populations. How to explain

[5] Clark (2010) constructs the economic efficiency index as the geometric weighted average of the real rental of capital, the real price of labor and the real rental of land.

China's high population density even though its technology was backward? Kremer (1993)'s endogenous growth model even suggests that high population spurs on technological progress.[6] China's high population combined with low industrial technology implies that pre-industrial China's technology investment only focused on the innovation in agriculture to sustain its dramatic population. Needham (1969, p211) believed that because Chinese bureaucratic system emphasized agricultural production and discriminated against merchants and artisans, it failed to combine its craftsmen's technology with scholar's mathematical and logical inference method. The pre-modern China's sophisticated agricultural only allowed high population growth but failed to raise the living standard above subsistence (Lucas, 1999).

Elvin's (1973) "high-level equilibrium trap" further explains why China's large population cannot motivate modern industrial technology to escape Malthusian trap: China's rapid population growth and limited amount of cultivated land implies that China's labour became increasingly cheap and capital increasingly expensive, which consequently reduces the demand of labour-saving technology. However, China was able to maintain high output through increase labour inputs from its expanding population. Yao (2003) used a dynamic general equilibrium model to show that Elvin's hypothesis requires two specific assumptions: all the surplus labour will be absorbed into agriculture, and the industry allows for increasing return to scale. Lin (1995, 2008) challenges Elvin's hypothesis. He focuses on the supply side. His arguments are that China's imperial civil service examination and the criteria of bureaucratic promotion distracted the attention of intellectuals from investing in the form of the human capital necessary for modern scientific research.

[6] Kermer (1993)'s theoretical conclusion bases on the assumption that each person's chance of inventing something is independent of population,

By way of contrast, institutions supporting technological innovation were encouraged in Europe for the most part. The development of "open science" in the 16th century helped with the spread of economically useful ideas (Mokyr, 1990) while the development of European institutions to protect property rights in knowledge created a market for new ideas and inventions, which supported modern industrial growth (North and Thomas, 1973). The military competition within Europe also pushed the gunpowder technology, which eventually allowed them to extend the conquests and create colonial empires in the world (Hoffman, 2012).

Property Right Institutions

There is widespread consensus among economists and political scientists that "property right institutions" are a primary determinant of economic performance. These institutions protect individuals from theft or expropriation of assets, innovations and ideas by the government or elites, which otherwise would undermine investment and negatively impact on the long-run economic development. The seminal works of North and Thomas (1973), North and Weingast (1989) and North (1981, 1990) emphasize the importance of private property institutions for long-term economic development. Recent empirical work has brought out the many ways institutions affect social and economic outcomes (Acemoglu *et al.* 2001, 2002, 2004, 2005; Banerjee and Iyer, 2005; Dell, 2008; and Fang and Zhao, 2011). Adam Smith and many economists since had the view the proper function of the state was to establish clear and secure property rights, which would best promote economic growth, and not otherwise intervene in economic growth.

Since China and Europe have evolved distinct social structures to sustain cooperation, they rely on different combination of formal and informal enforcement institutions (Dincecco and Onorato, 2013; Greif and Tabellini, 2010; Rosenthal and Wong, 2011). Under the unified political monarchy, China had little inner political competition, few transit taxes, relatively free private sector, and was rich for a long time in the past (Ma, 2012). In contrast, Europe with multiple polities bear the costs of war time, and even in peacetime these regions suffered distortions to trade. Although political integrated China gave a quasi-free-trade zone the size of Europe, Europe's fragmented polity was more supportive for the development of formal property right institutions. Informal contract arrangements were more typically used by Chinese, whereas Europeans relied more on formal property protection institutions to enforce contracts.

Western propertied and wealthy elites had direct access to political power through political representation in parliaments (van Zanden, *et al.*, 2012; Ma, 2011). From the collapse of Roman Empire, political fragmentation in Europe resulted in unceasing instability and warfare among the local lords, which at the same time led to power intensification at the local level. The political power was further decentralized by the wrestling of power between the king and church, which gave the feudal lords chances to acquire independent coercive power and allowed the development of autonomous towns (Tan, 2013). The fragmented polity and high reliance on commercial tax for military expenditure in medieval Europe favoured the merchants' political bargaining power to protect their commercial properties. The substantial increased wealth from the Atlantic Ocean and trade with the New World also strengthened merchant groups in Western Europe by constraining the power of the monarchy (Acemoglu *et al.*, 2005). Strong representation of commercial or property interest in city-states or federation of city-states combined with the warfare mobilization led to the rise of capital-intensive path, which accelerated the development of property right protection.

Contrasted with Europe, China's political centralization and stability led to the rise of coercion-intensive path, which subdued the interest of the commercial elites (Tan, 2013). China's wealthy elites had limited power to bargain politically with the emperor although they had access to large markets. The reproduction of the entrepreneurial elite was constrained by the state's paternalist disposition in managing urban class conflict (Hung, 2008). Compared with Europe, China's tax collection relied more on the local officials selected by bureaucratic competition rather than the local elite social member. Instead of commercial tax in Europe, China's fiscal system was centred on the taxation of private-own land. On the other hand, the centralized imperial state had monopolised production and trade of staple commodities such as salt, iron and tea, which were immense sources for fiscal revenues. China's emperors were restrained mainly by two concerns: the Confucian moral obligation of caring for the people and the fear of peasant rebellions (Tan, 2013). Their primary concern with commerce was market regulation rather than market revenue, and they don't have a need to establish the formal property right institutions.

According to Acemoglu and Johnson (2005), contracting institutions like informal contract enforcement regulated private transactions between citizens while property rights institutions regulated the relationship between ordinary private citizens and the political power holders. Property rights institutions were more important contracting institutions on for long-run economic growth since only they could provide significant checks against state expropriation. This comparison may explain why pre-modern China's informal contract enforcement could sustain its commercial cooperation and prosperity but was unable subsequently to trigger institutional change that favoured the long-run economic growth.

2.4 Market Performance and Institutions

2.4.1 Market Performance

Adam Smith articulated the importance of the state-protection of property rights for successful market-based economic development.

Commerce and manufactures can seldom flourish long in any state which does not enjoy a regular administration of justice, in which the people do not feel themselves secure in the procession of their property, in which the faith of contracts is not supported by law, and in which the authority of the state is not supposed to be regularly employed in enforcing the payment of debts from all those who are able to pay.

Market efficiency determines the long-run economic performance (Isham and Kaufmann, 1999; Rodrik *et al.*, 2004). Following the Smithian arguments, when markets expand, increased labour specialization will follow, which will increase the efficiency of resource re-allocation and cause output to rise. The historical process of European economic growth is marked by ever-expanding exchange relations, which shed light on the nature and evolution of modern institutions (Greif, 1993). The contribution of European states is to supply the formal framework that reduces certain types of risks that merchants encounter in the trade activities. One influential view to explain why Western Europe industrialized first holds that its exceptionally well-functioning markets provided the incentives to invest into the industry.

A well-functioning market is supposed to be supported with a set of institution (e.g. non-distortionary pricing systems, common law, and property rights) that would lead to more efficient resource re-allocation and provide far greater incentives to make investment (North and Weingast, 1989; North, 1981; North and Thomas, 1973). Consequently, market integration is an indicator for assessment of the quality of institutions. All the Great Divergence hypotheses agree that institutions are the final determinants of economic growth, and what varied were which mechanisms dominantly shape the institutions. Although it is difficult to disentangle empirically these varied different mechanisms, their combined impact would be reflected by market performance.

In contrast to the traditional view that the Qing state was hostile to mercantile activities and commercial growth because of Confucianism, Qing Dynasty was one of the most pro-commercial regimes in imperial Chinese history (Perkins, 1967; Rowe, 1993). In the 18th century, China's domestic commercial taxes were deliberately kept minimal, and China's merchants regulated their own local markets largely. While European commerce trade was regulated by state-supported property rights regimes, China's commercial expansion in Ming and Qing dynasty were governed by informal rules in the form of family bylaws, lineage rules and guild regulations that overcame the commitment problem (Ma, 2004; Wong, 2004). An important difference in commercial practices may have lessened the need for the formal contract enforcement in Imperial China. In long distance trade, the Chinese merchants bought goods from a local broker, shipped those goods in person, and sold the goods in another area to a local broker acting as middleman for local retail shops (Wong, 2004). Chinese merchants travelled with their goods over the entire journey. European merchants, by way of contrast, often entrusted their goods to others and waited for payment, and thus needed to enforce contracts at a distance. Chinese merchants therefore had less need for formal mechanisms to enforce their contracts at arm's length. But they had the additional cost of accompanying their goods over long distance.

The empirical finding of Shiue and Keller (2007) suggests that the performance of markets in China and Western Europe was overall comparable on the eve of the Industrial Revolution. This leads them to conclude that market performance is not sufficient for industrialization. Since China did not evolve the formal property right institutions, Shiue and Keller's results also imply that the formal property right institutions are not necessary for market performance. In another word, informal contract enforcement is substitutable for formal property right institutions at least in terms of market efficiency.

2.4.2 Did China's market matter?

Despite that the findings of past empirical literature show that Qing China's markets were "integrated" and "effective", it is too early to conclude that Qing China possessed "proper" markets needed by the modern economic growth because its institutions did not satisfy the requirements of "well-functioning market". With respect to Shiue and Keller's (2007) definition of market function, effective markets would provide sufficient investment for manufacturing and other non-farming activities, and thereby lead to industrialization. This definition implies two specific pre-conditions: 1) investors have the incentives to invest; 2) investors are able to collect sufficient investment. Both of these two conditions are violated by China's institutions.

China's persistent highly centralized polity combined with its developed informal enforcement institutions determined that formal property right institutions could not take root in China. While the Qing China established legal code was elaborate and comprehensiveness, China's law was not sufficient to enforce formal property protection in trade. Under the unified political monarchy, there were no independent power structures such as city-states or autonomous corporate bodies. The priority of the Qing code was to stabilize the social order rather than protecting private interests. The Qing state failed to develop the legal infrastructure to sustain formal contracting while the extended households and lineages had little demand for them (Rosenthal and Wong, 2011). The decision rules were designed only for the bureaucrats to meter out punishments proportionate to the extent of criminal violations (Ma, 2006). Under this legal environment, the incentives for merchants to invest were depressed since they were exposed to the risk of official intervention and expropriation.

In the 18th century, Qing China's financial development was not developed, which determined that it would be quite costly to collect sufficient investment from the credit market. By contrast, in Europe, the sharp increase in government borrowing to sustain state military expenditure and a substantial increase in the perceived “credible commitment” accelerated the development of financial markets. Coffman *et al.* (2013) suggests that many of the supposed benefits of political institutions during the industrialization were more properly the result of financial innovation.[7] China’s formal credit markets were less developed than European ones. Due to the political integration and lower frequency of war, China’s demand for credit was lower for both political and economic reasons than European demand despite comparable levels of economic development. The strong incentive for credit from China’s central state only occurred when the regimes were tottering, but under such dire circumstances few would have been willing to lend. As a consequence, there was no need for central state to progress the credit-market infrastructure. On the side of merchants, since capital volume was not large per trip[8], credit demand was met by informal network within clan or business forms.

With the absence of property rights protection as well as developed financial markets, China’s merchants shifted their investment into the official titles to protect their properties through bureaucratic hierarchy, or into the land to avoid the risk. Insecure property rights and the lack of formal political protection produced that land was the only suitable wealthholding for long-term investment (Brandt *et al.*, 2014).The absence of well-functioning market could also explain why China lacked investment in technology innovation in manufacturing, and why China’s merchants were unable to expand the oceanic commerce. Regardless of the effects of internal peace and the developed informal merchant network on commercial prosperity, China’s centralized polity constrained the scale of transition and commercial

[7] Coffman *et al.* (2013) argue that many institutions became weaker and the state became more extractive and rent-seeking to fund growing military spending after the Glorious Revolution.
[8] In the 18th century, most of China’s commodities were with low value per volume or weight (Wong, 2004).

development. A long-term view of economic growth suggests that informal institutions are not substitutable for formal property right institutions. China's political integration was not transformed into a corresponding market integration, which will be shown in my empirical analysis of grain trade market efficiency in Chapter 4 and 5.

2.5 Qing China's Grain Trade

Agriculture was the largest sector in preindustrial economies such as Qing China. Food grains were unsurprisingly the most important commodities in domestic trade. Grain output is estimated to account for 39%-45% of Qing China's gross domestic product (Peng, 2006). In the 18^{th} century, many rice cultivators were producing for the market and the marketing system effectively responded to the pressures of supply and demand over a vast territory (Eastman, 1988). Mark (1991) estimates that some 20%-28% of the rice produced entered the market in Guangdong Province. Basing on the dramatic historical evidence reflecting the grain trade prosperity, many historians and economic historians suggest that Qing China had a very large-scale integrated domestic grain market.

2.5.1 Food Security and State-Interventions

A famine is a widespread scarcity of food, which is usually accompanied or followed by regional malnutrition, starvation, epidemic and increased mortality, and was a chief concern of authorities. In pre-modern China, the failure to feed the population, civil officials, and military supporters is a visible sign of a dynasty's inadequacy and leads to political unrest. China's official granary system for famine relief started since the Han Dynasty (BCE202- CE220), which has been maintained and developed by each dynasty until its peak in the final dynasty- Qing Dynasty. The Qing state had varied measures at its disposal to deal with the food security: direct control of supply, indirect controls over marketing, reduced-price sales, policing of supplies, and direct relief (Li and Dray-Novey, 1999). Since the 17th century, the Qing State set up and maintained a national-wide reserve granary system, which became the material cornerstone of all its food security policies. The granaries were managed by local officials and primarily served local residents but the storage target was set by the central state.

There were three types of civilian granaries, the ever-normal granary (changping cang, 68% of total grain storage), the charity granary (yicang, 10% of total grain storage), and the community (shecang, 14% of total grain storage) granary.[9] Granaries primarily served to provide food relief in the event of harvest shortages and secondly to help smooth intra-annual price fluctuations through release of grain at various times in the grain growing and harvest cycle.[10] The ever-normal granaries were manage by the local government and served for local residents primarily. The charity and community granaries were relatively minor in size compared to the ever-normal granaries (Shiue, 2004; Wang, 1992). Of these three types of granaries, the ever-normal were the largest and most important, and with

[9] These storage share figures were estimated by Liu (1980) for the grain storage in Guangxi Province in 1800.
[10] One additional function of the granaries is to lend the grain to the farmers as seed.

documentation on them more complete (Marks and Chen, 1995; Liu, 1980).[11] Regularly, the local officials would follow the market price to buy the grain in the autumn (autumn harvest would decrease the market price), and sell them at the market price in spring (spring grain shortage would increase the price). Reduced-price sale would be implemented in case of extreme famine.

Although it is striking to compare the Qing state grain stock in the 18th century with the other countries, its total volume of granary storage was not large compared with the total grain consumption. In Guangdong and Guangxi Provinces, the official capacity of the granaries were 3.5 and 1.8 million *shi* (1 *shi* = about 84 *kg*) of paddy respectively, or about 7% and 8% of the estimated annual production (Marks, 1991). However, the actual stocks varied and never reached the official quotas. In some extremely situation, the local authorities had to purchase the grain from the grain surplus regions to maintain sufficient reserves in the granaries. Shiue (2004) estimates that in the 1750s the annual averaged civilian stocks were roughly about 3% of the consumption of an adult per year, meanwhile about 8% of national grain consumption was supplied via trade grain (Shiue and Keller, 2007). Liu (1980) estimates the civilian storage per capita was about 6.25% of adult consumption per year in Sichuan Province, but the national storage was only sufficient to support the whole population for 16.5 days. These rough estimated figures show that the volume of grain trade was much larger than the volume of grain stock. According to the annual provincial grain stock reports in Will and Wong (1991), the 18th-19th century

[11] In the period 1694-1877, the Qing state has authorized 97 times of irregular grain sale for local famine, of which 63 times used the grain from the local ever-normal granaries while the rest used the grain moved (or bought) from the other regions (Liu, 1980).

witnessed the decline of both the grain stocks and per capita grain stock, which paralleled the overall decline of the Qing Dynasty (in Figure 2.1).

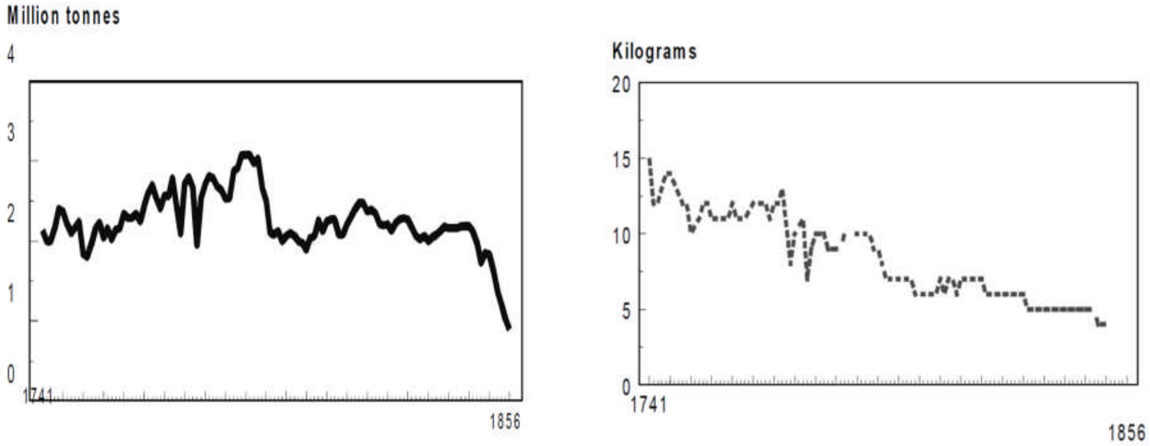
2.5.2 Grain Market Development

Between 1750 and 1913, China's population increased from 200-250 million to 430 million while the land acreage increased by 43% (Perkins, 1969). Unsurprisingly, a large aggregate demand for food ensured, which spurred the progress of agricultural productivity. Agricultural development was also stimulated by government policies that encourage improvements in seeds and irrigation and promoted cash crops (Naquin and Rawski, 1987). Pragmatic changes in cropping[12] were important for raising agricultural output such that there was sufficient grain to support this huge population size.

[12] "The southward migration of northern dryland crops such as wheat, the extension of rice cultivation to newly irrigated lands, the gradual increase in double cropping of rice in the south, and particularly the double cropping of winter wheat or barley with summer millet or rice all slowly but significantly increased output" (Naquin and Rawski, 1987, p23). On the other hand, the planting of American food (e.g. sweet potato and maize) dramatically expanded the marginal land output, which also caused land expansion on hilly land.

Figure 2.1 Grain Stocks and Per Capital Grain Stocks in Qing Dynasty (1741-1856)

(a) Annual Grain Stocks (b) Annual Per Capita Grain Stocks



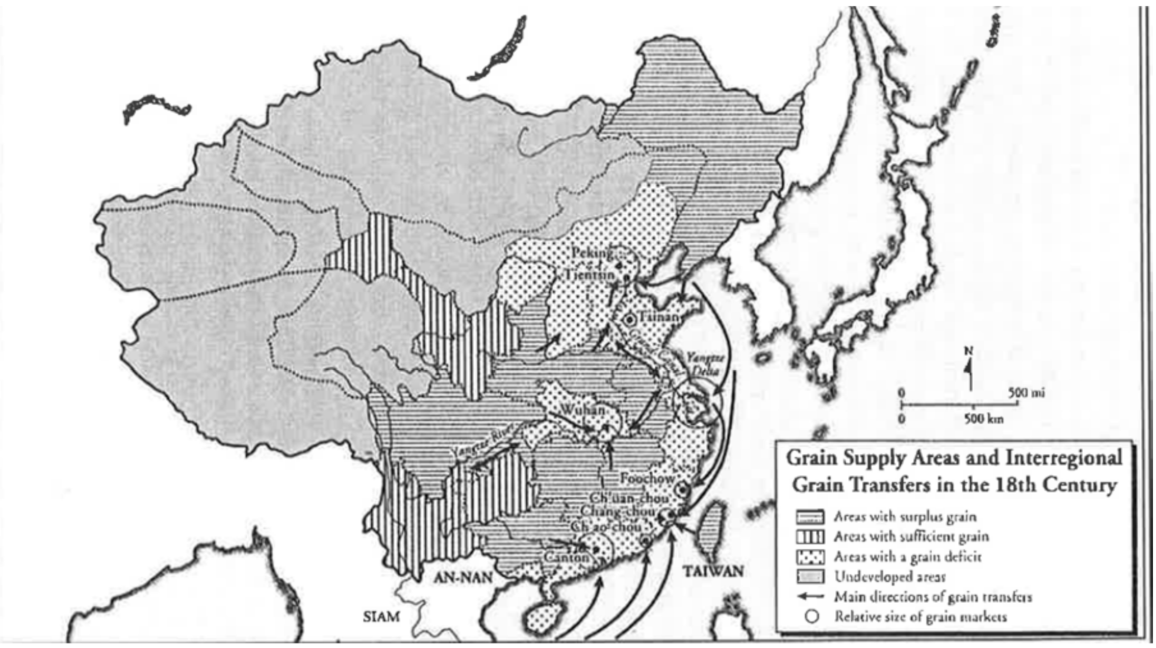
Source: Will and Wong (1991), Crook(1999)[13]

Since the 18th century, the condition of grain surplus was differed substantially across areas (see Figure 2.2). Due to the serious regional food shortage (especially in the Lower Yangtze region), Chinese emperors and his officials faced huge challenge of food security, especially in terms of maintaining stability, which forced the state to implement sufficient flexible policies to partially free the grain market from the state monopoly management during the Qianlong era (1735- 1799). Being different from his previous emperors, Qianlong was very cautious about state intervention in trade. In one debate of state grain policy in 1748, his perspective is that "with the affairs of the market-place, for the most part one should *let the people carry out the circulation for themselves*. If once the government begins to manage it, what was originally intended to be beneficial to the people will, with unsatisfactory

[13] The annual per capital grain stocks came from Crook (1999). Since there is no annual population data in the given period, it is possible that Crook uses the provided population in some specific years (e.g. 1776, 1820) to estimate the yearly population for yearly per capita grain stocks estimation.

implementation, turn out full of hindrances" (Naquin and Rawski, 1987, p26). To smooth price shocks and food-supply fluctuations across different regions, Qing central government permitted and encouraged the private merchants (i.e. local petty traders, brokers, wholesale dealers, and itinerant merchants) to trade grain, especially for the long-distance grain arbitrage. The market itself could be used to ensure that grain would be moved from grain surplus areas to deficit areas with high prices.

Figure 2.2 Grain Supply and Grain Demand Areas



Source: Wang (1992)

The increasing volume of grain demand motivated the prosperity of long-distance grain trade, especially between Upper and Middle Yangtze region (e.g., grain surplus areas) and Lower Yangtze region (e.g., grain deficit areas) by water transport (mainly on the Yangtze River). The annual trade grain volume in China was about 2.6 million tons during the 18-19th centuries – about 30 million shi[14] that were largely moved on waterways (Fang Xing *et al.*, 2000). To stabilize the grain prices and provide security in food crises, the Qing State established state-granaries in most of the counties to hold grain buffer stocks. During the years 1764-66 a survey of state, community and charity granaries reported 40.6 million shi of unhusked grain in storage, of which 30 million were held by the state (Chuan and Kraus, 1975, p.33). Since one-third of the stored grain needed to be turned over – sold – to prevent spoilage, the state had about 10-14 million *shi* available for price stabilisation, which is equivalent to 5-7 million *shi* of milled rice or wheat (Chuan and Kraus, 1975, p.35). As a consequence the Qing state was a major participant in the grain markets. Borne on the research of rice market in the early 18th century in Chuan and Kraus (1975), Eastman (1988) concludes that a large number of rice cultivators were producing for the market, and the marketing system succeeded in collecting large amounts of grain and in responding to the pressure of supply and demand over a vast territory.

Grain was not the only commodity in the long-distance trade. Although the fraction of trade grain varied both across regions and over time, the merchants frequently carried some other goods (e.g. cotton and cotton fabrics, silk and silk fabrics, tea and salt) exchanged by grain on the return trip. With the boom of grain trade, the grain import regions (e.g Lower Yangtze region) increasingly concentrated on producing high value-added products such as silk and cotton textiles, while the grain export regions (e.g. Upper and Middle Yangtze region) were transformed into

[14] The shi was a measure of volume for grain (1 shi = 103.6 liters), which was equivalent to 175-195 pounds (79.4-88.5 kg) of milled rice; many calculations assume a mid-range value of 185 pounds. Confusingly, retail purchases were in volume measures while trade was recorded in weight; the shi was often used interchangeably with dan, a measure of weight. See Chuan and Kraus (1975).

peripheral zones to support the development of the more economically advanced regions by exporting foodstuffs and other raw materials (e.g. timber, silk cocoon and raw cotton). In general, one empire-wide market promoted the regional specialization in this process.

2.5.3 Trade-support Institutions

The Qing had established the preconditions for grain trade prosperity by imposing law and order, investing into public institutions and encouraging private institutions to support the grain trade. Not only was Qing State one major participant in the grain trade over long-distance, it also maintained the national transport routes with bureaucratic and finance support. As a response to the developing monopolization and collusion in the grain market, Qing China instituted one brokerage system in which brokers with government-licenses supervised payments between buyers and sellers, oversaw delivery, inspected the quality and quantity, and served as a guarantor on the exchange (Susan Mann, 1987). By turning to this extra-bureaucratic group, the Qing state had replaced direct state supervision and established a system appropriate. Historians agree the state had relatively weak control over brokers and the brokerage system (Lufrano, 2013).

Private trade institutions in Qing China were permitted by the government a broad range of discretionary powers, which were established and developed by guilds and self-governing organizations. Although Qing China's guilds primarily protect local merchants (Rowe, 1984), they provided lodging and services for merchants, standard of calculating profits and losses, bargaining techniques training, and information as well as an institutional framework for contract enforcement. Often, the weight and measurements for transaction, and the regulation of local market (e.g. the dates for market to be open, the dates for deliveries) were unified and imposed by guilds. Thus, grain trade has been regulated and encouraged by guilds. In Mid Qing, native banks entered into the market, which conducted local money exchange, accepted deposits, issued private banknotes, and lent money to merchants in the local market (Zhou, 2000). After the establishment of local private banks, some merchants entered the banking system as a means of capitalizing their commercial properties (Rowe, 1984).

2.5.4 Grain Trade Transportation

"China's transportation system was inconvenient, inefficient and costly….The term "road", when applied to the paths and tracks that constituted the land-transport network, was usually a misnomer (Eastman, 1988, p103)". It would be expected that market institutions and transportation would have been less efficient in the 18th than in the 20th century. Astonishingly, Chuan and Kraus (1975) find the seasonal variations in rice prices in the Yangtze delta region in the years 1713 to 1719 were smaller than they were in the years 1913 and 1919. It is worth to note that Yangtze delta region was the most developed area during the whole Qing Dynasty, which also includes Shanghai City. [15] It implies that, in the 18th century, the transportation system was efficient enough that transporting the commodities like rice was profitable.

[15] Shanghai was the most developed city in the early 20th century, which was favoured by modern banking because it is easy access to warehouse facilities, steam and rail transport.

Since the 11th century, the expansion of trade networks in China was accompanied by improved access to waterway transport (Liu, 2012). Domestic grain trade over long distance relied on waterways that connected numerous prefectures. In Pre-modern China, with technology limited, transport was far more economical and convenient by water than by land. Land transport was between 1.5 to 5.5 times as expensive as waterway transport, depending on the ease of navigation of the waterway (Shiue and Keller, 2007). Watson (1972) estimates that junks may have had a 9-10 fold cost advantage over the main forms of land transportation (i.e. human and animal carriage). Even in the early 20th century Buck (1937) found Chinese junks 2-5 times cheaper than man or animal power land transport. There are three main waterway trade routes (see Figure 2.3): the Yangzi River and its major tributaries, the Grand Canal and the Coast (Wang, 1992; Fan, 1993). Laurence Evans (1984, p278) estimates that the total national water trade routes contained about 30,000 miles of waterway navigable year-round by junk. In the Hunan Province during the Qing Dynasty, the 18th century commerce largely followed the province's river system (Wong and Perdue, 1992). On the other hand, the Qing government needed the Yangtze River and Canal to transport the particular needed "tribute grain" levied from the selected provinces in northern and central China annually to Beijing (i.e. national capital). The functions of grain tribute were provisioning the court, officials and bannermen as well as support the capital population.

Figure 2.3 Three Main Trade Rivers

Map 1.1. Grain Trade Routes in Qing China.

Source: Wang (1992)

The government officials transporting rice- primarily tribute grain to the Capital Beijing and food for soldiers- were involved in the long-distance grain transaction so that the maintenance of transport routes was devoted from state revenues as public projects. The Qing State created three large new provincial-level bureaucracies to take responsibility for the complex interprovincial grain traffic and waterway maintenance involving the Yellow River and the Grand Canal that linked it to the Yangtze River, of which Yellow River was devoted some 10% of national total revenues (Naquin and Rawski, 1987). This national transport network also served military purposes (e.g. army movement), which implies the importance for the Qing State to sustain the efficiency of its transport system. The imperial state had assumed responsibility to maintain this transport network, but it did not devote persistent attention to both the land and water routes excepting some “roads where

Customs' dues are collected" (Eastman, 1988). Rarely did the government undertake to repair the roads. Most water routes suffered the neglect[16] as the local magistrates which were assumed to maintain the waterway received no funds from the central government. In particular after 1820s, the Opium War (1839-42) and the Taiping Rebellion (1851-64) further deteriorated the Qing state's fiscal and administrative disarray, weakened its support for river control.

Although the 18th century witnessed how the water-system extended China's commerce prosperity, it also witnessed its decay under the multi-faceted ecological pressure (Rowe, 2011). Long period encroachment on lakeshores and riverbanks of the middle Yangtze watershed, stimulated by the growing demand of commercial rice, had rendered the downstream of Yangtze River (i.e. Yangtze region) a source of flooding. Hillside land suffered topsoil runoff and progressively declining fertility. In the end of 18th century, the failure of Yellow River maintenance led to silting up of the Grand Canal and increased the difficulty of shipping grain to the capital and North China.

2.5.5 Grain Trade: State or Merchant?

In the May edict of 1748, the emperor enunciated that "letting the people carry out the [grain] circulation for themselves" and stated that the best way to control prices was to "govern by non-governance" (Dunstan, 2006, p126). Some anti-interventionist policies were implemented by the central government since the

[16] Few river and lake routes benefited from regular dredging, removal of dangerous rocks, cleared towpaths, or channel markings.

mid-18th century: grain price ceilings were removed, and both public and private institutions such as the government-licensed brokerage system and self-governing guilds were officially supported for their participation in the grain trade (Dunstan, 2006; Mann, 1987; Shiue and Keller, 2007). How much could be trusted that high prices could draw sufficient supplies by merchants to reduce local prices to levels at which the majority of famine victims could afford the grain they needed? During the mid of 18th century, there was an intensive ever-normal granaries debate argument among the central state and these provincial chiefs about that whether state precautionary stockpiling was as superior to merchant management. Throughout the ever-normal granaries debate, most of the provincial chiefs showed *little* trust: the state would always have to supplement the market by maintaining stockpiles of grain to sell, lend, or give to poor consumers as necessary (Dunstan, 2006).

Since the role of state on grain trade intervention was paramount, Qing's statesmen theorists expressed serious reservation about the extent to which the state should intervene into the market (Dunstan, 1996). Influenced by the benevolent rule and paternalist protection rooted in the Confucianist conviction, the Qing state was lenient toward tenant peasants to protect their livelihood, but viewed merchants as being "rich but not benevolent" (Hung, 2008). Despite that redistributing grain surplus was primarily the task of merchants, the Qing state took severe actions against merchants hoarding grain on the assumption that grain speculation harmed public interest. The Qing state often rewarded merchants' contributions to secure the grain storage through low commercial taxes or low-interest government loans. On the other hand, some high ranking officials suggested that merchant hoards were accumulated in years provided valuable storage against future famine. However, during the food crisis, the government often enforced local grain merchants to sell their stocks at discounted prices. Actually, the reasons for the emperor to reduce the role of the state in grain management went beyond arguing for the efficiency of unrestrained market forces and further related to the distrust of public bureaucracy, the desire of local officials to lessen their responsibility for food security and the pressing fiscal demands generated by various military campaigns (Dunstan, 2006).

Under the hierarchical structure of unified political system, the Qing state's tax remissions and central disaster aid policies was prone to moral hazard problem on the granary management. The evidence that granary storage levels were systematically lower in provinces that received more frequent central state disaster relief suggests that the Qing central state lacked sufficient information to monitor its local officials which allows local governments to allocate resource over their self-insurance (Shiue, 2004). In a broad sense, Qing state policy favoured free circulation of grain surplus. However, preference for free circulation was far from being the same as a *laissez-faire* approach for grain trade. In the sense of the Qing state, free circulation means that no *self-interested* parties should be permitted to impede grain trade no matter whether by hoarding grain or imposing trade embargoes to maximize the official reserve. Qing state's "free circulation" required every grain trade participant should be selfless, which violates the stone of market mechanism, and strengths the necessity of bureaucratic intervention.

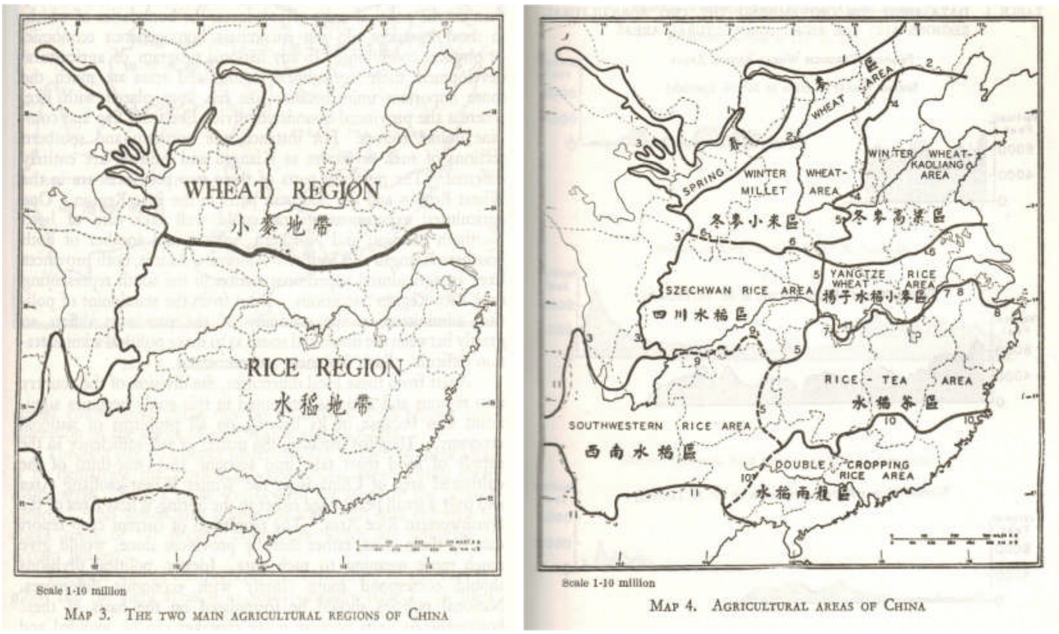
2.5.6 Southern Rice and Northern Wheat

In terms of geography China could be divided into two regions: South China and North China. "South China" and "North China" are traditionally defined as the regions separated by the Qinling Mountain and Huai River. North China is dominated by northern plains and dryland cropping, while South China favours wet-rice cultivation since it locates in the south of Huai River and the Qinling Mountain. Because of different tillage practices, agricultural implements and grain storage, rice and wheat are the main staple grain commodities for South and North China respectively (see Figure 2.4(a)). Rice and wheat differ in terms of cultivation, harvesting, transport cost and value added to trade cost ratio. Rice cultivation in Ming-Qing, including the soil preparing, harvesting, pumping water and collecting and transporting fertilizer, totally need 15 workday per mu (1*mu*=0.165*acre*), while wheat only required 3 days per mu (Allen, 2009; Li, 1998). Wheat has higher storage and transport cost than rice, so that rice was favoured for long-distance trade (Deng, 1995). The frequent large fluctuation in the size of harvest in North China reduces its grain yields and population density. On the contrary, the wet-rice cultivation system in South China is able to sustain high yields and support high population density.

Output of both agricultural commodities is sensitive to the climate (e.g. humidity, temperature). In a country of continental size such as China the soil and weather characteristics differed widely across regions, prescribing which crops could be grown in a particular region, the mix of crops, and the timing of harvests (See Figure 2.4 (b)). One survey in early 20th century counted 574 different rotation systems, and the earlier period was probably no different (Naquin and Rawski, 1987).

Figure 2.4 Agricultural Areas in China

(a) (b)



Source: Buck (1937)

2.6 Grain Prices and Market Integration

Since many economic historians regard the development of modern market institutions in the early modern period as one pre-condition for the industrial revolution and modern economic growth, they have extended their interest into market efficiency estimation. Fortunately, since the late Middle Ages, many European cities began to collect the price data for cereals as well as some other sensitive goods. In the 1930s, the foundation of the International Scientific Committee on Price History boosted and sponsored the publication of prices data with very high scientific standard. The grain price data availability combined with the interest in markets has spawned a huge literature on the grain market integration (Federico, 2011).

In Europe, as price data for cereals are much more abundant than for any other product, grain market is quite often implicitly assumed to be representative of the whole market. Was the grain market representative? In terms of definition, the relationship between grain market integration and market integration is ambiguous. Regions can be “economically integrated” in the sense that there are no border restrictions restricting the flow of goods, but not be integrated in terms of any specific market (Fackler and Goodwin, 2001). Federico (2010, 2011) questions the representativeness of grain market by three reasons: first, grain is the basic staple so that its market was more developed than others; second, the information cost for grain agents was low as cereals are more homogenous qualitatively than the manufacture goods; third, as cereals are bulky, grain market has always been intervened heavily by the authorities. However, Studer (2008, 2009) claim that grain is the most suitable good for assessing the course of commodity market integration as grain had a high bulk to value ratio so that the extent of grain markets reflected the transport capacities and cost.

Most of the empirical results show that the markets performed very well in Pre-modern Europe. Using the data of grain prices and yields for the years 1208 to 1500, Clark (2002) claims that England had an “elaborate market economy at least 500 years before it had sustained economic growth”. Persson (1999) uses the cointegration test to find that the reduction of transport cost was associated with an emerging integrated European wheat market in the 18th century. Federico (2007) examines market integration in Italy in the 19th century, and finds that waves of the market integration were mainly caused by improvements in market efficiency and a reduction in transport costs. Ejrnas and Persson (2000) show that French wheat markets were well integrated by the middle of the 19^{th} century. Using the asymmetric-threshold error-correction-mechanism model, Jacks (2005) investigates the course of intra- and international market integration in the 19th century of Atlantic economy, and his results indicate that Atlantic economy experienced dramatic improvements in market integration prior to the mid-19^{th} century. In the 19^{th} century of Europe, the level of domestic and international integration was determined for most of the period by war and political events (Federico, 2010). According to Studer (2009), the process of market integration in Europe was neither a concomitant nor an effect of the Industrial Revolution, but "indeed a plausible determinant for the rise of Europe".

Because of the grain price record of the authorities during the Qing Dynasty (1644-1911) in China, there is a sizeable history literature on China's grain market efficiency as well. It is hypothesized that there were well-established networks of long-distance grain trade in China, and the grain prices closely correspond to regional integrated markets (Chuan and Kraus, 1975; Perdue, 1992; Wu, 1985; Fan, 1993; Wang, 1989; Wong and Perdue, 1992). However, these beliefs above based more on narrative anecdote with data analysis of few price series. After the gradual opening of archive grain price data, an increasing empirical literature (Li, 2000b; Shiue, 2002; Shiue, 2004; Shiue and Keller, 2007; Keller and Shiue, 2007a, 2007b; Yan and Liu, 2011) suggest that Qing China's market efficiency has been underestimated, and water-transport played a dominated role in the grain market efficiency. Using conventional pairwise cointegration and novel heterogeneous panel unit root testing approaches, this thesis empirically argues about China's market efficiency on the eve of Western industrialization and challenge the traditional wisdom that China's market was well integrated.

Was the grain market representative for measuring the efficiency of markets in pre-modern China? In Qing China, although the state engaged and interrupted the grain trade, it was not able to dominate the grain market since its financial limitation. First, the official shipments of grain trade were only about 16.7% of China's total trade/shipments (Fang Xing *et al.*, 2000). Further, the decision of the Qing officials to engage in interregional grain trade was also influenced by market information: "Qing government officials both imitated merchant trade practices and followed trade routes long established by merchants" (Shiue and Keller, 2007, web appendix, p3). On the other hand, grain was not the only commodity in long-distance trade in China. Merchants frequently carried other goods to be exchanged for grain for the return trip. Since the primary purpose of the Qing State's grain market policy was to stabilize the grain price rather than to develop the market, it is ambiguous whether these grain market interventions had increased grain market efficiency or not: state grain trade for tribute and military purposes increased long-distance trade grain volumes as well as public transport infrastructure investment, but the state granary system encouraged local authorities to restrict inter-regional trade to maximize local grain stockpiling in case of extreme natural disasters. These arguments will be further developed in Chapter 4 later.

2.7 Conclusions

This chapter introduced the background to the empirical research in this thesis. In the 18th century, Qing China was at the height of its prosperity, politically stable and commercially thriving, with highly developed granary organizations and domestic inter-regional grain trade. However, this prosperity did not enable China retain its world economic status, and it was progressively eclipsed by Western Europe, which caught up and overtook it as a consequence of the long process of industrialization. The traditional wisdom holds the view that the market supporting institutions (such as formal property right institutions) sustained the ability of the market to reallocate resource, which eventually leads to the industrialization. Formal property right institutions could not take root in Imperial China since the political representation of merchant interests were repressed by the state, along with the prevalence of informal contract enforcement institutions. However, Shiue and Keller's (2007) finding suggests that the performance of markets in China and Western Europe were overall comparable on the eve of the Industrial Revolution. They conclude that "… [T]he constraints imposed by the state on economic incentives, which were in turn safeguarded by the development of "good" institutions in Europe, were apparently not binding in China". On the contrary, in Chapter 4 and 5 my results suggest that Qing China's market integration has been over-estimated, and experienced a process of disintegration and fragmentation following the Chinese political structure. Qing China may not have a well-functioning market like Western Europe during its history golden era. My results imply that we may need to reconsider the role of "good institutions" on the process of industrialization, and China failed to industrialize may due to its lack of well-functioning market.

Chapter 3
Data and Preliminary Analysis

3.1 Introduction

This thesis uses existing data on grain prices as well as detailed geographical information collected as part of the research, which I introduce in turn in the following. The grain data is collated from sources documenting the nationwide grain price system in the Qing Dynasty. This elaborate grain price reporting system was progressively implemented from the early years of the Qing, and became a formal system at the start of the reign of Emperor Qianlong (1736-1795). The system was based on monthly reports detailing the prevailing high and low prices for up to 20 commodities (not all grain were reported in every region) at the county level, which the provincial governor would aggregate to the prefecture level and convey in memorials to the emperor in Beijing monthly. These Qing price documents survive in archives in both Beijing and Taibei. I use a subset of these price data for rice and wheat compiled by the late Professor Wang Yejian [Yeh-Chien] and collaborators.[17]

Historians and economic historians have confirmed that the price data from this system is reliable and comparable across time and regions, providing a suitable basis for the analysis of market integration and other quantitative research in economic history (Lu and Peng, 2006; Chuan and Kraus, 1975; Wang, 1978). The period covered in this thesis (1740-1820) is known as the golden era of the Qing

[17] The Qing Dynasty Grain Price Database (*Qing dai liangjia ziliao ku*) is hosted at the Institute of Modern History, Academia Sinica, in Taiwan.

China[18], characterised by political stability and the absence of significant civil conflict or detrimental climate change (i.e. cooling). At the same time, the Qing economy was closed to external market forces and did not experience substantial innovation in either transport or agricultural technology. These characteristics of this period provide a convincing argument that the market integration process investigated in this thesis is driven by the domestic market determinants rather than the external political, technological or climatic shocks. An attractive feature is the scope of grain price data I am able to draw on: the geographical coverage of these data amounts to around two-thirds of China's administrative units and more than 80% of China's population in the mid-18th century.

Based on geographical information system (GIS) data from China Historical Geographic Information System (CHGIS) covering maps and other geomorphological information for 1820, I created two datasets for (i) the postal route network at the county level, (ii) the grain trade waterway network, which are aggregated and matched to the grain price data at the prefecture level. In pre-modern China, postal routes (which were land routes exclusively) acted as an "administrative traffic system", and were used as transportation highways for the movement of goods and people during the Qing Dynasty (Fan, 1993). The postal route distance measure I derive from the postal network gives a better proxy for trade distance than the widely used direct distance (as the crow flies) in the existing literature. In the same period, waterway transport was far more economical and convenient than land transport, especially in mountainous Southern China. The river and canal system therefore provided the skeleton of the national transport network (Skinner, 1977b).

[18] The peak period of this golden era was between 1760 and 1780.

Mountains and other geomorphological features can act as natural barrier to trade, and the third dataset I applied is the boundaries of nine “physiographic macroregions” introduced by William Skinner (1977a), who divide China into nine regions according to the mountain ranges, drainage basins of major rivers and other travel-constraining geomorphological features. Taken together the information on postal route network, waterway network combined with geomorphological data provide a unique and novel proxy for various determinants of transport costs in which I will apply in the analysis of market integration. To the best of my knowledge, this is the first study using such detailed historical information of the transport network and topographical distribution for the analysis of market integration in the mid-Qing.

This Chapter is organized as follows. Section 3.2 contains a brief overview of the Qing grain price system, data quality and coverage, and descriptive analysis and testing. Section 3.3 introduces the geographical data I digitized and applied including postal route network, grain waterway network and the Skinner macroregions. Section 3.4 begins by introducing the law of one price as the basic framework for using price convergence to measure market integration, and then distinguish the concept of market integration and market efficiency. Next, I employ some simple statistical tests to describe the general patterns of price variability in terms of spatial, time and seasonal variation.

3.2 Grain Price Data

The price data employed in this thesis comprises an unbalanced panel of monthly grain prices for 211 prefectures in China between 1740 and 1820, which is compiled from the Qing archive holdings of grain price memorials (reports), a rich source for the study of market integration in early modern China.

3.2.1 Price Report System

This grain price reporting system originated during the reign of the Kangxi emperor (1662-1723), expanded during the Yongzheng emperor's reign (1723-1735), and was formally adopted since the reign of the Qianlong emperor (1736-1795) until the collapse of the Qing Dynasty. Monthly price reporting – along with information on weather and agricultural conditions – originated at the lowest administrative level, the county (*xian*).[19] Roughly every 10 days the county magistrate would compile a list of the highest and lowest prices for the grains that were traded in the retail markets of the county. These prices were then aggregated at the prefecture-level by prefects– each prefecture on average comprised 6 counties – before the provincial governor would summarize the conditions in the province along with the price reports in a memorial to the emperor.

3.2.2 Data Quality

Several technical issues have long concerned scholars working with these data, in particular the comparability of the units used for price and weight and the veracity of the reports. Units of account in China during this period varied widely. Grain prices

[19] This summary draws on the studies of Chuan and Kraus (1975), Wang (1978, 1986, 1992) and Marks (1991).

were reported in silver taels (*liang*) per granary bushel (*cang shi*).[20] Yet the purchases in retail markets were made in copper currency (*qian*), the exchange rate of which differed from place to place, as did the measure of weight (retail purchases were usually in volume measures whereas bulk shipments were reported in weight measures). According to Chuan and Kraus (1975) and Wang (1978) the evidence compellingly supports the view that officials were competent in converting the many local units into the imperial standard units. Indeed, the bureaucracy from the emperor downwards used these reports to monitor grain supply and prices across the country, and they were hardly ignorant of the problems of comparability if money and weight units were inconsistent between distant locations. The memorials "accurately represented contemporary free market prices", despite spatial and temporal variation, and there was "a consistent effort to convert [local] market measures, as well as monies of account, into standard, official units" (Chuan and Kraus, 1975: 10, 14).

At times the accuracy of the reports might be questionable, and we sometimes see the same price repeated for several months, but the consensus in the literature is that over the long run there was a high degree of veracity. The officials at all levels of the administration were interested in accurate measurement as they needed to buy grain on the market to replenish stocks in the local granaries as well as for their office and retinue, and were moreover subject to frequent scrutiny (Lu and Peng, 2006; Wang, 1978). The Qing emperors keenly analysed and queried the provincial reports, admonishing governors to improve accuracy or to explain any anomalies. In addition, there were irregular reports from other officials residing in the province or on tour that provided a cross check, so that fabrication of data for any

[20] The median weight of one *shi* was 185 pounds or 83.9 kg and the treasury (*kuping*) tael was 575.8 grains of silver 1000 fine (Chuan and Kraus, 1975: 98, 13).

length of time was extremely risky and on detection would be punished severely. The reported grain prices were market prices. The available evidence supports a view of a sophisticated and hierarchical system of markets linking peasant producers to urban consumers, of peasant producers selling grain in a "free" market competing with other sellers, and where purchasers of grain had competitors as well (Brandt, 1989).

There were however some defects in this system. First, higher level officials might not have checked all the original grain reports from local officials, which enabled officials in charge of granaries to fabricate grain prices to embezzle the difference between the market price and the price recorded as paid by the granaries. Second, the province finance commissioner or the prefecture officers may have filled in prices if they could not obtain information in time. Though it is impossible to claim that there was no fabrication, guesstimates and intentional misreporting of grain prices, under the effective central bureaucratic control in the 18th century, the grain prices are generally deemed as highly reliable.

3.2.3 Period of Investigation

The choice of period analysed in this thesis (1740-1820) guarantees that the determinants and dynamic change in market integration I report was driven by China's internal pre-modern factors rather than external political, transportation technology innovation or climatic shocks.

As discussed in Section 2.2.1, the reign of the Qianlong emperor (1735-1796) has been widely described as Qing's "Golden Age" with its consolidated centralized authority, rapid population and commercial growth and a series of successful military expansions.

This stability of the Chinese economy and polity remained until the 1820s when outflows of silver to pay for opium became substantial, thus inducing deflation (Marks, 1998).[21] The reign of the emperor Jiaqing (1796-1820) is typically regarded as a turning point from prosperity to decline (Rowe, 2011). With economic stagnation and regression domestic rebellions became more frequent, as well as foreign incursions after the mid-19th century (e.g. the first and second Opium Wars). Living standards stagnated or fell compared with industrializing Europe, a process from which China only began to recover in the late 19th and early 20th centuries (Baten *et.al.*, 2010; Ma 2008; Morgan, 2004; Rawski, 1989). In the 18th century, China's economy had been almost entirely isolated from international trade as well as any external political influence due to its "closed door" policy.

During the "Golden Age", Qing China witnessed only limited innovation in transport technology, and wooden river boats ("junks") never lost their dominance in commerce in general and grain transport in particular before the introduction of the steamship after the 1850s (Wiens, 1955). The failure of regular maintenance on the Yellow River and the Grand Canal since the late Qianlong reign led to significant accumulation of silt and thus rising difficulties in shipping grain tribute rice by river in the course of the reign of emperor Daoguang (1821-1850) (Dodgen, 1991; Editorial Committee of Irrigation History of the Yellow River, 1982).

Climate change also frequently affected the development of per-modern societies by altering agricultural productivity. Warm but temperate climate may increase agricultural production, while episodes of significant cooling can directly impede agricultural production or even lead to crop failure (Zhang *et al.*, 2007). Most of the 18th century in Qing Dynasty China escaped the 'Little Ice Age' episodes of the second millennium[22] and its weather was characterized as wet and warm, which was conducive to intensified agricultural production. China started and developed double cropping for rice since the 6th century but the double cropping system had collapsed between 1620-1720 due to cooling temperatures (Yin *et al.*, 2003). China's agricultural yields in 1840-1890 (another cold phase) were reduced by 10-25% comparing with 1730-1770 (a warm phase) despite an increase total arable area of at least 10% between these warm and cold phases (Gong *et al.*, 1996).

3.2.4 Data Description

Basic Description

The data I use comprise monthly prices for rice[23] and wheat over a period of 81 years, from 1740 to 1820. As both monthly highest price and lowest price for each prefecture are available, I follow the literature (Marks, 1991; Keller and Shiue, 2007a, 2007b; Shiue, 2002; Shiue and Keller, 2007; Yan and Liu, 2011) in adopting

[22] Climatologists have identified a number of episodes of significant cooling periods in China (the so called 'Little Ice Age' periods) over the second millennium: 1100s~1150s, 1300s~1390s, 1450s~1510s, 1560s~1690s and 1790s~1890s (Wang et al., 1998).
[23] In the Price Report System, rice has been disaggregated into 1st grade rice (superior), 2nd grade rice (medium), 3rd grade rice (common), early-ripening rice, late-ripening rice, husked rice, polished early-ripening rice and polished late-ripening rice. In this study, we choose polished early-ripening rice for Zhejiang Province and 2nd grade rice for the other provinces in southern China.

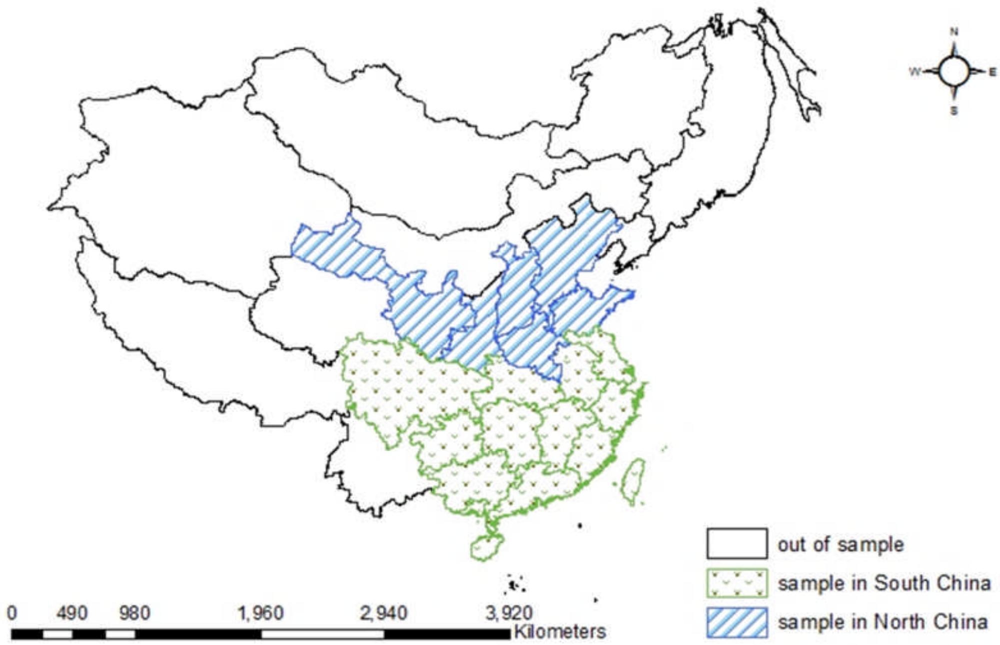
their average as the monthly prefecture price. The geographical coverage spans 131 prefectural rice markets in 11 provinces of South China and 80 prefectural wheat markets in 6 provinces of North China.[24] The geographical coverage amounts to around two-thirds of China's administrative units and more than 80% of China's population in the mid-18th century. The Southern (Northern) provinces were selected on the basis that they all produced rice (wheat) as a staple grain crop in this period. The prefectures covered most of the areas in South China and North China, including the more commercialized urban areas as well as more remote areas. Table 3.1 summarizes the number of available observations by province. Observations varied by province because of the different number of prefectures and different patterns of missing observations for various years.[25] Figure 3.1 shows the sample area within the provincial borders in 1820.[26] Table 3.2 provides basic data descriptive statistics by province, which shows considerable cross-province heterogeneity in average prices although it bears reminding that maximum and minimum prices may be the outliers. In South China, the average prices in the upper stream Yangtze River (grain surplus areas, e.g. Hunan Province and Hubei Province) are much lower than in the downstream Yangtze River (commercialized but grain deficit area, e.g. Jiangsu Province and Zhejiang Province).

[24] The names of prefecture are given in Appendix A.2

[25] My grain price dataset is not a balanced panel because I retain prefectures even where there may be a significant number of missing observations.

[26] Qing's provincial boundaries were fixed and identical after 1750s until its collapse. More details can be check in Section 4.2.2.

Figure 3.1 Map of China with sample provinces



GIS Data Source: "GHGIS, Version 4" (Harvard Yenching Institue, 2007)

Table 3.1 Geography Area of Data (1740-1820)

South China (rice)			North China (wheat)		
Province	No. of Prefectures	Obs.	Province	No. of Prefectures	Obs.
Anhui	13	10,583	Gansu	12	9,977
Jiangsu	10	8,296	Henan	13	10,111
Jiangxi	14	8,146	Shannxi	12	9,924
Fujian	12	9,842	Shandong	10	8,097
Guangdong	13	10,678	Shanxi	18	15,234
Guizhou	13	10,463	Zhili	15	9,490
Guangxi	12	10,339			
Hubei	10	7,872			
Hunan	13	10,985			
Sichuan	11	75,51			
Zhejiang	10	8492			
Total	131	103,247	Total	80	62,833

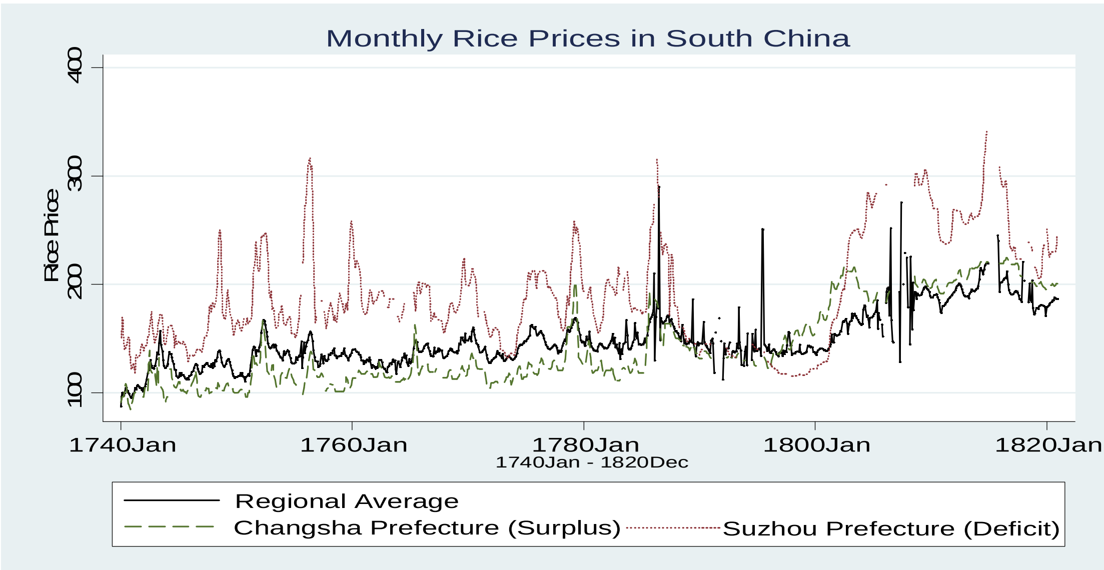
Table 3.2 Basic Descriptive Statistics by Province (1740-1820)							
South China (rice)				North China (wheat)			
Province	Mean	Max.	Min.	Province	Mean	Max.	Min.
Anhui	167.83	439	78.5	Gansu	109.76	448	41
Jiangsu	196.33	430	107	Henan	121.05	390	52
Jiangxi	140.89	276.5	86	Shannxi	144.53	829.5	41
Fujian	177.21	350	79.5	Shandong	165.46	524	77.5
Guangdong	152.56	297.5	65.5	Shanxi	195.03	398	84
Guizhou	96.16	247.5	58.5	Zhili	202.76	725	91
Guangxi	115.74	188	53.5				
Hubei	153.89	374	76.5				
Hunan	134.07	325	69.5				
Sichuan	151.43	565.5	49				
Zhejiang	180.08	351.5	96				

Figure 3.2 plots the monthly price series for selected prefectures compared with the regional (region henceforth referring to China's Southern or Northern provinces) monthly average price. As missing values are retained in the panel data, the time lines are not continuous. For illustrative purposes I here select a grain deficit and a grain surplus prefecture for each of the rice and wheat markets, respectively. As expected, the grain price is higher (lower) in the grain deficit (surplus) prefectures in both regions. A second common feature is that both rice prices and wheat prices trended upward over the sample period. In Figure 3.2a for rice, in most years during the 18th century the prices in both prefectures had similar fluctuations, though the spikes in deficit prefectures were larger, while after the start of the 19th century the similarity between price movements became weaker. I find a similar trend for wheat in Figure 3.2b. In general, one could suggest that there was a (trade) link between surplus and deficit areas that drove prices to co-move during the 18th century, though this appeared to effect diminished in the early 19th century. The

number of annual observation of rice and wheat prices is reported in Figure 3.3. There are more observations for rice than wheat price since there are more prefectures in rice sample. Figure 3.3 also shows that the share of missing observations was very high in the early 1800s, possibly due to local political disturbances. Fairly constant prices over several months represents a well-known problem of this data, especially after 1800.[27] In this thesis, all observatins involving the missing values are dropped from the pairwise cointegration and panel cointegration regression.[28] There is no doubt that the empirical results for the end of 18th century may in part be driven by missing values and the apparent constancy of prices rather than the market efficiency.

Figure 3.2 Selected Monthly Prices

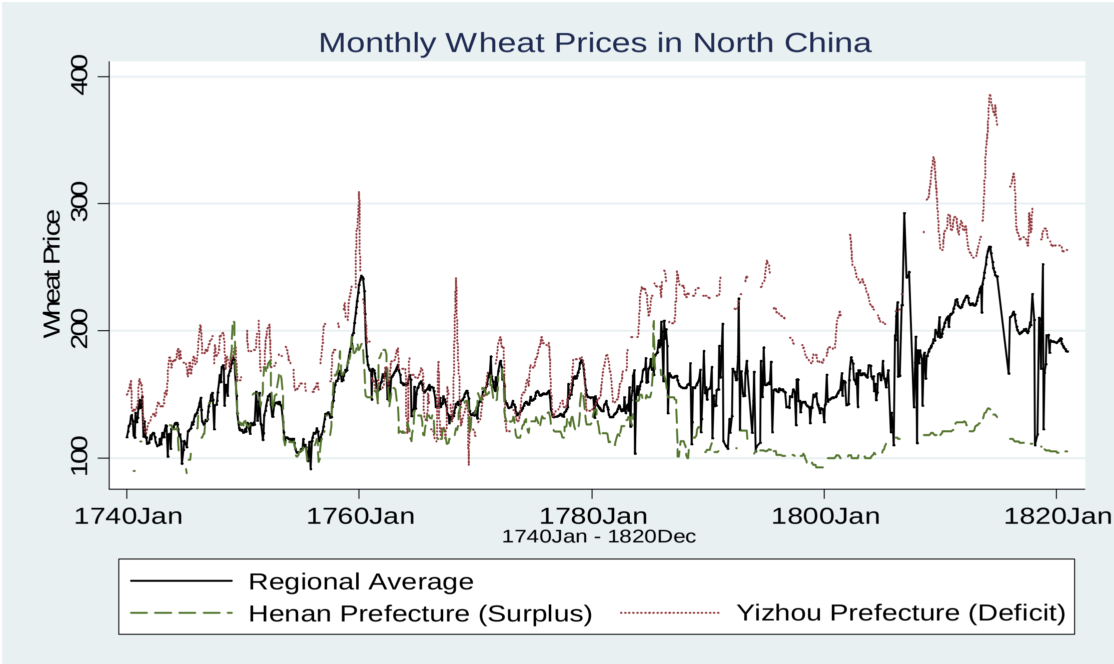
(a)



(Price Unit: silver taels per bushel ×100)

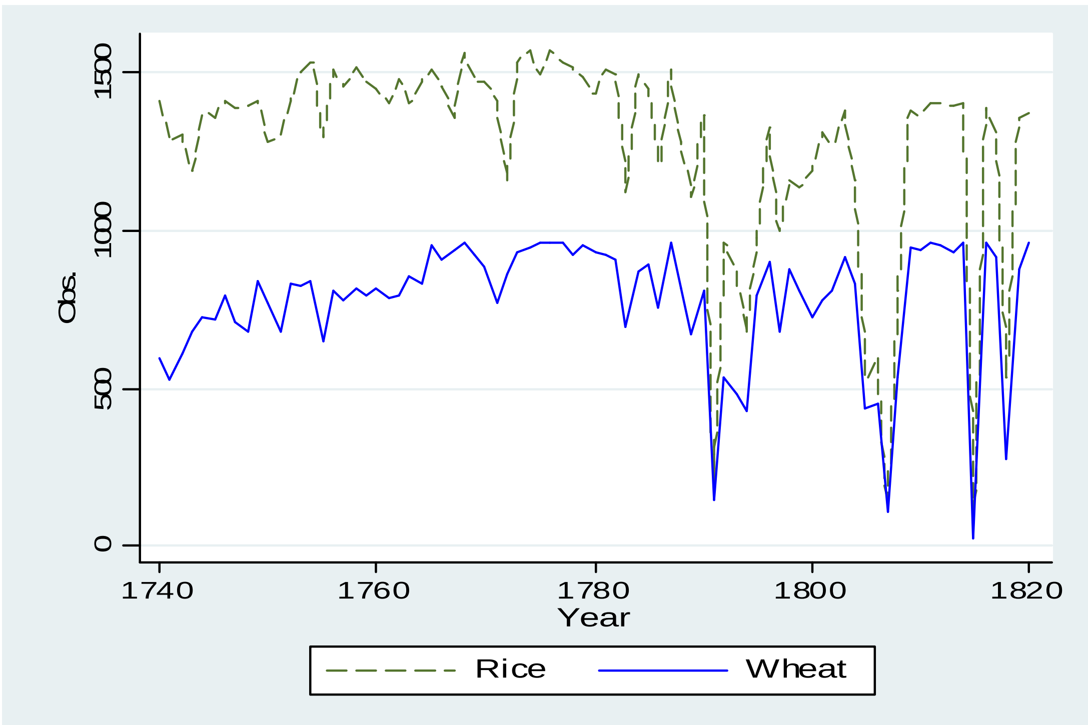
[27] For details about the share of constant price can be checked in Appendix A.3.
[28] There are two reasons that I don't interpolate the missing values. First, in some period the gap of missings is quite large, which is difficult to be interpolated by the normal ARMA model. Second, to interpolate is needed to impost more assumption, which may add more noise into the price information I already have.

(b)



(Price Unit: silver taels per bushel ×100)

Figure 3.3 Annual Observation Count



Unit Root Tests

Before formal cointegration analysis in later chapters, I test the order of integration for each price series. If these price variables do not have a unit root, their combination must be stationary so that it is meaningless to test the cointegration.

Similar to the prefectures in Figure 3.2, some price series show an upward trend. I therefore adopt unit tests with a drift and discuss whether the evolution of these prices is governed by a random walk. To allow for more general autoregressive [AR(*p*)] processes, the Augmented Dickey-Fuller regression setup (Dickey and Fuller, 1979) takes the general form given in (3.1), where lag length *p* is selected so as to address serial correlation and this choice is based on the Schwarz Bayesian Information Criterion. The p-values on the estimate of c_3 are corrected following Mackinnon (1991). The null hypothesis is that there is a unit root in the individual price series.

$$\Delta \log(p_t) = c_1 + c_2 t + c_3 \log(p_{t-1}) + \sum_{i=1}^{m} \delta_i \Delta \log(P_{t-i}) + \varepsilon_t \qquad (3.1)$$

H_0: c_3=0

H_1: c_3<0

The results suggest that 50% of time series in South China and 30% of time series in North China reject the null hypothesis (i.e. they do not have a unit root) by regression (3.1). In the second step, I test the unit root without a drift in regression (3.2). All the time series cannot reject the null hypothesis of unit root at the 5% significance (Detailed results are in Table A.1.1, A.1.2 and A1.3 in Appendix A.1).

The distinction between regression (3.1) and (3.2) suggests that those time series can reject the null hypothesis of unit root with drift in the first step but cannot reject the null hypothesis of unit root without drift in the second step may be trend stationary. In the third step of regression (3.3), I explore the KPSS test that is due to Kwiatkowski *et al.* (1992) to test the trend stationarity (Detailed results are in Table A.1.4 and A.1.5 in Appendix A.1).

$$\Delta \log(P)_t = c_1 + c_2 \log(P_{t-1}) + \sum_{i=1}^{m} \delta_i \Delta \log(P_{t-i}) + \varepsilon_t$$

(3.2)

H_0: $c_2 = 0$

H_1: $c_2 < 0$

Of these time series which cannot reject the hypothesis without drift in the second step, there are 18 prefectures in South China (13.7%) and 12 prefectures in North China (15%) cannot reject the hypothesis of trend stationarity using KPSS test. The ADF test and the KPSS test provide the ambiguous implication for this sub-sample. In this thesis, I extend my empirical analysis based on the ADF test results which suggest that some price series follow the random walk with drift and some without drift. In Chapter 4, the results of cointegration and further analysis with the sub-sample (exclude the possible trend stationary series) provide the similar pattern as given by the full sample.

$$\log(P_t)=\beta_0 t+\mu_t+u_t \quad (3.3)$$

$$\mu_t=\mu_{t-1}+\varepsilon_t,\ \varepsilon_t \sim WN\ (0, \sigma_\varepsilon^2)$$

$$H_o: \sigma_\varepsilon^2 =0$$

$$H_1: \sigma_\varepsilon^2 >0$$

3.3 Geography Data

In this thesis, I use the China Historical Geographic Information System (CHGIS) as the spatial database to construct my geographical variables. This database includes the boundaries of the administrative hierarchy down to the county level covering various points in time from 221BCE to 1911 CE. For 1820, the most relevant point time in my sample, counties and rivers are given as points and lines, while prefectures, provinces and Skinner macroregions are given as polygons for the territory administered.[29] In the following section I present the geographical data I constructed for the empirical analysis in later chapters covering the postal network, the grain waterway and the Skinner macroregions.

[29] More details about CHGIS can be checked in Bol (2007).

3.3.1 The Postal Route Network in the Qing Dynasty

<u>China's Postal Route</u>

In the pre-modern period, postal routes played a key role in the proliferation of a successful administration in China, whereby postal routes represented an 'administrative traffic system' to provide communication between the provincial capitals and the imperial court in Beijing. According to Fan (1993), "the postal routes were constructed of granite and were built wide enough to accommodate two carts travelling in opposite directions". The postal highway system during the Qing Dynasty mainly served for official travel, postal dispatch, and military actions (e.g. troop and military grain movement) with its maintenance allocated directly by the central government, although during the entire Qing (1644-1911), large-scale construction and maintenance of the postal routes was rare. In peaceful period, the private use of the postal routes by long-distance merchants became more and more prevalent. Information about these trade routes is provided in several route books and merchant manuals written during the Ming and Qing dynasties. Comparing these trade routes with postal routes, Fan (1993, p36) concludes that "these trade routes were merely transformed from existing administrative routes… [and] the commercial traffic network hardly extended beyond the pre-existing administrative traffic network".

In 1907 the Qing Dynasty administration produced the China Postal Almanac, which contains maps of the primary postal routes, railroads and telegraph lines in each province. These maps were produced by Statistical Department of the Inspectorate General of Customs in Shanghai, which was under the control of the

British-run Chinese Imperial Customs, which suggests that their quality follows the standard of contemporary Western cartography. According to Cai (2005), this Postal Almanac was the first set of detailed postal route maps in China. As the postal route system remained largely unchanged since the establishment of the Ming Dynasty in 1368 (Fan, 1993), the 1907 postal network can be used to measure 18th century trade routes. Tsai (2013) further confirms that the creation of the Great Qing Imperial Post Office in 1896 mostly based on the historical infrastructural post network.

In most empirical research on market integration and trade cost, the direct distance between two locations is used to measure distance. This measurement imposes the assumption that the real trade route follows the shortest bilateral direct distance. Quite apparently, this is not true in reality, especially in the pre-modern era using primitive transportation technology. Thus in practice the true trade route follows the topographical distribution of the land (e.g. valleys or navigable rivers), especially for heavy commodities such as grains. In this case, postal distance is a better measurement than direct distance to capture the trade cost.

Data Construction

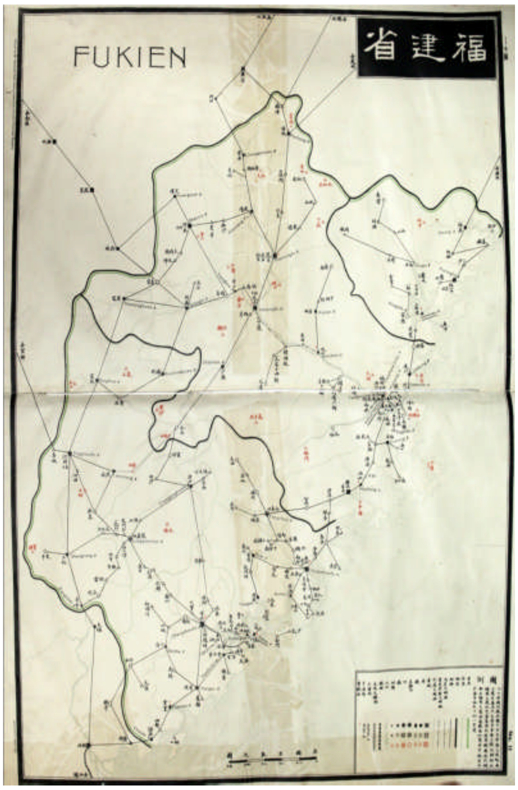
To capture the impact of trade cost on the transportable route, I digitize the postal route network from these archival maps to construct my variable of "effective" trade route distance within and between prefectures. The postal route computations are based on the historical point and polygon GIS layers for provinces, prefectures and counties in China in 1820 provided by the CHGIS project.

Figure 3.4 shows the digitization process of one Fujian Province as an illustration. In the original archival map in Figure 3.4(a), two administrative units (e.g. prefectures, counties or towns) are connected by a straight line if both of them have access to the same postal route. In Figure 3.4(b), every prefecture (county) point represents the centre point of the polygon of each prefecture (county). I digitize this postal network at the *county* level, which means I digitize all the postal lines from Figure 3.4(a) to 3.4(b) between any two prefectures or county points, and ignore postal routes going through town points (lower administrative unit than county). In Figure 3.4(b), I draw the green linear lines between any pair (i.e. prefecture to prefecture, county to county or prefecture to county) of the postal network. I digitize these provincial maps one by one adopting the same geo-spatial coordinate system and then connect all the province postal networks together to create a single national postal network. I use the longitude and latitude of the prefecture points to calculate the shortest postal route distance between each prefecture-point pair as a proxy for their bilateral trade route distances. Presented in Figure 3.5, the national postal network thus provides a unique basis for spatial analysis of China's historical transport infrastructure and its impact on trade in the 18th century. If two prefectures are further apart, it is more likely for their postal route distance to be larger than their linear distance as it is more likely for the transportable route needing to bypass mountains, rivers and valleys. Figure 3.6 compares the bilateral postal route distance and linear distance measures, which shows that postal distance is generally longer than linear distance and this gap increases with line distance. The pattern coincides with our prediction that the bias of direct distance from the real trade distance would be larger if two prefectures are farer apart. In the rest of this thesis, I use the term ‘distance’ to refer to the postal route distance unique to this thesis

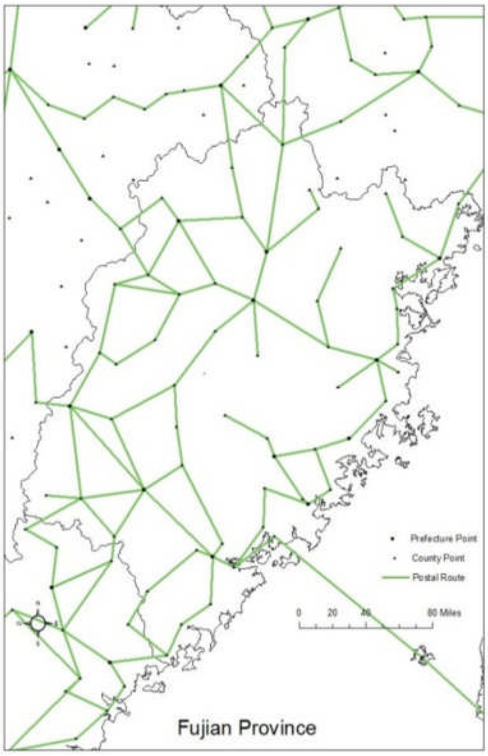
Figure 3.4 Postal Route Archive Map and its Digitization GIS Map

(Example of Fujian Province)

(a) Original Archive



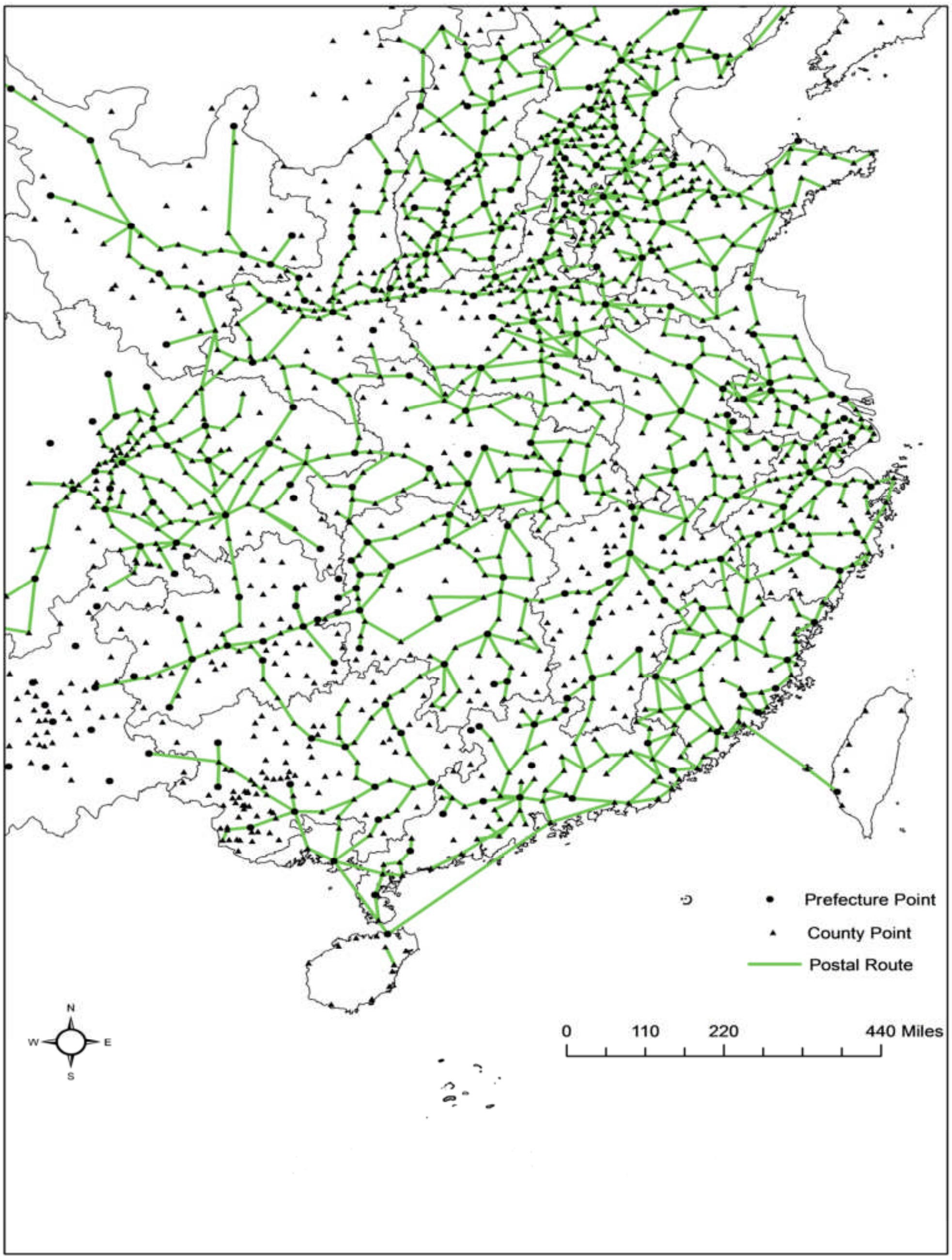
(b) Digitized Map



Archive Map Source: China Postal Almanac (1907)

GIS Data Source: “GHGIS, Version 4” (Harvard Yenching Institue, 2007)

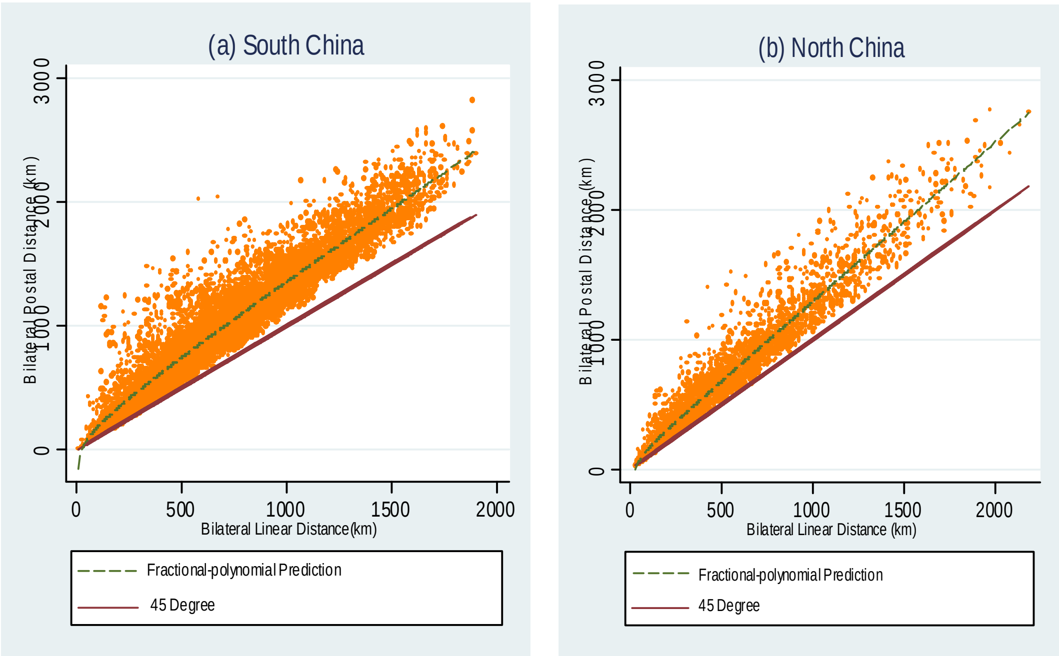
Figure 3.5 Postal Network in China (1907)



Archive Map Source: China Postal Almanac (1907)

GIS Data Source: "GHGIS, Version 4" (Harvard Yenching Institue, 2007)

Figure 3.6 Postal Distance and Linear Distance



3.3.2 The "Grain Rivers" Water-way Network

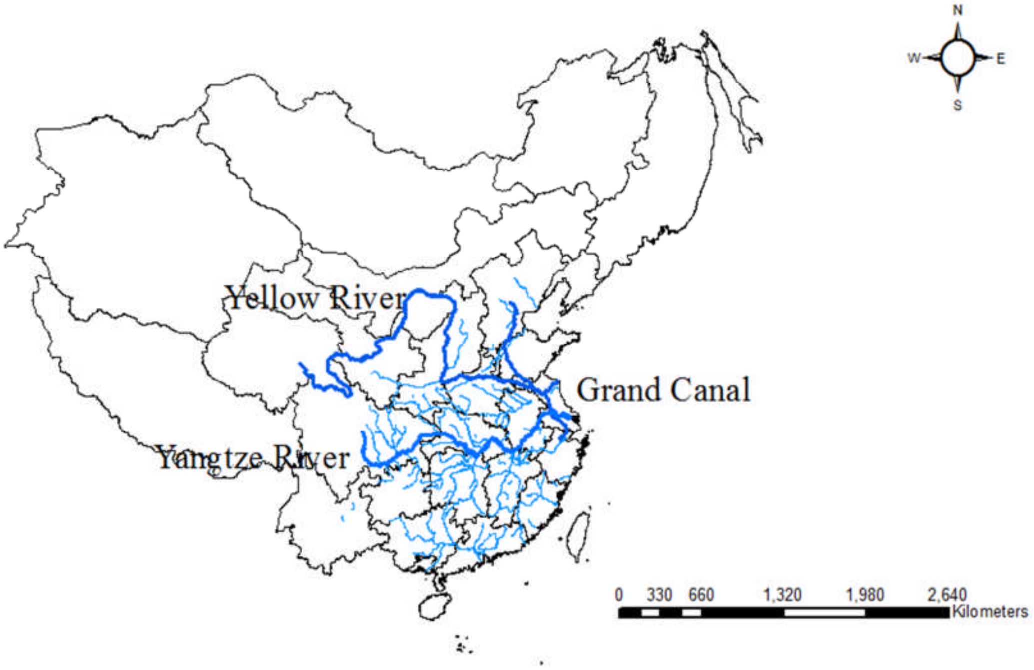
In the pre-modern period, China's domestic interregional trade over long distance primarily relied on natural waterways since waterway transport was far more economical and convenient. Writing during the 13th century Macro Polo observed, in the official reports of his time, that the annual count of junks ascending the Yangtze River through a particular Customs House approached 200,000 (Wiens, 1955), which points to be the significance of river shipping in China's economic history.

Three main grain trade routes in the Qing Dynasty were based on the three main waterway systems: the Yangzi River, the Grand Canal and the coastal trade system (Fan, 1993; Wang, 1992). In South China, the increasing grain trade volume was mainly carried by the long distance grain trade on the Yangtze River between upstream grain surplus and downstream deficit areas. The annual 'import' of rice to the Yangtze Delta area was in the range of 15-20 million *shi*, of which 5-6 million was trans-shipped (Wang, 1992: p.38). The lower Yangzi was estimated to require at least 5.5 to 9 million *shi* to support its own population (Chuan and Kraus, 1975: p.64-65). Connecting South China with North China, the Grand Canal transported a minimum of about 3.4 million *shi* a year of tribute grain from the Yangtze River area to the capital, and an unspecified amount also flowed southwards (Chuan and Kraus, 1975: p.36; Wang 1992: p.36, p.38).

The volume of grain traded is a function of on the ease of navigation of the waterway (Shiue and Keller, 2007). To construct a variable which captures the impact of the waterway network on market efficiency, I identify all the rivers that have been recorded for grain trade in gazetteers and archives reported by Deng (1994, 1995) as well as inland waterways reported in Wiens (1955, Figure 1, p252[30]). Represented on a map of China in 1820 in Figure 3.7, this grain trade waterway network for Qing Dynasty China comprises 95 rivers.[31] To the best of my knowledge this is the first empirical study to use detailed data on the waterway network in the analysis of market integration in China.

[30] This figure is given in Appendix A.4.
[31] These rivers' names are given in Appendix A.5.

Figure 3.7 Grain Trade Waterway Network in China



Blue Line: Grain Rivers

GIS Data Source: "GHGIS, Version 4" (Harvard Yenching Institue, 2007)

3.3.3 Skinner Macroregions

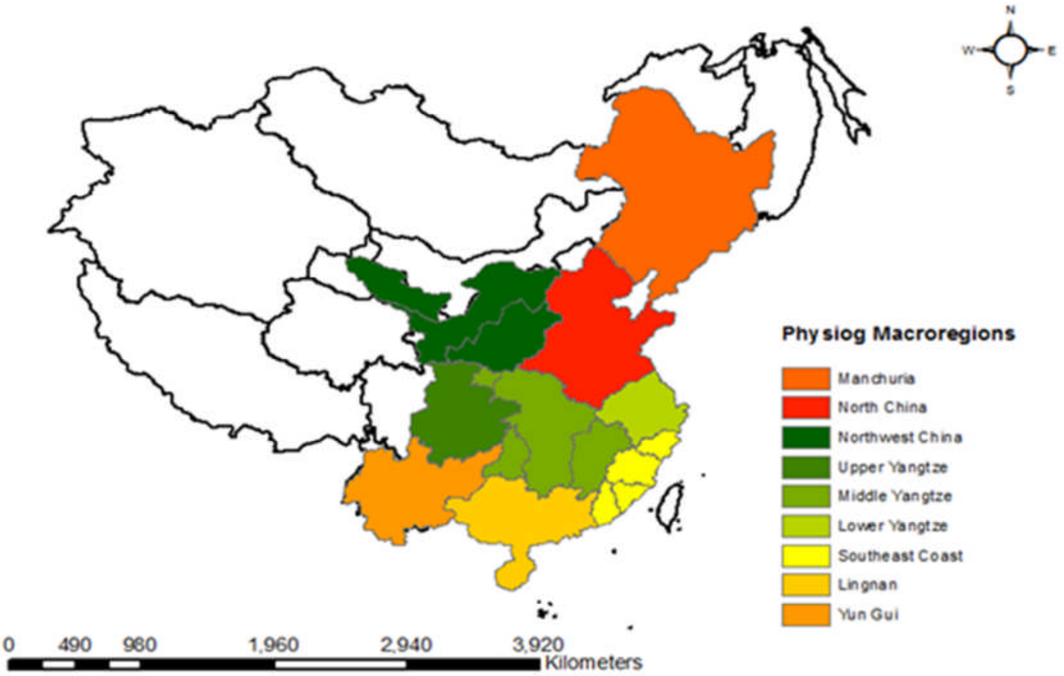
Mountain ranges and canyon systems represent natural barriers for trade. The anthropologist William Skinner (1977a) introduced a set of 'physiographic macroregions', dividing China into nine regions (presented in Figure 3.8) according to the drainage basins of major rivers and other 'travel-constraining' geomorphological features: Southeast Coast, Lingnan, Lower Yangtze, Middle Yangtze, Upper Yangtze, Yun-Gui, North China, Northwest China and Manchuria. Most of the regional boundaries adopted by Skinner follow watersheds and the crests of mountain ranges: the high-density "core" city of each macroregion is located in the river-valley lowlands and surrounded by concentric gradients of declining population densities until reaching the periphery. The river basin is taken as an essential macroregional determinant in Skinner's macroregions since urbanization, crop inventories and productive techniques in pre-modern agrarian China were specifically adapted to a plains-and–valley ecology and due to the great importance of water transport (Skinner, 1977b).

Because of these geomorphological barriers to inter-regional communication and trade, Skinner argues that the majority of trade was shipped within macroregion rather than sent out to other macroregions of the empire. In China's history, he further argues, major natural diaasters or imperial critical decision-making were always limited in scope to macroregion: disastrous floods were frequent in the lowland cores of North China and the Middle Yangtze region; disastrous droughts and invasions from Inner Asia affected Northwest China and North China more severely; the selection of Kaifeng as the Capital City of Northern Song Dynasty (960-1127) accelerated the development of North China; the selection of Hangzhou as the Capital City of Southern Song Dynasty (1127-1279) primarily affected the development of the Lower Yangtze region; the monopoly of overseas trade granted Guangzhou in 1757 accelerated development in the Lingnan region but doomed the economy of the Southeast Coast. These nine macroregions are distinct in terms of environment, economic resources and interdependence with other regions throughout history, which implies these various regions had their own development cycles and processes of urbanization.

Skinner divided China into nine Macroregions, of which Southease was divided into four sub-macroregion: Ou-ling Basins, Min Basin, Zhang-Quan, Han Basin; Middle Yangtze Region was divided into four sub-macroregions: Middle

Yangtze Proper, Gan Basin, Yuan Basin, Upper Han Basin; and Northwest region was divided into three Macroregions: Wei-Fen Basin, Upper Huang Basin and Gansu Corridor (Skinner *et al.*, 2007). These sub-divisions capture the natural barrier within the Macroregions, which are also included into my geographic variable. As a consequence, there are 17 regions divided by the Skinner distribution, of which 15 regions cover my grain price data.

Figure 3.8 Physiographic Macroregions in China



GIS Data Source: "GHGIS, Version 4" (Harvard Yenching Institue, 2007)

3.4 Preliminary Data Analysis

Few topics have attracted as much attention and controversy in International Economics as the topic of the Law of One Price (LOOP). In the empirical literature, price convergence is used as a standard measure for market efficiency. In this section, the concepts of LOOP, market integration and market efficiency will be developed. I also provide some basic empirical analysis adopting descriptive measures which confirms the standard finding in the literature that South China's market was more integrated than that of the North China and further highlights that both regions experienced a process of market disintegration over time.

3.4.1 Theoretical Framework: the Law of One Price

<u>The Law of One Price</u>

The Law of One Price holds that, in a frictionless undistorted world, regional markets that are linked by trade and arbitrage will have a common, unique price for a homogenous commodity:

$P_i = P_j = \ldots = P$ (i, j denote locations) (3.4)

A wide economic literature has studied the relationship between price, either spatial or vertical through the framework of LOOP. Although most of the empirical evidence is against the LOOP in this simple form, supportive evidence exists for its modified versions. One of the modified versions is the above standard framework adapted with the *band* of arbitrage. This framework assumes a two-stage adjustment process: in the first stage, producers and consumers in a given area clear the market at autarky prices (A_i) in location *i*. In the second stage, agents are informed about the autarky prices (A_j) in location *j*. The agents can compare the absolute value of the autarky prices differential ($A_i - A_j$) with the total costs (T_{ij}) of moving the good from the low-price market to the high-price market. Whenever the autarky price differential exceeds the trade cost, it is profitable to arbitrage. Arbitrage would cause the gap between market prices (P_i and P_j) to shrink until it equals the trade costs (T_{ij}). In this framework, trade can be transitory if the gap between autarky prices exceeds trade costs temporarily, or permanently if the gap reflects a structure imbalance (Federico, 2011).

In this basic framework, trade cost is assumed to be constant across time. Briefly, the actions of spatial traders to arbitrage will ensure that the prices of a homogeneous good at any two locations will differ by, at most, the cost of moving the good from the region with the lower price to the region with the higher price (Fackler and Goodwin, 2001).

$$P_i - P_j \leq T_{ij} \qquad (3.5)$$

where T_{ij} is the trade cost of moving the good from *i* to *j*. Here the trade cost includes all relevant cost of arranging transactions between spatially separate locations. The price differential between two locations measures trade costs *only if* the two markets trade (Coleman, 2007). The inequality function (3.5) is referred to as the *spatial arbitrage condition*, which is an equilibrium concept. In a well-functioning market, arbitrage actions will tend to move the price differential toward the trade cost. This insight has been formalized in the literature on non-linear deviations from the law of one price including Obstfeld and Taylor (1997), Taylor (2001) and O'Connell and Wei (2002).

Federico (2011) argues this standard framework relies on four key assumptions. The first is that there are only two locations. Adding one more location would change the basic equilibrium condition. Second, the trade costs T_{ij} are independent from the quantity traded, which questions the existence of bulk trade. Third, the agents know only the price information in these two locations, which seems unreasonable. Fourth, the price adjustment after an exogenous shock is instantaneous, which is never true even in the most efficient markets. Violating any of these assumptions creates bias in interpretation for the empirical results of testing the LOOP. In this thesis, my empirical concern is to estimate the strength of grain price convergence over the long–run, filtering out short-run deviations in the course of the analysis. It is then the homogeneity of the staple commodities studied (i.e. rice or wheat) which allows me to compare the price-movements across regions and time, and to draw conclusions for market integration during the mid-Qing period.

Spatial Market Integration

Market integration and market efficiency are two distinct concepts, although they are closely related. Market integration is a practical and empirical concept, referring to a measure of *degree* rather than a specific relationship. If the trade cost is assumed to be zero, a perfectly integrated market should exhibit the strong form of the LOOP (i.e. function (3.4)). In some literature, market integration is used to refer to the weak form of the LOOP (i.e. function (3.5)). In macroeconomics and international economics, a common conceptualization of market integration is ‘tradability’, which signals the transfer of excess demand from one market to another, captured as price convergence or trade flows. In the existing literature, market integration is defined either as the degree of co-movement of prices in different location or the bilateral trade volume under the gravity model.

Market efficiency is a theoretical concept somewhat less clearly defined than market integration. In some studies, it is considered as synonymous with the spatial arbitrage condition. Notions of market efficiency are usually treated as a motivation for the empirical analysis of market integration. The important and practical challenge of defining market efficiency is then how to test whether markets are efficient in allocating scarce goods and services (Barrett, 2001). In general, efficiency is used to imply that the allocation of resources is such that aggregate welfare cannot be improved through a reallocation of resources. In terms of arbitrage, market efficiency implies that no arbitrage profits are left to exploit for the traders.

Market efficiency is a broader concept than market integration. Precisely, market efficiency implies market integration but not necessary the reverse. Price co-movement for a given commodity (e.g. rice) can arise, however, for a number of alternative reasons (e.g. similar climate condition or similar external shocks) rather than the existence of an integrated trading network (Fackler and Goodwin, 2001). Consequently, using price convergence to measure market efficiency, the empirical challenge is to identify non-market links underlying the price co-movement.

Federico (2012) argues that market integration involves two different processes: the increase in the speed of return to equilibrium levels after a shock in the short-run and the convergence of prices in the long run. Following the framework of spatial market integration, the data analysed in this thesis allow me to test the degree of price convergence in the long run as one indicator of China's market integration, which points to China's market efficiency. In Chapter 4, I still maintain the empirical assumption of statistical independence across trading pairs which has characterised virtually all studies in the literature; in Chapter 5, I relax this assumption through the introduction of common factors.

3.4.2 Coefficient of Variation

The coefficient of variation provides a sound first descriptive indicator to measure price variability for market integration as it is "simple to compute, intuitive and, as a single dimensionless figure, easy to compare across time and space for the same good" (Federico, 2011). In the simple version of LOOP (i.e. function (3.1)), the price of homogenous commodity across prefecture should be the same and the CV therefore should be (nominally) zero. The lower the CV more integrated the market.

Table 3.3 reports the coefficient of variation by province for the whole sample period, which highlights that provincial price covariance in Southern China is smaller than in Northern China. However, the pattern among provinces within regions is the exact opposite to that expected: for instance in South China, the highly commercialized province of Jiangsu has the highest CV while the isolated and poor provinces Guizhou and Guangxi have the lowest CV. This unexpected pattern may be due to the distortion caused by time-varying heterogeneity across provinces.

In Figure 3.9, all the pairs are categorized by their bilateral postal distance, the CV of price ratio between any two prefectures ($P_{i,t}$ / $P_{j,t}$, for $P_{i,t} > P_{j,t}$ by construction) are given by postal route distance group, both for rice (South) and wheat (North). A smaller CV for the pairwise price ratio indicates lower price differentials in a given distance group. As can be seen, the CV of price ratio *increases* with distance both for South China and North China, which implies that trade costs (proxied by the price ratio) increase with distance. On the other hand, spatial price variability is always smaller in Southern China than Northern China, especially for the distance up to 1,200*km*. North's spatial CV increases to about 0.33 in the distance group of 600-800*km* while South China arrive at this level until in the distance group of 1600-1800*km*. This pattern suggests that markets in Southern China were more integrated than those in the North.

To avoid distortion of these results by time-varying heterogeneity, the annual CV at the regional level (i.e. South and North China) are plotted in Figure 3.10(a). The figure shows price dispersion for rice was typically lower than for wheat in most years. An upward trending of price variability is more notable for rice prices and wheat prices. This result again implies that markets in Southern China were more integrated than in the North but the extent of market integration was not stable over time and arguable declined in both regions. Since this price dataset is unbalanced, it is difficult to determine whether the implication from annual CV still holds if the strong assumption maintained here that observations are missing randomly is relaxed.

Table 3.3 CV by Province (1740-1820)

South China (rice)		North China (wheat)	
Province	Coefficient of Variation	Province	Coefficient of Variation
Anhui	0.271	Gansu	0.342
Jiangsu	0.295	Henan	0.246
Jiangxi	0.146	Shannxi	0.454
Fujian	0.215	Shandong	0.348
Guangdong	0.211	Shanxi	0.243
Guizhou	0.195	Zhili	0.296
Guangxi	0.166		
Hubei	0.330		
Hunan	0.256		
Sichuan	0.333		
Zhejiang	0.218		

Figure 3.9 Spatial CV of Price Ratio

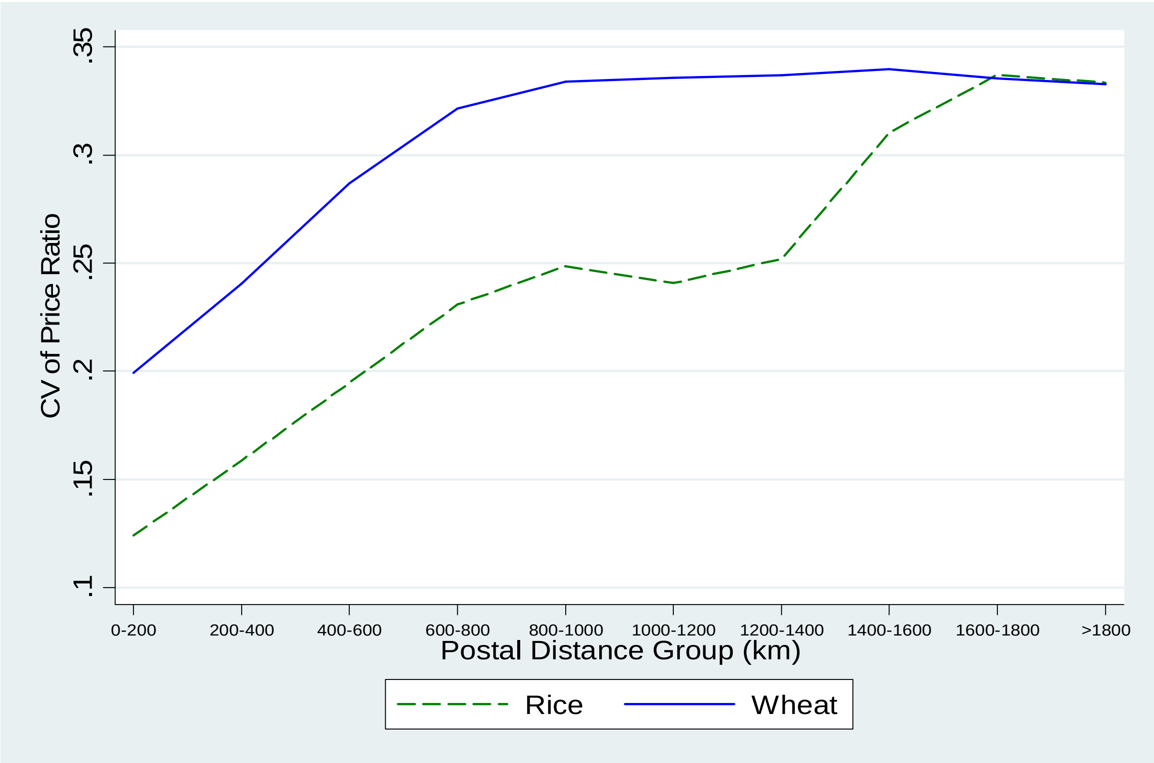
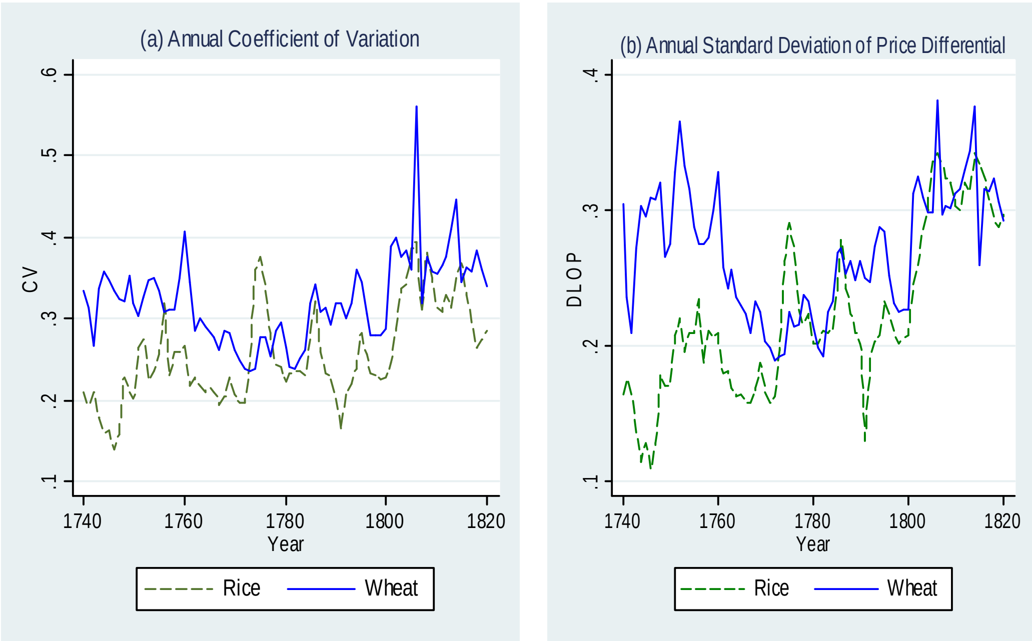


Figure 3.10 Annual CV and DLOP



3.4.3 Deviation from the Law of One Price (DLOP)

The measurement of *deviations from the law of one price* (DLOP) is another widely used empirical index to quantify the strength of price convergence, indicating the extent of market integration (Parsley and Wei, 2003; Fan and Wei, 2006; Young, 2000). CV measures the deviation of prices while DLOP measures the deviation of price differentials. The measure of DLOP is theoretically motivated by the *spatial arbitrage condition* (in function (3.2)) that the existence of positive costs of arbitrage imposes an inequality constraint on the price difference of an identical good in two different locations. There are two thresholds that define a band of no arbitrage, and arbitrage would bring the price difference back to the edge of the band if the realized price difference is outside the threshold (Parsley and Wei, 2003).

In Parsley and Wei (2003), Fan and Wei (2006) and Young (2000), their price data involve three dimensions: *m* products across *i* cities varied over time *t*. However, my grain price data only has two dimensions: the same product across prefectures varied over time. The definition of standard deviation in the existing literature can be modified for my data-set. First, define log rice (or wheat) price differentials at time *t* between any city pair *i* and *j* as

$$Q_{ij,\,t} = lnP_{i,\,t} - lnP_{j,\,t}\ , \quad (\text{for } P_{i,t} > P_{j,\,t}) \qquad (3.3)$$

where $P_{i,,\,t}$ denotes the raw rice (or wheat) price in prefecture *i* at time *t*

Then, define

$$q_{ij,\,t} = Q_{ij,\,t} - Q^*_{\ t}\ , \qquad (3.4)$$

where Q^*_t is the mean of $Q_{ij,\,t}$ over all pairs at time *t*. Then, S_t is denoted as the standard deviation of $q_{ij,\,t}$ at each point of time, which is used as a measure of the deviation from the law of one price. Intuitively, once the price differential, $Q_{ij,,\,t} = lnP_{i,\,t} - lnP_{j,\,t}$, goes out of a certain band, arbitrage activity becomes profitable and is likely to take place to bring the price differential back inside the band. S_t describes the deviation in price differentials rather than in price, and a smaller S_t is associated with more integrated markets. The annual S_t for South China and North China are presented in Figure 3.10(b), indicating a similar pattern to the annual CV in Figure 3.10(a). Thus, both deviation in price and price differential provide the same conclusions, namely that on balance Southern China was more integrated than the North, and that there is some evidence for a secular decline in market integration in both regions.

3.4.5 Seasonality

Grain production is sensitive to both weather conditions and harvest time. A characteristic of grain commodities is that a surplus exists at harvest time which is consumed throughout the whole year (Wilson, 1981). Consequently, grain prices tend to follow seasonal patterns. In an autarkic economy, the grain price is predict to plummet to the bottom during harvest time (i.e. local supply glut) and increase after the harvest time in a fashion which approximately covers the costs incurred in storing grain. Rice and wheat have different planting and harvest times, which are presented in Table 3.4. However, even within the same rice or wheat region, the exact times for the harvest and planting patterns can still considerably vary. The solid lines in Figure 3.11 give the seasonal variation both for rice and wheat, which show that they each have significant but different seasonal variation. Seasonal variation (i.e. SV_m) is defined here as the mean of the ratio between the monthly price and its yearly average price for each calendar month *m*, *i.e.*

$$SV_m = [\sum (P_{i,y,m} / \overline{P_{i,y}})] / (N \times T) \qquad (3.5)$$

$P_{i,y,m}$ is the price of prefecture *i* in month *m* of year *y*;

$\overline{P_{i,y}}$ is the annual average price of prefecture *i* in year *y*;

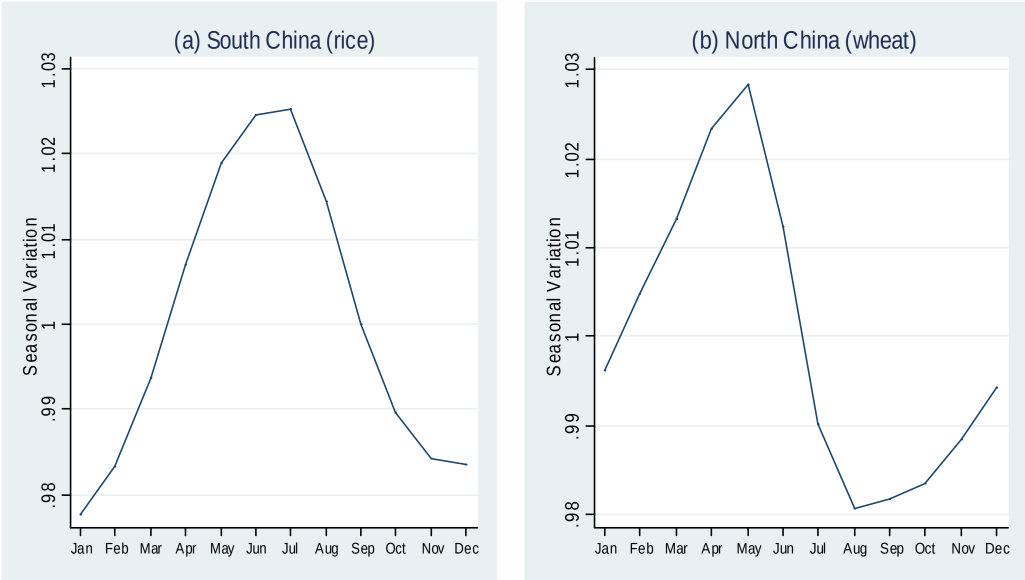
N is the number of prefectures, *T* is the number of years.

Rice and wheat regions show some similar patterns of seasonal variation. For example, in January, the average rice price across prefectures was 98% of the annual average price, while for wheat it was 99.5% of the annual average price. Both of them are lower than the annual mean. Both of their monthly variations are in the range between 98% and 103% of the annual average price, which implies that, in general, the monthly price moved around the trend with comparatively small deviation. For rice prices, the seasonal peak appears during the first harvest time (June and July), while the wheat's peak also comes at the first harvest time (May and June). Both of their low price floors arrive around the second harvest time, i.e. in October and November for rice, and July and August for wheat. This temporal distinction between the two harvest periods implies that consumers may increase their storage before the first harvest time to prepare for food shortage between the two harvest seasons. Typically with grain commodities, we would expect that twin annual harvests imply twin peak in the annual price movements. The fact that I observe only one peak suggests that consumers anticipate grain shortages between two harvest seasons and adopt intertemporal storage to smoothen their consumption, which acts as a smoother to seasonal price variation. Note however that the seasonal indeces in Figure 3.11 with respect to the whole period across the whole sample, the observed patterns therefore may hide significant heterogeneity in terms of either time or space. Nevertheless the apparent seasonal variation detected confirms that grain price seasonality cannot be ignored in the later econometric analysis.

Table 3.4 Planting and Harvest Time

	Rice			Wheat	
	Single-crop	Double-crop (early)	Double-crop (late)	Spring Wheat	Winter Wheat
Planting	Mar to Jun	Feb to Apr	Aug	Mar to Apr	Sep to Oct
Harvest	Oct and Nov	June and July	Oct and Nov	July to Aug	May and June

Figure 3.11 Index of Seasonal Variation



3.5 Conclusions

This chapter introduces the details of the grain price data and the geographic data I constructed and collated. This grain data covers the monthly rice and wheat price data across 211 prefectures between 1740 and 1820. Data quality was of high concern to the Qing emperors and their high ranking officials for food security such that its reliability and comparability was an explicit target of the bureaucratic system. In later chapters, the postal distance measure will be used as a proxy for trade route distance, which provides a better measure of trade cost than direct distance. The network of grain waterways and the Skinner macroregions enable me to identify the role of geography on the market performance. From 1740 to 1820, China experienced an era of politically stability, and absence of large scale natural disasters, which in combination with de-facto autarky, and limited or no technological innovation in the transport system imply that market evolution observed in this period was mainly driven by the market determinants rather than the external political, technological or climatic shocks. The large scale of this price data allows me to recognize the process of market evolution in terms of both the spatial and time dimension. Preliminary descriptive analysis confirms previous findings in the literature that markets were more integrated in Southern China than in the North while there is also some evidence of market disintegration over time in both regions. These aspects will be further investigated with more advanced econometric techniques in later chapters of the thesis.

Chapter 4
Geography, Institutions and Market Integration

4.1 Introduction and Motivation

This chapter examines the determinants of grain market integration within China during the middle period of the Qing Dynasty (1740-1820), with a spatial comparison between rice markets in Southern China and wheat markets in Northern China. Applying Engle-Granger cointegration and conventional cross-section method I provide robust evidence to identify that Southern markets were more integrated than Northern markets, and quantify the role of river transport in the extent of market integration for the subtle differences between China's Southern and Northern regions. My empirical results suggest that geographical determinants were important but dominated by the political structure on the market evolution.

This chapter contributes to the classic recent argument contrasting institutions and geography on the long-run development. Advocates of "geography hypothesis" emphasize the persistent effects of fixed geographic variables on human actions and productivity, and therefore the economic development in the long-run (Engerman and Sokoloff, 2000; Nuun, 2009; Sachs, 2000, 2001). On the other strand, the seminal works written by North and Thomas (1973), North and Weingast (1989) and North (1981, 1990) strength the importance of institutions, especially of private property institutions, on economic development, which is supported empirically by

Acemoglu *et al.* (2001, 2002, 2004, 2005), Banerjee and Iyer (2005), Dell (2008) and Fang and Zhao (2011). This Chapter's results support the "institutions hypothesis" as they indicate that Qing China's provincial border produced larger impact than waterway network and physiographic distribution on shaping the market integration. Despite the past "institutions hypothesis" literature quantifies the statistical correlation between history and current development, the greatest shortcomings lie in the inability to identify the exact channels through geography or institutions on the long-term economic growth. This chapter concerns that how the past geography or institutions affect the historical market integration, which may fit the gap for the channel how past institutions affect today's income through the market integration.

This chapter also contributes to the trade and political border effect literature. Despite technological advances and negotiated reductions in formal trade tariff, market segmentation continues to exist. Political and administrative borders have long been considered as a major source of trade costs to explain that international markets have been more fragmented than intra-national markets (Engle and Rogers, 1996; McCallum, 1995; Parsley and Wei, 2001; Wei, 1996).The border effects can be caused by political intervention (e.g. tariffs or quotas) or policy differentials (e.g. exchange rate) accompanied directly by borders or deeper structures behind the borders which have existed prior to the borders and may persist when the political border is gone (e.g. geography or linguistic)(Heinemeyer *et al.*, 2008; Wolf, 2005). Qing China's provincial hierarchy provides a good environment to capture the real "political" border effects on trade since: first, under the unified political system like Imperial China the nation's currencies, weights, measures, languages and policies were more standardized than in politically fragmented regions; second, Qing provincial boundary was interlocked rather than coincided with the physiographic boundary, which avoid the possibility that the observed political barrier is just a reflection of natural barrier. Food security, instead of grain market revenue, was the primary concern of the Qing State. Qing's provincial governorship enables and encourages its provincial officials to intervene the grain trade to maximize local storage as "grain protectionism", which will be reflected by the impact of provincial border on the grain trade.

This Chapter also shed new light on the role of transport costs on market efficiency and further economic growth. In the United States, the introduction of railroads, steamboats and canals contributed to the transformation between inland backwoods and agricultural centres and the formation of a national labour market, while, in Europe, the transportation innovation promoted the ability of trade over a wide area (Shiue, 2002). The rise of the West implies the importance of transport cost reduction for the market performance and economic growth. However, the revolutionary decline in transport cost is always associated with institutional changes and technological innovations (Bogart, 2011). It is difficult to identify the impact of isolated transport cost. In the pre-modern period, without substantial technological revolution in transportation, geographical factors were definitely the main sources of transport cost. The grain market of 18th century in China was an environment that allows us to isolate and quantify the impact of transport cost through geographical factors since there was no substantial change affecting technology or domestic policies.

This Chapter is organized as follows. Section 4.2 discusses how geographical determinants and integrated provincial bureaucratic hierarchy affected Qing China's grade. Section 4.3 introduces a simple theoretical model of grain price behaviour linked to the framework of the Law of One Price, which gives the theoretical foundation to use Engle-Granger cointegration method for market integration estimation. Section 4.4 begins by confirming the negative relationship between market integration and distance, and South China was more integrated than North China. The results indicate that the river network affected the market efficiency heterogeneously by distance, which only plays a significant role on pairwise price cointegration of Southern China, but a significant role on pairwise price comovement in both South China and North China for the cointegrated pairs. In both regions, instead of geographic determinants, provincial borders represent the most significant barriers to market integration. One robustness check is given by comparing Southern rice and wheat market integration to make sure the differential observed between Southern rice and Northern wheat markets was not driven by the rice-wheat differentials. One conclusion is given finally.

4.2 Trade Cost Determinants: Geography or Institutions?

Following the framework of the Law of One Price, trade cost affects the strength of arbitrage, which eventually determines the extent of market integration. This section discusses how geography and institutions affect the trade cost in Qing China's grain market.

4.2.1 Geography and Transport Cost

Estimates of transport cost vary depending on source and method used, though all studies agree that the main division in transport costs was between land and water transportation (Shiue, 2002). In Pre-modern China, with limited transportation technology, water transport was far more economical and convenient than by land. China's developed waterways network connected numerous prefectures, and was essential for long-distance grain trade and commercial prosperity (See Section 2.5.4 and Section 3.3.2).

The navigability of waterways in Southern China was superior to those in the North during the Qing Dynasty: between the 13th and 19th century, the frequency of extreme flooding and breach of the Yellow River, the largest river system in Northern China, was five times larger than that of Yangtze River, the largest river system in the South (Chen, 2001; Liu, 2000). In the 18th century, the Yangtze was navigable by sizable watercraft for at least 1000*km* upstream from its mouth near the city of Shanghai (Worcester, 1971, cited in Keller and Shiue, 2007a). Yan and Liu (2011) attribute the higher level of market integration in South China to the region's more developed water transport network vis-à-vis the North. The spatial autocorrelation pattern of rice prices in Southern China in the 18th century vary systematically with access to water transport as well as other geographical determinants (Keller and Shiue, 2007a). In the Hunan Province, the rice commerce in the 18th century largely followed the province's river systems which are the main branches of upstream Yangtze River (Wong and Perdue, 1992). Easy access to waterways not only advantaged the transporting of heavy commodities, but also represents the lowered market information cost for merchant. On the production side, these waterways supplied irrigation water for high-yield rice agriculture (Elvin, 1977).

According to Skinner (1977a, b), the physical macroregion barrier was a more representative marker than the provincial barrier of the trading system. Skinner (1977a) divides China into nine 'physiographic macroregions' defined by the drainage basins of major rivers and other travel-constraining geomorphological features (see Section 3.3.3). For Skinner transport costs in the pre-modern period were determined by the geographical endowments. He concludes (Skinner, 1977b) that China's trading structure followed its natural geographical structure rather than administration structure since 1) commercial centres, which possessed geographical advantages were logical sites for public institutions such as communal temples, schools, benevolent institutions as well as the headquarters of the nonofficial institutions; 2) it was easier to extract the economic surplus the political institutions were centred in commercial centres. Skinner's model has been challenged: Wang (1989), using grain prices, shows significant prices correlation between key macroregions in the 18th century; Sands and Myers (1986) present historical evidence to show that the macroregions were not independent trade systems.

The geographical comparison between pairs of prefectures in South China and North China is given in Table 4.1 using geographical data introduced in Section 3.3. Dis_{ij} is the postal route distance between prefecture i and j; $River_{ij}$ equals to 1 if two prefectures access to the same grain river; Pro_{ij} equals to 1 if two prefectures are in the same province; Ski_{ij} equals to 1 if two prefectures are in the same macroregion. Most of the prefectures in North China were located on the plains while many prefectures in South China were in hilly areas. There are 15 Skinner regions (including macroregions and sub-macroregions) over which my grain price data are distributed, of which 11 regions are Southern provinces (11 provinces) while four regions cover Northern provinces (six provinces). North China's prefectures located closer to each other (lower average and standard deviation of distance) and they possessed fewer natural barrier (the likelihood of being in the same macroregioin was higher), which is a geographical advantage for market evolution. Since Southern China possessed more developed waterway transport network, 31.1% of pairs in South accessed the same grain-trade river whilst the corresponding rate in North China was 24.3%.

Table 4.1 Geographic Comparisons

	South (17030 pairs)		North (6320 pairs)	
	Mean	Standard Deviation	Mean	Standard Deviation
Dis_{ij}	1062.23	506.403	783.369	466.565
$River_{ij}$	0.311	0.463	0.243	0.429
Pro_{ij}	0.085	0.279	0.162	0.368
Ski_{ij}	0.121	0.326	0.437	0.496

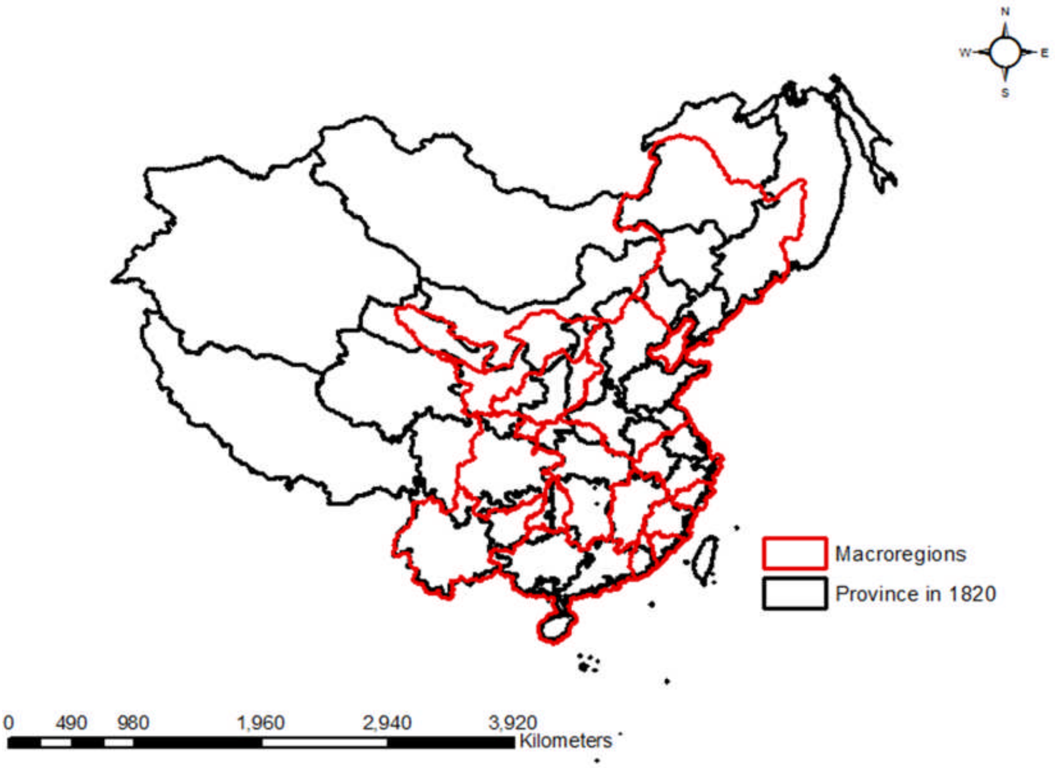
4.2.2 Qing Provincial System

In China, the creation of provincial administration under the unified regime can be traced back to its Yuan Dynasty (CE 1721-1368), developed in Ming Dynasty (CE 1369-1644), and became stable, comprehensive and effective in the Qing Dynasty

(CE 1644-1911). The Qing’s integrated provincial bureaucratic hierarchy was initially created by Shunzhi Emperor (CE 1638-1661) and Kangxi Emperor (CE 1662-1722), which was transitioned and partitioned from five main military regions into eighteen provinces. It took place in North China in the 1650s, the Lower Yangtze in the 1660s and 1670s, the southeast coast in the 1680s, the Middle Yangtze and Lingnan by 1700, and finally Guizhou and Yunnan in the 1740s and the northwest in the 1750s (Duan, 2009; Fu, 2008, 2009; Guy, 2010). This transition process was almost completed before the data period I investigated.

The Qing State delegated power at the provincial level to provincial governors. These governors were appointed by the emperors. They were the pivotal middlemen between the central state and a provincial administrative organization that reached down to the prefecture and county. On the one hand, the governors served as a central agent who was bound to the central court interest and agenda. On the other hand, they served as the head of provincial hierarchy, and bore overall local responsibility including fiscal accounting, official evaluation and promotion, judicial review, grain storage and relief, and military policing (Guy, 2010). Qing’s administrative territory boundary seldom coincided but interlocked with natural boundaries. The purpose of this system was to sustain a high level of centralized governmental power, which would prevent the military independence based on the natural barriers (Zhou, 1996). From Figure 4.1 we see that most of the provincial boundaries did not coincide with the Skinner macroregional boundary.

Figure 4.1 Boundaries of Macroregions and Provinces



GIS Data Source: "GHGIS, Version 4" (Harvard Yenching Institue, 2007)

4.2.3 Bureaucratic System and Provincial Border Effect

Innovations in provincial governorship in the Qing period enabled the Qing state to rule effectively a territorially, culturally and economically diverse empire (Guy, 2010). The comparative autonomy of the provincial governors, who bore the responsibility of grain storage, allowed them to intervene in the grain trade to maximize local storage as a form of "grain protectionism".

Food Security and Grain Protectionism

Although the central state had a formal policy of non-intervention in markets from the mid-18th century, the state nevertheless sought to maintain stockpiles of grain to sell, lend, or give to poor consumers in the event of grain shortages. Confucian-trained officials conventionally perceived the profit-mindedness of merchants threatened the subsistence of the poor. However, the low fiscal revenue constrained the local official ability to import grain if local storage targets were unmet or the local area suffered the risk of widespread famine. The absolutist regime like imperial China could achieve a relatively stable path of low fiscal extraction co-evolving to prevent over-exploitation that could foment civil unrest (Ma, 2011, 2012). Consequently, Qing emperors kept taxation light and limited locally available fiscal resources, which squeezed the size of official bureaucracy at a time when population grew three fold (Sng, 2014). During the first half of 19th century before the Opium War, the Qing state's total central revenue amounted to 24% of that of Britain, while per capita tax revenue was strikingly only 1% (Ma, 2011, pp.20). After the 1740s, the high storage-level target of imperial policy put huge fiscal pressure on provincial official who needed to purchase sufficient grain as a reserve (Dunstan, 2006). In the 18th century, ever-normal granaries were expected to sell 30% of the reserves each spring, which means the local officials needed to purchase the grain every year to re-fill the granaries.

During the 18th century, a balance between local and state interests was achieved because trading taxes at the local level were very low, and the central government cared little if local magistrates appropriated these funds as revenue (Mann, 1987). According to data for 1753 in Wang (1973), taxes on internal and foreign trade accounted for only 7.3% of total tax revenue, dwarfed by the 73.5% from the taxation of privately-owned land. Food security is closely related to local peace and stability, which in turn represented the primary criterion for assessing the political achievement of local bureaucrats. Provincial level officials especially were not willing to give up grain-supply protectionism as a means to guarantee their political career in return for meagre trade tax revenue. Each year after the harvest time, the local officials at the county level would purchase the local grain with low price as much as possible. Merchant buying did not start until official purchasing was over (Dunstan, 2006). If a granary's stocks were badly depleted, arrangement should be made to buy in an adjacent province where prices were low, with a provincial subsidy if necessary. *"…[a]n ambitious state stockpiling policy would have brought trading interests unaccustomed and unwelcome levels of officials competition, especially in those markets that attracted the most buyers"* (Dunstan, 2006, p163). In addition, there were no imperial guidelines based on economic principles to guide officials' action against grain trade: these officials trained in Confucianism would tie local grain storage

Archives of officials' reports show that the high storage target encouraged provincial governors to compete for grain purchase outside of their provinces. These historical archives show that the provincial governors favoured maximizing local storage rather than selling the grain out of their administrative area.

<u>Bureaucracy and Local Merchants' Monopoly</u>

The resulting local protectionism and intervention in the grain trade was not only the outcome of political coercive power constraining merchants, but also resulted from a combination of merchants' pursuit of security and officials' search for personal enrichment. Although in China's traditional official doctrine merchants were at the bottom of the social ladder, the Qing government policy had evolved to rewarded with high social ranks and official titles for market regulation (Hung, 2008). Many Qing government officials not only understood commerce, but were deeply involved in it through the merchant network.

In the absence of formal commercial and civil codes the foundation of property rights in imperial China rested on politics rather than the law (Brandt *et al.*, 2014). The weak fiscal position and limited bureaucratic control of local governments increased their dependence of local officials on elites such as the local gentry and wealthy merchants as well as the informal taxation from local merchants. Merchants thus became key members of the informal "liturgical" structures of local governance and won the right to raise taxes (Mann, 1987). Officials expected these merchant leaders to deliver tax revenues and to control the actions of all merchants in the region/prefecture. In return, local merchants would exploit their ready access to Qing officials to guarantee the status of officially-established monopolies. Mann (1987, p62) finds that "marketers and traders unprotected by patronage or family connections were vulnerable to harassment and extortion".

Since the provincial governors served as the head of tightly organized provincial bureaucracy, it was easy for them to use the political power to intervene in grain exports (to the other provinces) through the merchant leaders who relied on their patronage. Since the primary concern of the Qing state was market regulation rather than market revenue, the unified political system tied merchants closely to its hierarchical structure, which determined that merchants' primary concern is their official status.

4.2.4 Trading Network: Geography or Bureaucratic Structure?

There are two hierarchies of China's spatial structure: bureaucratic structure of "official" China (i.e. a formal hierarchy of graded administrative posts) and natural structure of China (i.e. mountain and river network). The boundaries of administrative units seldom coincided with the boundaries of physiographic. Skinner suggests that the network of trading followed the geography while Qing officials imposed their grain trade intervention within boundaries shaped by the bureaucratic structure.

The validity of Skinner's hypotheses depends on that whether transport cost was as important for commercial development as he describes. Many literatures suggest that the role of transport cost on market integration has been over-estimated. Based on yearly grain price from 100 European cities between 1620 and 1913, Chilosi *et al.* (2013) found evidence that the integration of the European market was primarily due to liberal policies rather than transport technology. Jacks and Pendakur (2008)'s estimates of the impact of bilateral freight rates on bilateral trade from 1870 to 1913 suggests that income growth and convergence were the primary drivers of the global trade boom in the 19th century rather than the revolution in maritime transport. Federico and Persson (2007) argue in their study of the process of wheat market integration between the United States and the United Kingdom from the early 19th century to present that changes in trade policies rather than international transport cost reductions were the single most important factor explaining convergence and divergence of prices in the long run. Although British India witnessed sharp price convergence in wheat and rice markets, the vast railway system established during the same period 1861 to 1920 explains only about 20% of the decline in grain price dispersion, which implies that the effect of railways cannot be separated from the other institutional forces pushing towards more market integration (Andrabi and Kuehlwein, 2010).

Since South China possesses a more developed waterway network than North China, it is expected that the South China market was more integrated since river transport is central to the grain trade. If the role of transport cost has been over-estimated, the importance of geographical endowments for commercial development in the pre-modern period would have been over-stated as well. In the latter empirical section, I will compare the different impacts from provincial barriers, macroregional barriers, and the river network and the other geographical determinants for market integration, which would help us to re-consider and identify the dominated driving force behind the market performance in pre-modern China.

4.3 Methodologies

The Law of One Price (LOOP) implies that prices for the same product sold in different markets converge to a stable differential (representing trade costs) due to arbitrage and market forces. The convergence to the LOOP in my case of grain markets implies that within integrated markets the time series of the grain price ratio between any two locations is stationary, with transportation and transaction cost in trade providing reasons for a permanent (fixed) price wedge between specific locations. In the following I set out my theoretical motivation and discuss the Engle-Granger cointegration methodology employed to investigate the nature and determinants of grain price convergence in Qing Dynasty China.

4.3.1 Theoretical Framework

This chapter focuses on the spatial grain market integration in Qing China based on the analysis of Southern rice markets and Northern wheat markets. The empirical work in this study is based on a theoretical framework developed in Deaton (1999) and Deaton and Laroque (1996) which I sketch in the following paragraphs.

I begin with a price model for an agricultural commodity within a single market. In each time period t, t=1,…, T, there is an inelastically supplied harvest output h_t, which follows a stochastic process characterized by the cumulative distribution function $\Phi(h, \mathrm{H})$.

$$\Phi(h, \mathrm{H}) = \Pr\,(h_{t+1} \leq \mathrm{H}_t \mid h_t = h) \qquad (4.1)$$

Shocks to harvest output are exogenous, determined by the conditions in agricultural production, which ultimately drive the behaviour of price.

As there is assumed to be no storage, all of the harvest output h_t will be consumed within each period. The local price at time t can then be written as a function of output:

$$P_t = a + bh_t \qquad (4.2)$$

where $a(>0)$ and $b(<0)$ are parameters. Because consumers are assumed to be the only buyers in the market (no speculation), price behavior is driven by production behavior and harvests. It is assumed that harvest output follows a simple AR(1) process

$$h_{t+1} = \rho h_t + \varepsilon_{t+1} \qquad (4.3)$$

where $-1 < \rho \leq 1$, and the error term ε_t is i.i.d with mean 0. In equation (4.3), in the case of $\rho=1$, weather shocks or other unexpected events will have a permanent effect on h_t and thus through equation (4.2) on the grain price. Following Shiue and Keller (2005, 2007) I maintain this assumption in the present study and provide further motivation below. Given this assumption, both harvest output and grain prices follow a random walk process,

$$P_{t+1} = P_t + u_{t+1} \qquad (4.4)$$

where $u_{t+1} = b\varepsilon_{t+1}$. I adopt the equation (4.4) here as the point of departure for the latter cointegration analysis. Until now there is no consensus yet on a model of agricultural price behavour which both account short-term and long-term dynamics.

I now move away from a single location and adopt the LOOP framework to link prices to trade cost. Consider an economy with many locations, n=1,…, N, where consumers in all locations have the same preferences and all producers have the same technology for grain production. There is no grain storage facility in any of the locations or at any period in time. Geographical separation (remoteness, distance, accessibility) is one main reason why prices across regions may not equalize across markets.

Iceberg transport costs are widely used in the trade literature to describe this feature theoretically, for example: exporters in location *i* have to send z>1 units for each unit of good to arrive at the destination market *j*. Price arbitrage in grain markets will drive the price ratio between locations *i* and *j* within the following band:

$$1/z \leq (P_{it} / P_{jt}) \leq z \qquad (4.5)$$

T_{ij} is defined as the trade cost for each unit of grain to be shifted from *i* to *j*.

$$T_{ij} = z - 1 \qquad (4.6)$$

Following the standard literature T_{ij} is defined as a function of bilateral distance given that the transport cost between neighboring locations can be assumed to be smaller than that between distant location pairs. Because transport costs differ by mode of transport (e.g. overland grain transport is more costly than grain transport on water), transport cost also reflects an area's topography (e.g. waterways and mountains) as well as the quality of the trade route (e.g. road maintenance). Trade cost is however a broader concept than transport cost. In addition to distance there are other factors that determine the degree of price arbitrage and thus price equalization between locations, such as differential taxation and property rights, risks associated with bandits on specific trading routes as well as the monopoly power of local guilds (i.e. local protectionism) (Wong, 2004; Shiue and Keller, 2005).

$$T_{ij} = T\,(\text{Distance, Other Factors})_{ij} \qquad (4.7)$$

Market integration can be measured using T_{ij}. The smaller T_{ij} the smaller is the band of arbitrage for the price ratio between locations *i* and *j* in the long-run equilibrium.

4.3.2 Engle-Granger Cointegration Method

In econometric terms, if there is a linear combination between nonstationary price series which turns out to be stationary, these price series are said to be cointegrated (Granger, 1981; Engle and Granger, 1987). Pair-wise cointegration then implies that market integration induces price arbitrage between these two locations, such that while prices may deviate for short time periods the difference between the two price series cannot become arbitrarily large over the long time horizon. *A priori*, I would hypothesise that it is more likely that the price series between two locations cointegrate if their bilateral trade cost T_{ij} is smaller.

I begin my analysis by investigating the time-series properties of grain price data in pairs of prefectures for the South (rice) and North (wheat) of China, respectively. In this part of the analysis I assume cross-section independence between prefectural pairs and investigate the long-run price behavior over the entire time horizon from 1740 to 1820. Having established that all price series represent non-stationary processes, I investigate whether pairs of prefectures nevertheless display co-movement over the long-run, which is taken to be a test for market integration between the two locations (Goldberg and Verboven, 2005; Fan and Wei, 2006). Prices do not need to equalise in order to be cointegrated, given that a host of trade cost factors as mentioned above can continue to sustain differential pricing. As indicated above my analysis here uses the entire time-series dimension of the data and for each prefecture pair I arrive at a single (cointegration) statistic.

In line with the existing literature on market integration in China (Shiue and Keller, 2005, 2007), the canonical Engle and Granger (1987) method to investigate cointegration is implemented as follows. All of the price series enter the regressions below transformed using logarithms. I estimate the candidate cointegration regression for each prefectures pair *ij*

$$\ln(P_{it})=\alpha_{ij}+\beta_{ij}\ln(P_{jt})+\varepsilon_{ij,t} \qquad (4.8)$$

where P_{it} and P_{jt} denote the price series in locations *i* and *j* respectively. The constant α_{ij} captures long-run differences in the price levels.[32] If $\ln(P_{it})$ and $\ln(P_{jt})$ are cointegrated, the linear combination $\varepsilon_{ij,t} = \ln(P_{it}) - (\alpha_{ij}+\beta_{ij}\ln(P_{jt}))$ will be stationary, with the coefficient β_{ij} capturing the long-run relationship between the two prices. The practical econometric test for cointegration is to establish whether $\varepsilon_{ij,t}$ is stationary, which in this first part of my study is implemented in line with Shiue and Keller (2005, 2007) by use of augmented Dickey and Fuller (1979) tests for the N(N-1) residual series $\varepsilon_{ij,t}$ for rice and wheat respectively:

[32] Although Qing China nominally had unified currency, the exchange rate between silver and copper varied between areas. Local officials converted local prices into the standard treasury tael for reporting grain prices.

$$\Delta\hat{e}_{ij,t} = \varphi_{ij}\hat{e}_{ij,t-1} + \sum_{l=1}^{p_{ij}} \delta_{ij,l}\Delta\hat{e}_{ij,t-l} + \nu_{ij,t} \qquad (4.9)$$

H_0: $\varphi_{ij}=0$

H_1: $\varphi_{ij}<0$

where the sum on the right hand side of equation (4.9) represents lagged differences of the residual series to capture short-run variation in the data. P_{it} and P_{jt} are not cointegrated if the null hypothesis of unit root (i.e. $\varphi_{ij}=0$) cannot be rejected. The rejection of the null hypothesis of unit root behavior is determined by the t-ratio of the φ_{ij} parameter (critical values follow non-standard distributions).[33] The stronger is the evidence that $\varphi_{ij}<0$, the more evidence favors the market integration between locations *i* and *j*. In an integrated market, the non-stationarity of the error term $\varepsilon_{ij,t}$ in equation (4.8) can also be driven by the non-stationary transport cost even though two prices cointegrate (Goodwin, 1992;Granger, 1986; Hsu and Goodwin, 1993). To maintain that my cointegration results are interpretable, it is necessary to assume that transportation technology in the period I investigated does not change, which has been strongly suggested in the historical literature (Eastman, 1988; Fan, 1993).

In practice I will estimate a variant of the candidate cointegration relationship in equation (4.8) by adding monthly indicator variables (i.e. μ_m)[34] to the model to avoid seasonal effects:

[33] The critical values of the ADF t-statistics are a function of time series length T. It is easier to reject the null hypothesis as T increases. In practice, I will drop out the missing observation for each pair-wise such that T is varied across pair-wises. I use the response surface results in MacKinnon (1991) to adjust the critical values and then ensure that the significance levels stay constant while T changes.
[34] I set the monthly dummy equal to 1 for the months in the harvest seasons during which the grain prices are expected to be lower than the normal months. According to Buck (1937) and seasonality

$$\ln(P_{it}) = \alpha_{ij} + \beta_{ij}\ln(P_{jt}) + \mu_m + \varepsilon_{ij,t} \qquad (4.8')$$

The magnitude of the t-ratios on the α_{ij} parameters in my Augmented Dickey Fuller regressions, which were subject to further empirical analysis in Shiue and Keller (2005, 2007), merely provide evidence for the *likelihood* of cointegration between two prefectures' price series: cointegration is not a continuous concept, but a binary one, in that variable series are either cointegrated or not. Higher *t*-ratios beyond specific critical values provide strong evidence for cointegration and thus market integration, while lower *t*-ratios provide weak evidence of market integration. My analysis will thus result in a set of cointegrating (C_{ij}=1 at the 5% level) and a separate set of non-cointegrating (C_{ij}=0) bilateral price series corresponding to prefecture pairs with integrated markets and prefecture pairs whose markets are not integrated. My subsequent analysis outlined below differs from the approach taken in Shiue and Keller (2005, 2007) by investigating presence or absence of cointegration rather than the magnitude of the *t*-ratios.

Note that in practical terms I cannot employ the simple cross-section average augmentation as developed in the next Chapter (Chapter 5) to the cointegration equation setup in equations (4.8) or (4.8'): whether P_{it} and P_{jt} cointegrate or not, the cross-section averages would account for any non-stationary elements in the unobservables so that the remaining residuals from the augmented regressions will be *I(0)* by construction.

---

analysis in Chapter 3.4.5, both for rice and wheat, the months of May, June, July, August and September and October are selected as harvest months. I have experimented with alternative selections, all of which yield the same qualitative conclusions in the cointegration approach.

4.4 Results

Following the methodology discussed above, I first present Engle-Granger cointegration tests based on the comparison between South China and North China, and then employ cross-section regression to identify the role of water-way network on the South-North differential. Then, focusing on the rice markets in South China, I run cross-section regressions to determine whether and to what extent price convergence was affected by physiographic or political structure.

4.4.1 Southern and Northern Market Integration

Following methodology in Shiue and Keller (2005, 2007), Figure 4.2 presents the average ADF *t*-statistics (lag augmentation determined by AIC differs by prefecture-pair) for the rice price series of 131 prefectures in South China (17,030 prefecture pairs) and the wheat price series of 80 prefectures in North China (6,320 prefecture pairs) as a function of bilateral distance. Both for rice and wheat the highest average t-statistics in absolute terms (strongest evidence for cointegration) are in the distance category of less than 200 kilometers, and the average *t*-statistics decrease in absolute value (weaker evidence for cointegration) with bilateral distance. This evidence supports the expectation in the trade literature that it is more likely for relatively nearby markets to be integrated due to the comparatively smaller bilateral trade cost. Figure 4.2 also features the comparison between rice markets in South China and wheat markets in North China, which suggests that there is more robust evidence for market integration in South China than in North China for any bilateral distance category.

As argued above the *t*-statistics given from ADF regressions merely indicate the likelihood of two prefecture price series being cointegrated, but are not indicative of the extent of market integration or strength of price arbitrage. This aside, the average *t*-statistics in Figure 4.2 may be driven by extreme *t* values in each distance group. In Figure 4.3, I therefore present the share of cointegrated prefecture pairs both for rice and wheat markets as another indication for the degree of market integration in each region. In both cases the highest share of cointegrated price series appears in the smallest distance category. For the pairs in the distance category between 0 and 200*km*, 80% of pairs in South China but only about 60% of pairs in North China were cointegrated. The shares monotonically decline with bilateral distance but South China possessed larger shares for any distance group. Figures 4.2 and 4.3 imply that in the period between 1740 and 1820 grain markets in South China were more integrated a finding which is consistent with qualitative evidence on the relative degree of commercialization and development in South China, especially in the Yangtze River Delta (Fan, 1993; Li, 1998; Shiue, 2002; Wu, 1985). To avoid the bias driven by the possible trend stationary time series, I replicate the methodology in Figure 4.3 for the sub-sample excluding the series with possible trend stationarity, which is shown in Figure B.4 in Appendix B.4 and gives the same quantitative conclusion.

Figure 4.2 Average Cointegrated Test Statistic in Distance

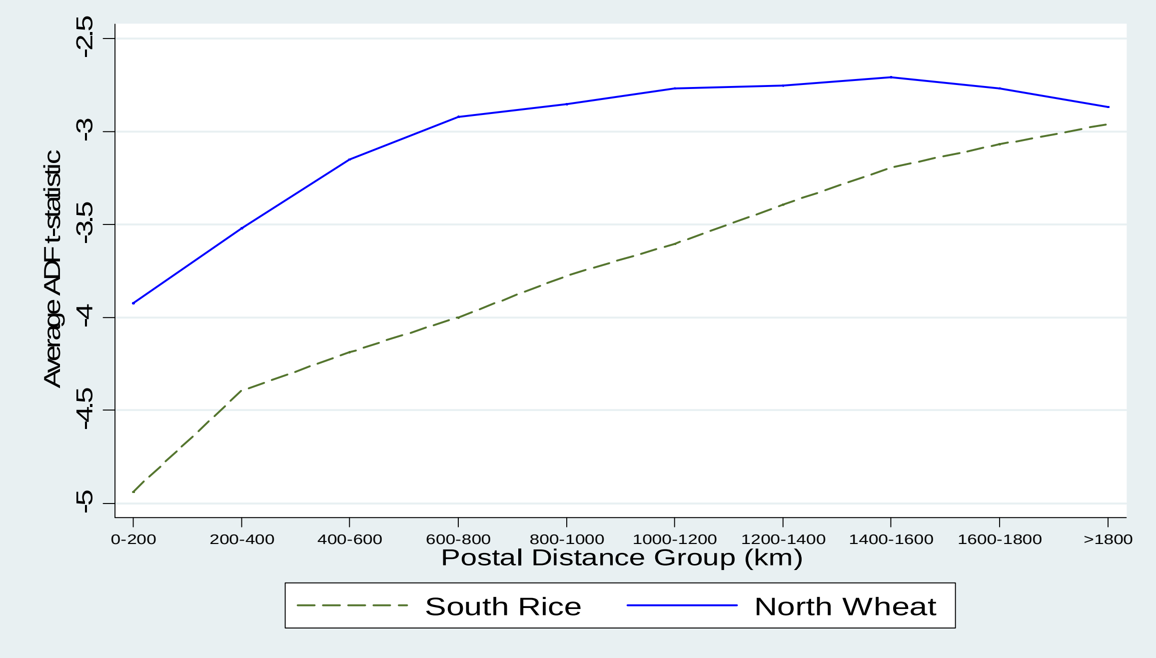
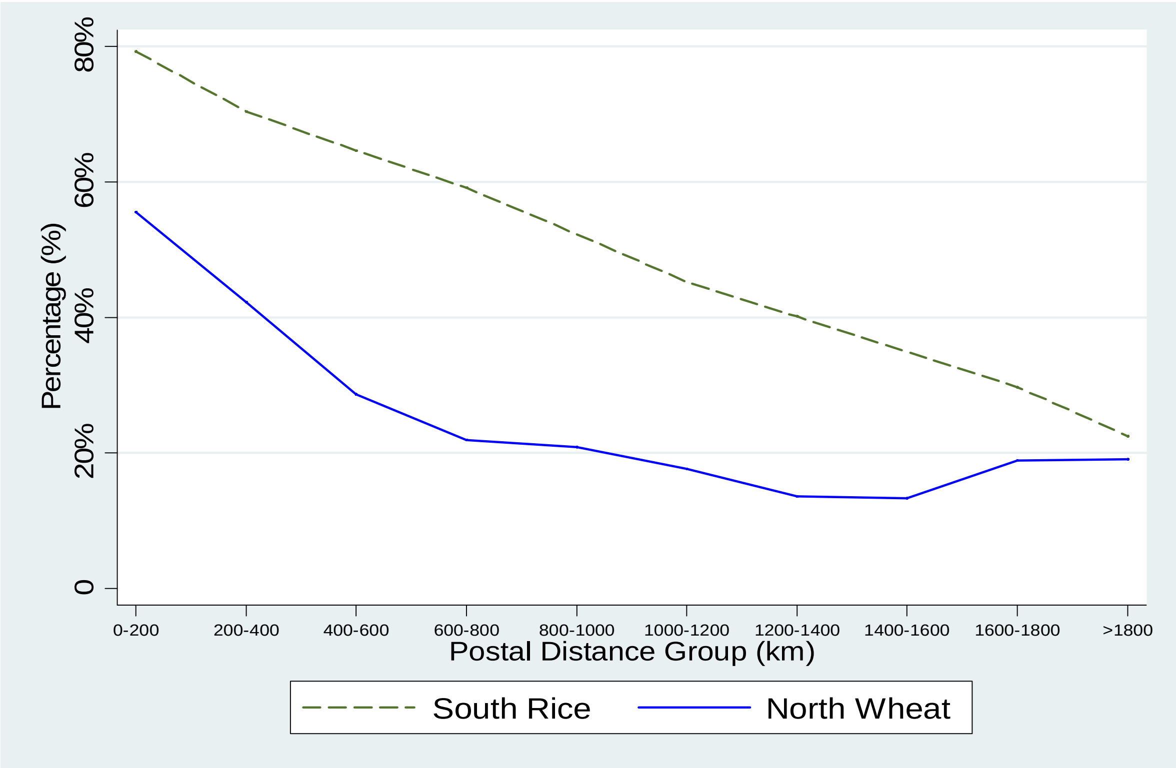


Figure 4.3 Share of Cointegrated Prefecture Pairs by Distance



4.4.2 Determinants of Market Integration

I now turn to the analysis of the patterns and determinants underlying the observed market integration results. It is hypothesized that market evolution in pre-modern China were dominated by the impact of the transport network, which was mainly composed of the navigable waterway system (Skinner, 1964; 1977a, 1977b). The importance of water transport for the grain trade during the Qing has received substantial attention in the economic history literature (Evens, 1984; Fan, 1993; Wang, 1992; Wong and Perdue, 1992; Yan and Liu, 2011). Yan and Liu (2011) attribute the higher level of market integration in South China to the region's more developed water transport network vis-à-vis the North. In a first step to investigate the patterns and geographical determinants of market integration, I use the following linear probability regressions to analyze the N(N-1) prefecture pairs:

$$C_{ij} = \alpha + \pi_1 \ln(Dis_{ij}) + \pi_2 River_{ij} + \pi_3 Pro_{ij} + \pi_4 \left[\ln(Dis_{ij}) \times Pro_{ij}\right] + \sum_{k=1}^{9} \nu_{ij,k} \left[River_{ij} \times Dis\_G_{ij,k}\right] + \theta_i + \theta_j + \theta_{i^* j^*} + \mu_{ij} \quad (4.10)$$

where C_{ij} is the binary dummy for cointegration from the pairwise Engle-Granger tests; Dis_{ij} is the postal route distance in kilometers between prefectures *i* and *j*; Pro_{ij} is a dummy variable indicating whether both prefectures are locate within the same province; $River_{ij}$ is a dummy variable indicating whether one of the main grain trade rivers passes through both prefectures *i* and *j*; θ_i and θ_j are fixed effects for prefectures *i* and *j*; and θ_{i*j*} captures the seasonality across different cropping patterns. Based on Figure 2.4(b) in Section 2.5.6, i^* denotes the crop area for prefecture i while j^* denotes this for prefecture j. $\theta_{i^*j^*}$ represents a group of dummies for any combination of crop area between i^* and j^*, which will capture the price co-movement driven by the similar climate and harvest time in the long run[35]. To capture potential heterogeneity of river impact across different distance, $Dis\_G_{ij,k}$ is defined as a set of categorical dummies[36] for each distance group as below:

$$Dis\_G_{ij,k} \begin{cases} =1 \text{ if } (k\text{-}1)\times 200km < Dis_{ij} \leq k\times 200km & (k=1,2,\ldots 9) \\ =0 \text{ if otherwise} \end{cases} \qquad (4.11)$$

The linear probability models are employed for regression (4.10) results of which are reported in Table 4.2. Results from separate regressions of equation (4.10) for rice (South) and wheat (North) will provide insights into the determinants of market integration, distinguishing markets that do from those that do not integrate. In my discussion I focus on the sign and statistical significance of covariates in the linear probability model results. Although the dependent variable is binary in nature, I prefer to employ this approach over a nonlinear estimator (e.g. Probit Model) since this make interpretation, especially of interaction effects, much easier to handle. [37]

In all columns reported in Table 4.2, except column 4 for Northern China, the distance variables are negative significant, which implies that the probability of market integration is higher for markets which are closer to each other. This result supports our findings in Figures 4.2 and 4.3. In column 1 and 2, the magnitudes of

[35] It is possible that the agricultural price co-movement was driven by the common factor (e.g. weather) rather than market link. In this chapter, I am interested in the market determinents in the long run rather than short run such that the fixed effects of agricultural areas (discussed in Section 2.5.6) are suffiecnt to capture the climate common factors in the long run.
[36] The omitted category is the group dummy for the distance between 1800*km* and 2000*km*.
[37] Probit results for (4.11) also strongly support our conclusions based on the OLS results, see Appendix B.1.

$\ln(Dis_{ij})$ for Southern China are smaller, which implies that in the South distance is associated with lower trade costs since a decrease in distance between two markets ceteris paribus induces a higher likelihood of price integration. In column 4, the insignificance of the distance variable has two possible interpretations: 1) the regional market was highly integrated such that there was no association between trade and distance; 2) the regional market was highly disintegrated such that the trade costs associated with distance became infinitely large. The empirical results provided below suggest that the second explanation is a better fit to the extent of North China's market integration.

In columns 1 and 2, both prefectures being on the same grain river significantly increases the probability of integrated markets in Southern China, but not in Northern China. This feature suggests that the network of waterways strengthen price arbitrage only in South China, a finding which is consistent with previous suggestions that waterway navigability in South China was considerably better than in the North of the country. The results for the common province dummy in the first two columns of Table 4.2 suggest that it is more likely for prefecture pairs to have integrated markets if they are located within the same province. The coefficients on the common province dummies are considerably larger than those for the common grain river dummies, which indicate that provincial borders represent comparatively stronger barriers even in a political unified economy, where currencies, weights, measures and languages were more standardized than in comparable politically fragmented regions of the world (e.g. Western Europe).[38]

[38] It is possible that the significant province dummies are driven by the distinction between short and long distance trade rather than province border barrier since bilateral distance is much smaller within the same

This evidence of provincial barriers on grain trade implies that the water transport network on its own cannot fully explain the differences in market performance between South China and North China. It also suggests that provincial officials significantly intervened in the grain trade.

In columns 3 and 4 of Table 4.2, I add a series of interaction terms to test the additional 'distance penalty' on the common province and grain river dummies. In both columns, Pro_{ij} is still significant to confirm the trade barrier nature of provincial borders while the interaction term $Pro_{ij} \times \ln(Dis_{ij})$ reflects that the distance penalty only applies to the provincial border in Northern China. These findings support the hypothesis that China's market was fragmented along provincial borders, and that the extent of fragmentation was more substantial in Northern China.

In terms of water transport, the combinations between $River_{ij}$ and its interaction terms with the set of distance dummies - $River_{ij} \times Dis\_G_{ij,k}$ $(k=1,2\ldots,9)$ capture the heterogeneous impact of waterway network across different distance group. In Table 4.3, I test the joint significance of $River_{ij}$ dummy and its interaction terms in each distance group. If I can reject the null hypothesis that their joint impact in one specific distance group (e.g. $200<x\leq400km$) is zero (e.g. H_0: $\pi_2 + v_{ij,2} = 0$, where π_2 and $v_{ij,2}$ are the coefficients of $River_{ij}$ and $River_{ij} \times Dis\_G_{ij,2}$ in regression (4.10)), this can provide support for the significant net impact of waterways network on the market integration in this distance group.

province. As robust checks, we compare the pair cointegration percentage of within and without the same province, which yields the same qualitative conclusions. These results are in Table B.2 and B.3 in Appendix B.2.

Table 4.2 Market Integration, Geography and Institutions (OLS)

Dependent Variable: $C_{ij} = \{0,1\}$	South Rice	North Wheat	South Rice	North Wheat
	(1)	(2)	(3)	(4)
$\ln(Dis_{ij})$	-0.0314	-0.0587	-0.0336	-0.0223
	(0.0076)***	(0.0127)***	(0.0091)***	(0.0147)
$River_{ij}$	0.043	0.0086	-0.065	0.0794
	(0.0105)***	(0.0169)	(0.027)**	(0.091)
Pro_{ij}	0.222	0.264	0.343	0.833
	(0.0139)***	(0.0176)***	(0.124)***	(0.146)***
$Pro_{ij} \times \ln(Dis_{ij})$			-0.0183	-0.096
			(0.0207)	(0.024)***
$River_{ij} \times Dis\_G_{ij,1}(x \leq 200km)$			-0.0127	-0.0153
			(0.0428)	(0.0998)
$River_{ij} \times Dis\_G_{ij,2}(200 < x \leq 400km)$			0.1033	-0.0472
			(0.0327)***	(0.0948)
$River_{ij} \times Dis\_G_{ij,3}(400 < x \leq 600km)$			0.1347	-0.0777
			(0.031)***	(0.0928)
$River_{ij} \times Dis\_G_{ij,4}(600 < x \leq 800km)$			0.1607	-0.092
			(0.0296)***	(0.0918)
$River_{ij} \times Dis\_G_{ij,5}(800 < x \leq 1000km)$			0.1403	-0.112
			(0.0285)***	(0.093)
$River_{ij} \times Dis\_G_{ij,6}(1000 < x \leq 1200km)$			0.101	-0.0492
			(0.0287)***	(0.0953)
$River_{ij} \times Dis\_G_{ij,7}(1200 < x \leq 1400km)$			0.068	-0.117
			(0.029)**	(0.0945)
$River_{ij} \times Dis\_G_{ij,8}(1400 < x \leq 1600km)$			0.0425	-0.127
			(0.0303)	(0.0941)
$River_{ij} \times Dis\_G_{ij,9}(1600 < x \leq 1800km)$			0.0399	-0.1723
			(0.0298)	(0.0937)*
θ_i	Yes	Yes	Yes	Yes
θ_j	Yes	Yes	Yes	Yes
θ_{i*j*}	Yes	Yes	Yes	Yes
No. of Obs.	17,030	6320	17,030	6,320
R^2	0.4819	0.3865	0.4542	0.3898

Note: We omit reporting fixed effects, seasonality and the constant. Robust standard errors provided in parentheses; ***, ** and * denote 1%, 5% and 10% significance level, respectively

Table 4.3 Heterogeneity of Water Impact on Cointegration			
Distance Group	*Null Hypothesis*	*p-value*	
		South Rice	North Wheat
(0, 200km]	H_0: $\pi_2 + v_{ij,1} = 0$	0.0226	0.1218
(200, 400km]	H_0: $\pi_2 + v_{ij,2} = 0$	0.0527	0.2813
(400, 600km]	H_0: $\pi_2 + v_{ij,3} = 0$	0.0000	0.9390
(600, 800km]	H_0: $\pi_2 + v_{ij,4} = 0$	0.0000	0.5948
(800, 1000km]	H_0: $\pi_2 + v_{ij,5} = 0$	0.0000	0.2565
(1000, 1200km]	H_0: $\pi_2 + v_{ij,6} = 0$	0.0286	0.4191
(1200, 1400km]	H_0: $\pi_2 + v_{ij,7} = 0$	0.8637	0.3264
(1400, 1600km]	H_0: $\pi_2 + v_{ij,8} = 0$	0.2918	0.2724
(1600, 1800km]	H_0: $\pi_2 + v_{ij,9} = 0$	0.2652	0.0381

Note: π_2 and $v_{ij,k}$ are the coefficients of $River_{ij}$ and $River_{ij} \times Dis\_G_{ij,k}$ in OLS regression (11); p-value below 0.05 means reject the H_0 with 5% significance.

The results in Table 4.3 confirm that the 'grain rivers' had statistically significant impact on Southern market integration for distances below 1200km. The significant net coefficients between $River_{ij}$ and $River_{ij} \times Dis\_G_{ij,k}$ in each distance group (e.g. in $200<x\leq400km$, $-0.065+0.1033>0$) suggest that $River_{ij}$ in this distance group is associated with higher probability of market integration. For South China in column 3, although the $River_{ij}$ dummy enters negatively significant, its interaction terms with distance dummies are positive significant and larger than the absolute value for the *400km* to *1400km*. However, for the distance group between 1200 and 1400*km*, the net impact from river is considered to be insignificant since the sum of coefficients is tiny (i.e. $-0.065 + 0.068 = 0.003$). These results imply that water transport does not have expected positive impact for the closest pairs ($\leq200km$) and the most distant pairs ($>1200km$) in South China. One possible explanation for this finding for proximate prefectures is that the distance-unrelated cost of water transport (e.g. cost of loading and uploading) is large relative to benefit of water transport, such that short-distance water transport was not profitable. On the other hand, the insignificant impact of river transport observed for distances larger than *1200km* suggests grain river over the very long distance did not shape market integration and its evolution in Southern China. In stark contrast, for North China, both the river and most of its interaction terms with distance dummies are insignificant. In column 4 the pattern of results for the role of river transport in northern China's market integration strongly supports the previous conclusion that river transport has no impact on market performance in North China.

In the probit results for regression (4.10), presented in Table B.1 in Appendix B.1, I calculated the magnitude and statistical significance of the interaction effect for all interaction terms, following the re-derived formulas in Ai and Norton (2003) and Norton *et.al.* (2004) (see results in Appendix B.1). All results are consistent with the result pattern in Table 4.2. The Table B.4 in Appendix B.4 gives the regression of (4.10) for sub-sample excluding the possible trend stationary series, which gives the similar quantitative conclusions compared with Table 4.2. The only difference is that the river dummy for South rice is insignificant in column 1 of Table B.4, which is due to that most of possible trend stationary prefectures (have been excluded) locate in the Jiangxi Province along the largest transportable river Yangtze River.

4.4.3 Physiographic or Political Boundaries?

In the previous section I have shown that the impact of river transportation was one crucial determinant of greater market integration in Southern China, but that this effect was dominated by the province dummy. It is still possible that the provincial border effect observed was driven by the physiographic environment, rather than political boundaries. In Section 4.2.2, I noted that Qing China's provincial boundaries did not coincide with the physiographic boundaries of Skinner's macroregions, a distinction which offers a suitable experiment to investigate the influence of the latter (and thus that of geography) on grain market integration. Focusing on Southern rice markets[39] I analyse the relationship between Skinner macroregions and market integration by adding a dummy variable into equation (4.10) :

$$C_{ij} = \alpha + \pi_1 \ln(Dis_{ij}) + \pi_2 River_{ij} + \pi_3 Pro_{ij} + \pi_4 Ski_{ij} + \pi_5 \left[\ln(Dis_{ij}) \times Pro_{ij}\right] + \sum_{k=1}^{9} v_{ij,k} \left[River_{ij} \times Dis\_G_{ij,k}\right] + \theta_i + \theta_j + \theta_{i^* j^*} + \mu_{ij} \quad (4.12)$$

where Ski_{ij} is equal to 1 if two prefectures located into the same Skinner macroregion.

The results for regression (4.12) are presented in Table 4.4. In column (2), the coefficient of Ski_{ij} enters statistically significantly with positive sign, its magnitude slightly larger than that of the river dummy but still substantially smaller than that of the province dummy. This result suggests that macro-regional frontiers do act as barriers to trade since they reduce the likelihood of cointegration for any pair of prefectures in different Skinner regions. Compared with column (1), adding Ski_{ij} in column (2) reduces the magnitude of all the other variables, which confirms that the impact from river transport and political structure is overestimated if we omit including geographical/natural barriers to trade. However, in terms of

[39] In Northern China there were fewer physiographic barriers with most prefectures in the sample located in the plains such that 60% belong to the same Skinner macroregion ('North China').

magnitudes of these effects, provincial boundaries still dominate geographical boundaries. In column (3) and (4), after adding interaction terms with distance for $River_{ij}$ and Pro_{ij}, the pattern of the result is still consistent with the results in column (1) and (2).

In this section, combined with the two earlier ones, I have provided further evidence to conclude that the role of transport cost in determining market performance in pre-modern China has been overestimated:. river transport and physiographic boundaries affected the market integration significantly, but were dominated by the influence of provincial frontiers. I would argue that under the Qing's centralized polity, provincial governors were given a political monopoly in their localities and were further incentivised to limit grain exports (i.e. "grain protectionism") in order to maximize local food security. At the same time merchants were incentivised to submit to this political intervention on the grain trade in exchange for security for their assets and properties. While there is no direct evidence to link the political barriers to trade I observe to this grain protectionism discussed, I would argue that the magnitude of provincial barriers to trade at the very least highlight that in terms of market evolution institutional barriers dominated geography during this period of the Qing Dynasty.

Table 4.4 Market Integration, Geography and Institutions (OLS, South only)

Dependent Variable: $C_{ij} = \{0,1\}$

	(1)	(2)	(3)	(4)
$\ln(Dis_{ij})$	-0.0314	-0.023	-0.0336	-0.029
	(0.0076)***	(0.0077)***	(0.0091)***	(0.0091)***
$River_{ij}$	0.043	0.034	-0.065	-0.069
	(0.0105)***	(0.0106)***	(0.027)**	(0.028)**
Pro_{ij}	0.222	0.187	0.343	0.278
	(0.0139)***	(0.0157)***	(0.124)***	(0.1237)**
Ski_{ij}		0.07		0.072
		(0.0125)***		(0.0127)***
$\ln(Pro_{ij}) \times ln(Dis_{ij})$			-0.0183	-0.013
			(0.0207)	(0.0207)
$River_{ij} \times Dis\_G_{ij,1(x\leq 200km)}$			-0.0127	-0.027
			(0.0428)	(0.0426)
$River_{ij} \times Dis\_G_{ij,2(200<x\leq 400km)}$			0.1033	0.089
			(0.0327)***	(0.033)***
$River_{ij} \times Dis\_G_{ij,3(400<x\leq 600km)}$			0.1347	0.12
			(0.031)***	(0.031)***
$River_{ij} \times Dis\_G_{ij,4(600<x\leq 800km)}$			0.1607	0.155
			(0.0296)***	(0.03)***
$River_{ij} \times Dis\_G_{ij,5(800<x\leq 1000km)}$			0.1403	0.14
			(0.0285)***	(0.0286)***
$River_{ij} \times Dis\_G_{ij,6(1000<x\leq 1200km)}$			0.101	0.101
			(0.0287)***	(0.0286)***
$River_{ij} \times Dis\_G_{ij,7(1200<x\leq 1400km)}$			0.068	0.068
			(0.029)**	(0.0291)**
$River_{ij} \times Dis\_G_{ij,8(1400<x\leq 1600km)}$			0.0425	0.041
			(0.0303)	(0.03)
$River_{ij} \times Dis\_G_{ij,9(1600<x\leq 1800km)}$			0.0399	0.04
			(0.0298)	(0.03)
θ_i	Yes	Yes	Yes	Yes
θ_j	Yes	Yes	Yes	Yes
θ_{i*j*}	Yes	Yes	Yes	Yes
No. of *Obs*.	17,030	17030	17,030	17,030
R^2	0.4819	0.483	0.4542	0.4854

Note: We omit reporting fixed effects, seasonality and the constant. Robust standard errors provided in parentheses; ***, ** and * denote 1%, 5% and 10% significance level, respectively

4.4.4 Determinants of Price Comovement

Instead of a binary dependent variable (presence or absence of price cointegration) in regression (4.10), I now consider a continuous measure for the strength of arbitrage between prefectures whose markets (price series) are (co)integrated. In regression (4.8) and (4.8'), two cointegrated price series are linear in their relationship such that captures their long-run co-movement. The larger the $\hat{\beta}_{ij}$ the stronger is the arbitrage to bind the prices to move together. There is a negative relationship between the extent of price co-movement $\hat{\beta}_{ij}$ and trade cost T_{ij}. In equation (4.13), I adopt the same set of independent variable as in equation (4.10) and adopt $\hat{\beta}_{ij}$ from the subset of cointegrated prefecture pairs as the dependent variable.

$$\begin{aligned}\hat{\beta}_{ij} &= \alpha + \pi_1 \ln(Dis_{ij}) + \pi_2 River_{ij} + \pi_3 Pro_{ij} \\ &+ \pi_4 \left[\ln(Dis_{ij}) \times Pro_{ij}\right] + \sum_{k=1}^{9} \nu_{ij,k} \left[River_{ij} \times Dis\_G_{ij,k}\right] + \theta_i + \theta_j + \theta_{i^* j^*} + \mu_{ij} \qquad (4.13)\end{aligned}$$

The identification in regression (4.10) allows me to quantify the determinants of market integration. By contrast, regression (4.13) identifies the impact of geography and polity on the extent of price co-movement *conditional on cointegration*. Since some pairs have negative $\hat{\beta}_{ij}$, I do not use the logarithmic transformation for the dependent variable.

The results of regression (4.13) are reported in Table 4.5, which provides a similar pattern as the results in Table 4.3. In my discussion I focus on the sign and statistical significance of the coefficient estimates. In column 1 to 4, all distance variables enter significantly with negative signs. Since $\hat{\beta}_{ij}$ is negatively correlated with trade cost T_{ij}, the negative sign of these distance variables suggests that, unsurprisingly, trade cost is smaller for more proximate cointegrated prefecture pairs resulting in more pronounced long-run price co-movement. The second feature is that the absolute values of coefficients for distance are larger for Southern China, which implies that per unit of distance trade in South China was associated with less trade costs than trade in the North.

In column 1 and 2 of Table 4.5, the river and province dummies are positive significant. This suggests that water transport reduced bilateral trade cost in both regions, while provincial borders acted as barriers to trade. However, with respect to coefficient magnitudes, conditional on market integration grain rivers had a larger impact on price co-movement in Northern than in Southern China, while provincial borders impeded price co-movement more substantially in the South. In column 3, for Southern China, the river dummy is negative significant but this was mitigated by the distance-river interaction in all distance categories, albeit with declining significance. By contrast, in column 4 for North China, river transportation afforded significant impact on price co-movement but did not vary by distance. The test of the joint significance for river dummy and its interaction terms with distance groups are given in Table 4.6, which suggests that in South China the positive impact of river transport on price co-movement covered the distance categories from 200*km* to 800*km* (thus not extending to as many categories as the analysis for the presence/absence of price cointegration above), while in the North the impact of grain rivers is limited to the shortest distance categories (e.g. 0-400*km*). In column 3 and 4, the interaction term for $Pro_{ij} \times \ln(Dis_{ij})$ reflects that the 'distance penalty' only applies to provincial borders in northern China, which supports the hypothesis that the extent of fragmentation was more substantial in that region, since even within the same province price co-movement for prefecture pairs decreased with distance. In general, the results in Table 4.5 suggest that, in line with the cointegration analysis in Table 4.3, the waterway network reduced trade costs and fostered greater price co-movement, while provincial borders acted as impediments. Although the Northern waterway network afforded no additional probability of cointegration, it did increase the strength of price co-movement conditional on markets being integrated.

In column 2 and 4 of Table 4.7, I add the Skinner macroregion dummy into the regression (4.13) to discuss whether the observed provincial border effect on the price co-movement is really driven by physiogeographic factors. The result pattern is highly consistent with the previous finding, and the inclusion of the Skinner dummy only marginally changes the original results in column 1 and 3: geography.acted as a barrier to trade and thus the extent of price co-movement, but its influence was dominated by that of provincial/political borders. Across Tables 4.5 to 4.7 all results suggest that instead of geography political boundaries were the dominated force in driving grain price co-movement.

Table 4.5 Price Comovement, Geography and Institutions				
Dependent Variable: $\hat{\beta}_{ij}$	South Rice	North Wheat	South Rice	North Wheat
	(1)	(2)	(3)	(4)
ln($Dis_{i,j}$)	-0.057	-0.09	-0.0546	-0.1033
	(0.0043)***	(0.009)***	(0.0055)***	(0.0126)***
$River_{ij}$	0.0114	0.0418	-0.242	0.063
	(0.0063)*	(0.0125)***	(0.085)***	(0.0377)*
Pro_{ij}	0.16	0.0523	0.128	-0.3016
	(0.0068)***	(0.0112)***	(0.062)**	(0.098)***
ln(Pro_{ij}) × *ln(Disij)*			0.0054	0.0595
			(0.0105)	(0.0164)***
ln($River_{ij}$)×$Dis\_G_{ij,1(x\leq 200km)}$			0.228	0.042
			(0.087)***	(0.0437)
ln($River_{ij}$)×$Dis\_G_{ij,2(200<x\leq 400km)}$			0.284	-0.176
			(0.086)***	(0.041)
ln($River_{ij}$)×$Dis\_G_{ij,3(400<x\leq 600km)}$			0.277	-0.0448
			(0.086)***	(0.039)
ln($River_{ij}$)×$Dis\_G_{ij,4(600<x\leq 800km)}$			0.266	-0.0257
			(0.085)***	(0.038)
ln($River_{ij}$)×$Dis\_G_{ij,5(800<x\leq 1000km)}$			0.238	-0.048
			(0.086)***	(0.038)
ln($River_{ij}$)×$Dis\_G_{ij,6(1000<x\leq 1200km)}$			0.247	-0.006
			(0.0852)***	(0.041)
ln($River_{ij}$)×$Dis\_G_{ij,7(1200<x\leq 1400km)}$			0.242	-0.06
			(0.086)***	(0.05)
ln($River_{ij}$)×$Dis\_G_{ij,8(1400<x\leq 1600km)}$			0.205	0.0707
			(0.087)**	(0.04)*
ln($River_{ij}$)×$Dis\_G_{ij,9(1600<x\leq 1800km)}$			0.104	-0.017
			(0.088)	(0.0303)
θ_i	Yes	Yes	Yes	Yes
θ_j	Yes	Yes	Yes	Yes
θ_{I*J*}	Yes	Yes	Yes	Yes
No of Obs.	8176	1681	8176	1681
R^2	0.795	0.887	0.7984	0.889

Note: We omit reporting fixed effects, seasonality and the constant. Robust standard errors provided in parentheses, ***, ** and * denote 1%, 5% and 10% significance.

Table 4.6 Heterogeneity of Water Impact on Price Co-movement

Distance Group	*Null Hypothesis*	*p-value*	
		South Rice	North Wheat
(0, 200*km*]	H_0: $\pi_2 + \nu_{ij,1} = 0$	0.3895	0.0001
(200, 400*km*]	H_0: $\pi_2 + \nu_{ij,2} = 0$	0.0001	0.007
(400, 600*km*]	H_0: $\pi_2 + \nu_{ij,3} = 0$	0.0001	0.2694
(600, 800*km*]	H_0: $\pi_2 + \nu_{ij,4} = 0$	0.0056	0.0355
(800, 1000*km*]	H_0: $\pi_2 + \nu_{ij,5} = 0$	0.7139	0.5056
(1000, 1200*km*]	H_0: $\pi_2 + \nu_{ij,6} = 0$	0.5435	0.0741
(1200, 1400*km*]	H_0: $\pi_2 + \nu_{ij,7} = 0$	0.9818	0.9344
(1400, 1600*km*]	H_0: $\pi_2 + \nu_{ij,8} = 0$	0.0969	0.0001
(1600, 1800*km*]	H_0: $\pi_2 + \nu_{ij,9} = 0$	0.0007	0.211

Note: π_2 and $\nu_{ij,k}$ are the coefficients of $River_{ij}$ and $River_{ij} \times Dis\_G_{ij,k}$ in OLS regression (4.13); *p-value* below 0.05 means reject the H_0 with 5% significance

Table 4.7 Price Comovement, Geography and Institutions (South only)

Dependent Variable: $\hat{\beta}_{ij}$	(1)	(2)	(3)	(4)
$\ln(Dis_{ij})$	-0.057	-0.054	-0.0546	-0.054
	(0.0043)***	(0.0044)***	(0.0055)***	(0.005)***
$River_{ij}$	0.0114	0.008	-0.242	-0.243
	(0.0063)*	(0.006)	(0.085)***	(0.085)***
Pro_{ij}	0.16	0.149	0.128	0.106
	(0.0068)***	(0.007)***	(0.062)**	(0.063)*
Ski_{ij}		0.021		0.018
		(0.006)***		(0.006)***
$\ln(Pro_{ij}) \times ln(Disij)$			0.0054	0.008
			(0.0105)	(0.011)
$\ln(River_{ij}) \times Dis\_G_{ij,1(x\leq 200km)}$			0.228	0.224
			(0.087)***	(0.087)***
$\ln(River_{ij}) \times Dis\_G_{ij,2(200<x\leq 400km)}$			0.284	0.28
			(0.086)***	(0.086)***
$\ln(River_{ij}) \times Dis\_G_{ij,3(400<x\leq 600km)}$			0.277	0.273
			(0.086)***	(0.086)***
$\ln(River_{ij}) \times Dis\_G_{ij,4(600<x\leq 800km)}$			0.266	0.264
			(0.085)***	(0.085)***
$\ln(River_{ij}) \times Dis\_G_{ij,5(800<x\leq 1000km)}$			0.238	0.239
			(0.086)***	(0.086)***
$\ln(River_{ij}) \times Dis\_G_{ij,6(1000<x\leq 1200km)}$			0.247	0.249
			(0.0852)***	(0.086)***
$\ln(River_{ij}) \times Dis\_G_{ij,7(1200<x\leq 1400km)}$			0.242	0.243
			(0.086)***	(0.086)***
$\ln(River_{ij}) \times Dis\_G_{ij,8(1400<x\leq 1600km)}$			0.205	0.206
			(0.087)**	(0.087)**
$\ln(River_{ij}) \times Dis\_G_{ij,9(1600<x\leq 1800km)}$			0.104	0.104
			(0.088)	(0.089)
θ_i	Yes	Yes	Yes	Yes
θ_j	Yes	Yes	Yes	Yes
θ_{I*J*}	Yes	Yes	Yes	Yes
No of Obs.	8176	1681	8176	1681
R^2	0.795	0.887	0.7984	0.889

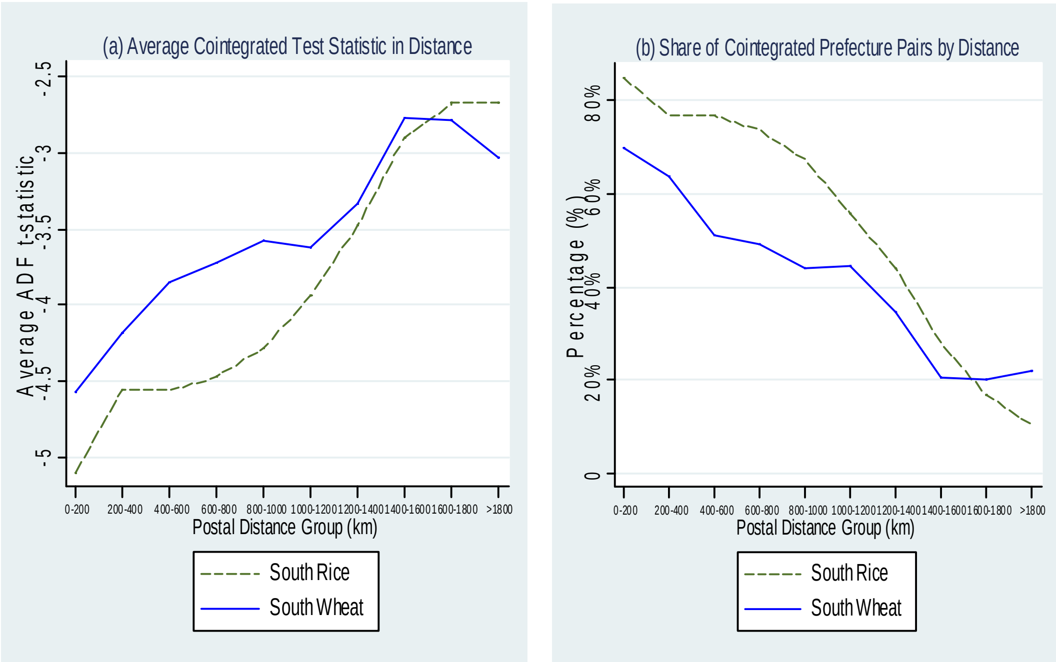
Note: We omit reporting fixed effects, seasonality and the constant.Robust standard errors provided in parentheses, ***, ** and * denote 1%, 5% and 10% significance.

4.4.5 Robustness Test

Wheat and rice are two different agricultural commodities, which have different production cost, storage cost and transport cost. It is therefore possible that my comparison between Southern and Northern grain markets in Figures 4.2 and 4.3 was driven by the differences in the price behaviour of rice and wheat instead of differential market performance between the regions. As a robustness check, I select a sub-sample of prefectures (77 prefectures out of 131 prefectures)[40] in Southern China for which I have both sets of prices for rice and wheat, and then compare price cointegration for each commodity within the same geographic region. As Figure 4.4 suggests, the price cointegration differential between rice and wheat in the South is significantly smaller than that between rice in the South and wheat in the North, suggesting that my analysis in Figure 4.2 and 4.3 captures market integration rather than idiosyncrasies of the commodities analysed. In this sub-sample, most market pairs had direct access to a grain river such that the extent of price integration was more substantial than in the full sample of Southern China. We can argue that the higher share of market integration for rice as opposed to wheat in the South is due to the fact that rice is the staple crop in this region.

[40] The name of these prefectures can be checked in Appendix A.6.

Figure 4.4 Cointegration of Rice and Wheat within South China



4.5 Conclusions

This Chapter analyses the extent and determinants of spatial grain market integration in China during the prime of the Qing Dynasty, using monthly rice and wheat price data across 211 prefectures between 1740 and 1820. Following the LOOP theoretical framework, I applied pair-wise Engle-Granger cointegration test to examine the strengths of grain price cointegration and co-movement. I examine the role of river transport on market evolution in this pre-modern period, using GIS data on the national-wide postal route and waterways network following the historical geography literature.

My results comparing the Southern rice and Northern wheat markets strongly indicate that the extent of market integration in Southern China was larger than in the

North. The role of waterways transport and physiographic distribution in heterogeneously shaping the pattern of China's market performance has also been quantified. Geographical determinants played an important role albeit dominated by provincial boundary in market integration. One interesting question is triggered by my results: under a unified political regime like Qing China, what was the driving force behind the provincial border that seemed to have served to fragment the market? Political "grain protectionism" at the provincial level can be one explanation. Qing China's integrated province hierarchy authorized the monopoly political power and responsibility for grains storage to its provincial generals, which enabled and encourage them to embargo the grain export for grain storage maximization. On the other hand, without formal property right institutions, grain merchants would not refuse to obey the imposed restriction since they need to cater the bureaucratic organization to secure their property.

The Chapter sheds new light on the important question of how geography and institutions shape the evolution of interregional trade in a pre-modern economy that did not experience substantial technological progress. My results suggest that the importance of transport cost has been exaggerated in its impact on historical market evolution, and institutions overwhelmed geography on market integration. However, this chapter's results are not sufficient to conclude that China's market was fragmented although the strong provincial barrier has been identified. In this Chapter, the pairwise cointegration methodology allows me to investigate the cross section determinants of market integration in the long run. However, the time varied size of missing value limited its extension on the time dimension since the power of Enger-Granger cointegration test is changeable with respective to the ratio of missing value. Using the more advance panel cointegration methodology, next chapter will allow analyzing the pattern of China's market integration on the time dimension.

Chapter 5
Geography, Institutions and Market Decline

5.1 Introduction and Motivation

This chapter examines the changes in grain market integration within China during the middle period of the Qing Dynasty (1740-1820). In contrast to results in Chapter 4, which provide spatial comparison of market integration determinants, this chapter provides a dynamic comparison between rice markets in Southern China and wheat markets in Northern China. Applying novel panel time series methods and conventional cross-section method, I provide robust evidence for continuous market disintegration and fragmentation during the sample time period for markets in both Southern and Northern China. The analysis shows the provincial borders rather than the physiographic determinants shaped these patterns and drove market fragmentation. My results suggest that China's markets were not fully integrated in spite of the unified political system during the Qing's so-called economic golden era.

This chapter contributes to both the literatures on market integration and economic history. One seminal question in world and Chinese economic history is why China, in contrast to Western Europe, failed to industrialize. This is a question about the origins of the 'Great Divergence', which has spawned a large and growing literature (Brenner and Isett, 2002; Clark, 2008; Diamond, 1997; Elvin, 1973; Huang, 2002; Hung, 2008; Landes, 2006; Lin, 1995; Pomeranz, 2000). As introduced in Chapter 1, one candidate condition for industrialization has been the degree of market integration of an agricultural economy, providing sufficient incentives to invest into industrialization. Shiue and Keller's (2007) empirical finding suggests that the performance of markets in China was comparable to Western Europe's on the eve of the Industrial Revolution, which supports Pomeranz's (2000) conjectures that both China and Europe's institutional frameworks and demographic patterns were equally favorable to growth in their most advanced areas. However, my discussion in Section 2.4.2 argues that "well-functioning" markets could not take root in Qing China, which is supported by my empirical results in this chapter.

My previous results in Chapter 4 which suggest that provincial border played a more dominant role as trade barrier than physiographic determinants on the market evolution are not sufficient to conclude that China's markets were fragmented by the provincial boundaries. However, the combination of results in Chapters 4 and 5 provides a convincing argument that Qing China's grain market was disintegrated and fragmented along its provincial boundaries, which indicates that grain markets had been shaped by bureaucratic intervention. This observation is not surprising. As discussed in Sections 2.4, 2.5 and 4.2, the Qing state emphasized and maintained its role in grain storage and re-distribution across the empire because its primary concerns were food security and social stability.

This chapter also contributes to the literature on spatial analysis and regional integration. I motivate my empirics with a simple theoretical model with a common factor framework for a panel of grain price behavior, building on Deaton (1999). My contribution here is to add a structure to the unobserved heterogeneity in the harvest output equation, which allows us to relax the assumption that output and thus price behavior was not subject to global shocks or local spillover effects ('cross-section dependence'). Next I employ the Pesaran (2006, 2007) common correlated effects methodology to investigate heterogeneous price convergence to the provincial and regional mean, respectively. Here I make the most of the substantial time series dimension of my data by estimating price convergence regressions using a 20-year rolling window. My method allows me to quantify the statistical correlations between heterogeneous price convergence and geographic proximity, which provides a new and unique method to identify market fragmentation. In addition, my findings suggest that the empirical *extent* of price convergence in one market is not sufficient to judge whether this market constitutes a *unified integrated* market or not.

My results trigger a further question: Why did China's market decline? The answer to this question could help us to explore deeper why industrialization could not take root in China. In my further analysis population growth is identified as playing a minor role in the observed market disintegration: I adopt a cross-section regression approach to disentangle trade cost determinants, which reveals that even the dominant provincial border effect was only able to explain around 30% of total trade cost. Since most of the potential geographical determinants have been accounted for in the regression models, it is possible that the unexplained trade cost gap is due to the impact of institutions.

This Chapter is organized as follows. Section 5.2 introduces the theoretical framework for my panel analysis of price integration. The empirical results and interpretation are provided in Section 5.3. Section 5.4 discusses and tests the possible driving forces behind the process of market disintegration and fragmentation, which is followed by a brief conclusion.

5.2 Methodologies

In the following section I set out the theoretical motivation and discuss the empirical methodologies employed to investigate the dynamic nature and determinants of grain price convergence in Qing China.

5.2.1 Theoretical Framework

This chapter focuses on the dynamic grain market performance in China. The empirical work in this chapter is based on a framework developed in Chapter 4. I start by replicating the functions and assumptions in Chapter 4. I begin with a price model for an agricultural commodity within a single market with an inelastically supplied harvest output h_t, which follows a stochastic process characterized by the cumulative distribution function $\Phi(h, \mathrm{H})$.

$$\Phi(h, \mathrm{H}) = \Pr\,(h_{t+1} \leq \mathrm{H}_t \mid h_t = h) \qquad (5.1)$$

I assume that shocks to harvest output are exogenous, determined by the conditions in agricultural production, which in the absence of technological change ultimately drive price behaviors. Here I maintain the assumption that there is *no* grain storage, which will be relaxed in later analysis. All of the harvest output h_t will be consumed within each period. The local price at time t can then be written as a function of output:

$$P_t = a + bh_t \qquad (5.2)$$

where $a(>0)$ and $b(<0)$ are parameters. Because consumers are assumed to be the only buyers in the market (no speculation), price behavior is only driven by production behavior and harvests. It is assumed that harvest output follows a simple AR(1) process as below:

$$h_{t+1} = \rho h_t + \varepsilon_{t+1} \qquad (5.3)$$

where $-1 < \rho \leq 1$, and the error term ε_t is i.i.d with mean 0.

In equation (5.3), similar to Chapter 4, I maintain the assumption that $\rho=1$ following Shiue and Keller (2005, 2007) such that both harvest output and grain prices follow a random walk process,

$$P_{t+1} = P_t + u_{t+1} \qquad (5.4)$$

where $u_{t+1} = b\varepsilon_{t+1}$. From equations (5.3) and (5.4), price movements are entirely determined by the random shock ε_{t+1} rather than technological progress in agriculture. Consider an economy with many locations, n=1,…, N, where consumers in all locations have the same preferences and all producers have the same technology for grain production.

Thus far I have assumed that any shock to harvest output ε_{t+1} is location-specific and I assumed that within locations these shocks are i.i.d. When moving from the single price series in a single location to a panel of price series in N locations, typically this i.i.d. assumption in the time dimension is extended to the panel dimension: $\varepsilon_{i,t+1}$ ~ i.i.d. (μ_i, σ^2). This distribution of shocks across locations recognizes that some prefectures will be prone to negative shocks (e.g. locations close to a river's flood plain) whereas others will be prone to positive shocks (e.g. locations within a safe basin secure from flooding), while on average across all locations the impact of these shocks is zero: $E[\mu_i] = 0$. The econometric expression for the independence of shocks across locations is 'cross-section independence'. In this chapter I relax this assumption of cross-section independence and allow shocks to be correlated across locations. There are (at least) two sources for this type of correlation: first, I allow for the presence of global shocks which affect all locations within the economy, but to a different extent. For instance, the silver inflow from the coastal areas affects the grain price in the economy but to different extent across locations (Chen and Liu, 2009; Li, 2009; Shiue, 2004). Second, I allow for the presence of local shocks and spillover effects which affect a small number of locations which are perhaps geographically very close to each other or along the same trade route. For example, between 1470 and 1900, there were a total of 249 officially recorded localized civil conflicts in China. Peasant revolts in particular were closely related to agricultural harvest, and such revolts have typically been suppressed swiftly by the central state (Jia, 2012). I model this cross-section dependence property of harvest output by adopting a common factor framework

$$h_{i,t+1} = h_{i,t} + \varepsilon_{i,t+1} \qquad \varepsilon_{i,t} = \mu_i + \lambda_i' f_t + u_{i,t} \qquad (5.5)$$

where f_t is a set of common factors representing global shocks (strong factors) and local shocks/spillovers (weak factors) with λ_i the corresponding 'factor loadings' in each location *i;* $u_{i,t}$ is white noise. This form of empirical framework has been very popular in the recent panel time series literature (Bai and Ng, 2002, 2004; Bai, 2009; Eberhardt *et al.*, 2013; Eberhardt and Teal, 2013; Pesaran, 2006) and in line with the analysis in Chudik *et al.* (2011). I can assume a finite number of global factors and an infinite number of local factors for the empirical setup.

The common factor framework also allows me to relax the assumption of no storage. The agricultural price function with storage would be complicated since it is difficult to gauge the interaction between expected price and current storage. Instead I model grain storage as an unobserved common shock in a *future* period involves in factors f_t. In the current period, storage is part of current consumption, but in the future it will become a shock to the price in the local market or the other markets through grain trade if the stored grain is traded. In period *t* for prefecture *i*, the local price is already determined by local supply and demand in the market, factoring in the presence of storage. In this period *i*'s grain supply can be increased by sale of stored grain in *i* or in its trading partner prefecture *j*, which will lead to a reduction in the local price in *i*. In the next section, I will link this common factor framework with my panel unit root econometric methodology.

5.2.2 Panel Price Convergence

In this chapter I make use of novel methods developed in the recent panel time series literature which allow studying the price behavior in diverse sets of prefectures in a very flexible way which furthermore accounts for the heterogeneous impact of global price shocks such as droughts, rebellions or locust plagues. In addition the long time series dimension of the data allows me to study the evolution of price convergence or divergence over time.

My starting point is a simple convergence regression model familiar from the study of per capita income convergence across countries in the empirical growth literature (Mankiw, Romer and Weil, 1992; Bernard and Jones, 1996; Lee, Pesaran and Smith, 1997; Rodrik, forthcoming). A pooled convergence regression model imposes the assumption that all countries converge to the same long-run growth path, which is implicitly given by construction. The equivalent interpretation in a pooled price convergence regression model for our data would be that all prefectures converge toward the same long-run equilibrium price level. An example of this approach is the analysis of the *LOOP* in the European car market by Goldberg and Verboven (2005) who apply a pooled panel unit root test (Levin and Lin, 1992). In the following I allow for heterogeneous price convergence by prefectures to the same long-run price level at the (provincial) regional level (North for wheat, South for rice). Econometrically, my Mean Group estimates of price convergence (see below) are unbiased if our assumption of heterogeneity is false, but they are inefficient.

I begin with my analysis of heterogeneous convergence to the *provincial* price level:

$$\Delta LPP_{it} = \alpha_i + \beta_i^{LPP} LPP_{i,t-1} + \sum_{l=1}^{p_i} \delta_{i,l} \Delta LPP_{i,t-l} + \varepsilon_{it} \qquad (5.6)$$

where the relative log price level is defined as $LPP_{it} = \ln(p_{it} / \bar{P}_{Pt})$ and $\bar{P}_{Pt}$ is the respective provincial average for prefecture *i* in time *t* (on average I have 15 and 12 prefectures per province in our Northern and Southern regions, respectively). The dependent variable in the so-called 'Dickey-Fuller regression' equation (5.6) is the first difference of this relative log-price level and the sum on the right-hand side represents lags of this difference included to capture the short-run behavior. If an individual price series in location *i* converges to its provincial average, then β_i^{LPP} will be negative significant. Under the null of no convergence, β_i^{LPP} is equal to zero. In (5.6), α_i captures prefecture-level time-invariant heterogeneity which will help explain price differentials across diverse locations within the Southern and Northern regions of China. The above empirical equation yields a total of N heterogeneous convergence coefficients and I follow the standard in the panel time series literature (Pesaran and Smith, 1995; Pesaran, 2006) to report the Mean Group estimate of this set of coefficients:

$$\hat{\beta}_{MG}^{LPP} = (\Sigma w_i \hat{\beta}_i^{LPP}) / N \qquad (5.7)$$

where w_i represents a set of prefecture-specific weights applied in the computation of the average to reduce the impact of outliers.[41]

[41] In practice I employ robust regression models to estimate these weights (Hamilton, 1992).

Alternatively, if all individual markets were jointly integrated in a single unified market within Chinese regions (South and North), prefectural price series would converge to the *regional* average price:

$$\Delta LPR_{it} = \alpha_i + \beta_i^{LPR} LPR_{i,t-1} + \sum_{l=1}^{p_i} \delta_{i,l} \Delta LPR_{i,t-l} + \varepsilon_{i,t} \qquad (5.8)$$

where the relative log price level is defined as LPR_{it} = ln $(P_{it} / \overline{P}_{Rt})$ and $\overline{P}_{Rt}$ is the regional average price at time *t*; the dependent variable is the first difference of this relative log price level, and the lagged differences once again capture the short-run behavior. If the individual price series in prefecture *i* converges to the regional average, then β_i^{LPR} would be negative significant. The Mean Group estimate can be constructed in analogy to equation (5.7):

$$\hat{\beta}_{MG}^{LPR} = (\Sigma w_i \hat{\beta}_i^{LPR}) / N \qquad (5.9)$$

My empirical implementation thus far resembles a standard first generation panel unit root test such as the Maddala and Wu (1999) or Im, Pesaran and Shin (2002) tests which were used in previous studies of market integration (e.g. Fan and Wei, 2006). Significant progress in this econometric literature has been made since these methods were introduced, with a strong focus on dealing with the biasing impact of unobserved time-varying heterogeneity in the panel, commonly referred to as cross-section dependence (Bai and Ng, 2002; Pesaran, 2007), arising from global shocks and local spillover effects. To capture the impact of these shocks, we follow the approach by Pesaran (2007) and augment the prefecture-level regression with cross-section averages of the dependent and independent variables. These averages are constructed using province-level data and regional level data in the two implementations for province-level price convergence and regional price convergence, respectively. Specifically, $\overline{LPP_{t-1}^{P_i}}$ and $\overline{\Delta LPP_{t-l}^{P_i}}$ are the provincial average of $LPP_{i,t-1}$ and $\Delta LPP_{i,t-l}$ respectively while $\overline{LPR_{t-1}^{R_i}}$ and $\overline{\Delta LPR_{t-l}^{R_i}}$ are the regional average of $LPR_{i,t-1}$ and $\Delta LPR_{i,t-l}$ respectively. This aside I include centered seasonal dummies (i.e. M_c)[42] to capture the effect of heterogeneous harvest seasons across China's different climatic areas. Estimation equations (5.6) and (5.8) are thus altered to

$$\Delta LPP_{it} = \alpha_i + \beta_i^{LPP} LPP_{i,t-1} + \sum_{l=1}^{p_i} \delta_{i,l} \Delta LPP_{i,t-l} + \underbrace{\lambda_i^{P1} \overline{LPP_{t-1}^{P_i}} + \sum_{l=0}^{p_i} \lambda_{i,l}^{P2+l} \overline{\Delta LPP_{t-l}^{P_i}}}_{\text{captures } \lambda_i' f_t} + \sum_{C=1}^{11} \gamma_C M_C + \varepsilon_{i,t} \qquad (5.6')$$

$$\Delta LPR_{it} = \alpha_i + \beta_i^{LPP} LPR_{i,t-1} + \sum_{l=1}^{p_i} \delta_{i,l} \Delta LPR_{i,t-l} + \underbrace{\lambda_i^{R1} \overline{LPR_{t-1}^{R_i}} + \sum_{l=0}^{p_i} \lambda_{i,l}^{R2+l} \overline{\Delta LPR_{t-l}^{R_i}}}_{\text{captures } \lambda_i' f_t} + \sum_{C=1}^{11} \gamma_C M_C + \varepsilon_{i,t} \qquad (5.8')$$

In equations (5.6) and (5.8) as well as their cross-section average augmented versions, the number of lags p_i are determined by the Akaike Information Criterion (AIC) in each regression. In equation (5.6') and (5.8'), the introduction of cross-section average variables allow me to relax the assumption of cross-section

[42] The construction of centered (orthogonalized) seasonal dummy variables follows Juselius (2006), which shift the mean of price without contributing to the trend. I construct centred seasonal dummies for each month. For example, for January, $M_{c=1}$ = (11/12) if C is equal to 1, otherwise, $M_{c=1}$ = (-1/12).

independence by acting as de facto placeholders for the unobserved common factors with heterogeneous factor loadings $\lambda_i^{'} f_t$ introduced in the theoretical discussion above. As the time dimension of my data is very long (monthly data for up to 81 years), instead of analyzing price convergence over the entire time horizon in a single regression model I investigate a 20-year rolling window (a maximum of 240 monthly observations) so as to capture any structural change in the convergence process over time. My main results are then presented in graphical form.

5.3 Results

Following the methodology discussed above, I present the Mean Group price convergence results. I also run cross-section regressions to determine the extent of any price convergence and the effects of geography and institutions over the entire time period.

5.3.1 Market Disintegration

In this section I present the results from heterogeneous convergence regressions, which allow me to observe the dynamics of price convergence in Qing Dynasty China.

Figures 5.1 and 5.2 plot the (Common Correlated Effects) Mean Group estimates of the 20-year rolling window for provincial convergence (based on equation (5.7)) and regional convergence (based on equation (5.9)) in China's two regions, respectively – both results account for cross-section dependence in the price (convergence) evolution. Recall that the larger (in absolute value) the provincial (regional) Mean Group estimate, the faster prefectural prices converge to the provincial (regional) average price. My first observation is that provincial convergence is faster than regional convergence in all periods investigated. The interpretation of this result is that the force for price arbitrage was stronger for nearby markets as bilateral trade costs were smaller. In Chapter 4, it has been robustly shown that provincial borders seem to represent substantial trade barrier for price convergence in Southern and Northern China. The second common feature of Figures 5.1 and 5.2 is that both the provincial and regional convergence estimates follow an upward trend over all periods, which implies both provincial and regional markets became *less* integrated over time.

Accounting for observed and unobserved heterogeneity across prefectures, Figures 5.1 and 5.2 suggest that the grain markets in Qing Dynasty China before the 19th century suffered a process of prolonged market *dis*integration. I estimate the rolling robust Mean Group convergence coefficients for each province separately, in both the South and North China samples. The findings, presented in in Appendix B.3, confirm that the trends in Figure 5.1 and 5.2 are not driven by some extreme outlier province(s). It is worth noting that the plots in Figures 5.1 and 5.2 do not *per se* imply that there is no unified regional market within either South or North China. Provincial convergence would be stronger than regional convergence even under the unified integrated market as trade cost is always a positive function of bilateral distance.

In Figure 5.3, I rearrange the plots in Figures 5.1 and 5.2 to compare market integration between South and North China. The left graph (a) shows that *provincial* price convergence is more pronounced for rice than wheat, while the right graph (b) yields a similar conclusion for the comparison of *regional* convergence estimates. These findings further confirm our conclusions in Chapter 3 that market integration in South China was superior to that of the North in our period of analysis. These disintegration findings during the economic golden era may be driven by the dynasty decline, which can be associated with increasing population pressure, more local revolt, more corruption in the political system and less bureaucracy efficiency.

Figure 5.1 Provincial/Regional Convergence (South Rice)

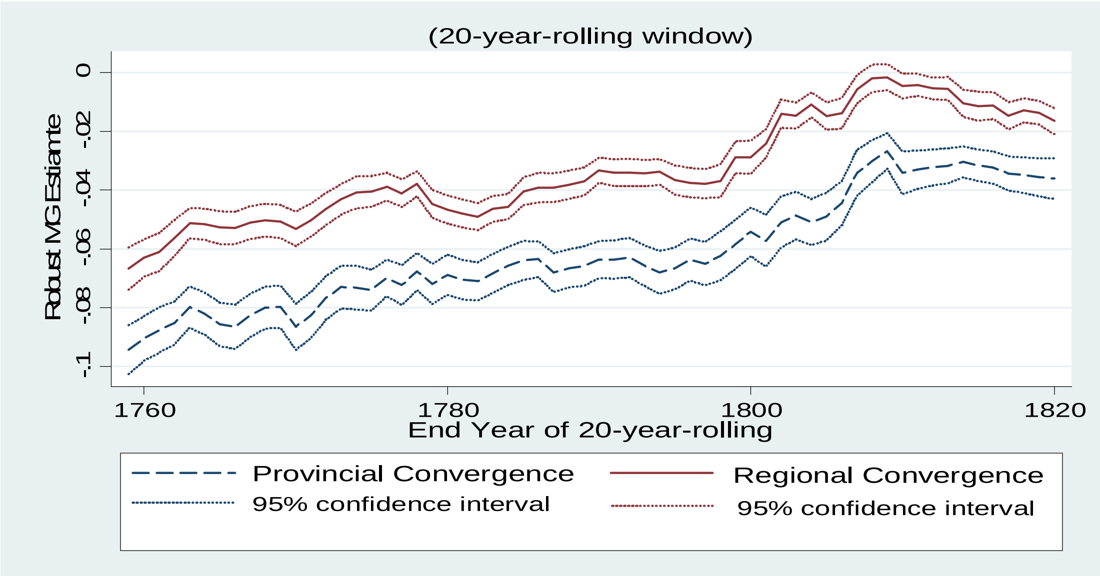


Figure 5.2 Provincial/Regional Convergence (North Wheat)

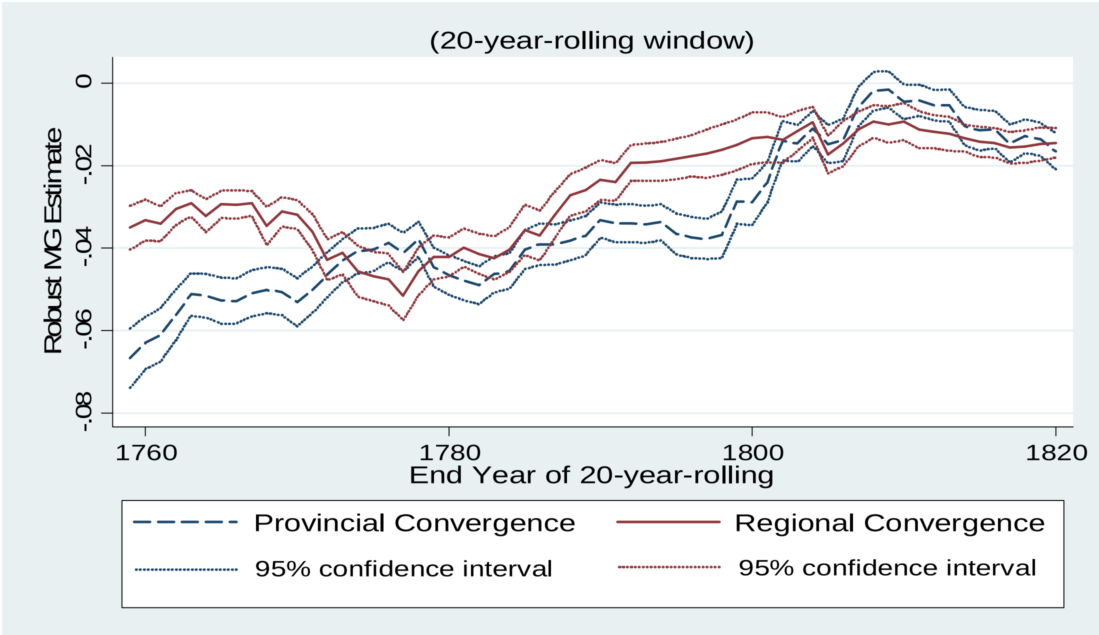
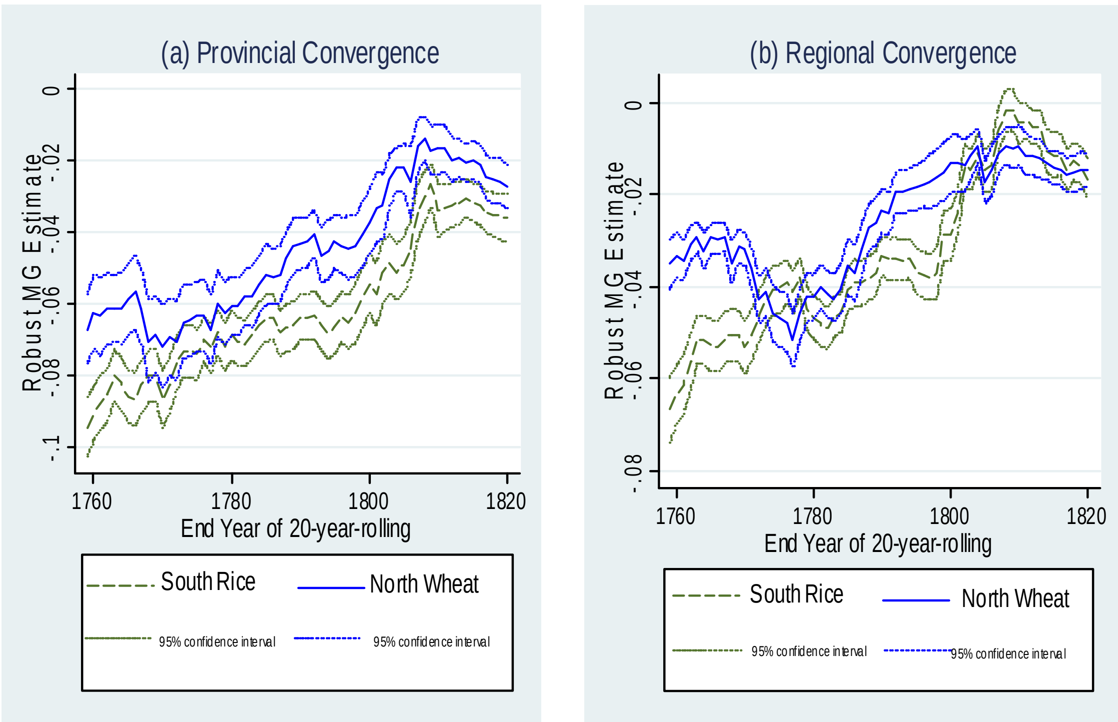


Figure 5.3 Provincial/Regional Price Convergence (South vs North)



5.3.2 Unified or Fragmented Market Integration

Despite the results in Section 5.3.1 strongly suggesting that Southern China's grain markets were more integrated than those of northern China, these results do not suffice to show that Southern China, which comprised the most commercialized areas in the country, had a *single* unified (integrated) market in the pre-modern era. It is uncertain whether the extent of price co-movement within the entire region (either Southern China or Northern China) was actually driven by one single unified regional market mechanism. The results in this section shed some light on this issue, which concerns whether the grain markers were fragmented at the provincial or regional level.

Four geographic variables for trade network analysis are constructed following Shimbel (1953) and Hansen (1959). The *regional accessibility* of prefecture i, RA_i, is defined as the sum of postal distances to all other prefectures within the region (South China or North China), while the *provincial accessibility* of prefecture i, PA_i, is defined as the sum of the postal distances to all other prefectures within the same province. To capture the potential demand for grain in prefecture i, *regional potential demand* (RPD_i) and *provincial potential demand* (PPD_i) are constructed as the sums of population-weighted postal distance to all other prefectures within the region and province, respectively, using population density data for 1776. Prefectural population density data for 1776 and 1820 are available in Cao (2000), and as 1776 is around the median year of my sample I adopt the population density for this year as a proxy for the prefectural average population density over my data period.

Regional accessibility: $$RA_i = \sum_{k=1}^{R_i} Distance_{ik} \tag{5.10}$$

Provincial accessibility: $$PA_i = \sum_{k=1}^{P_i} Distance_{ik} \tag{5.11}$$

Regional potential demand: $$RPD_i = \sum_{k=1}^{R_i} \left(Population\_Density_{k,1776} / Distance_{ik} \right) \tag{5.12}$$

Provincial potential demand: $$PPD_i = \sum_{k=1}^{P_i} \left(Population\_Density_{k,1776} / Distance_{ik} \right) \tag{5.13}$$

I use the following cross-section regressions to investigate whether provincial convergence is significantly correlated with prefectural accessibility:

$$\hat{\beta}_i^{LPP} = \alpha + \omega^{PA} \ln(PA_i) + \chi_i + \varepsilon_i \tag{5.14}$$

where the dependent variable is the provincial convergence estimate for each prefecture from equation (5.6') for the whole 81-year period; χ_i denotes province dummies, which account for unobserved heterogeneity across provinces. If ω^{PA} is positively significant, it favors the hypothesis that there was one *unified integrated provincial market* to drive the observed provincial convergence. In analogy to equation (5.14), equation (5.15) emphasizes the influence of geographical distribution on regional convergence. If there exists one *unified integrated regional market*, ω_i^{RA} is expected to be positively significant.

$$\hat{\beta}_i^{LPR} = \alpha + \omega^{RA} \ln(RA_i) + \chi_i + \varepsilon_i \qquad (5.15)$$

As a robustness check, I use potential demand PPD_{i} and RPD_i to replace PA_i and RA_i in equations (5.14) and (5.15), respectively. It is expected that, for each prefecture, regional (provincial) price convergence should be negatively correlated with its regional (provincial) grain potential demand if a single unified regional (provincial) market drives the price co-movement. To observe the dynamic changes of ω^{PA} and ω^{RA}, I again use a 20-year rolling window for equations (5.14) and (5.15) and present results graphically.

First, however, I provide the results for the *entire* time period. The results for the provincial convergence analysis in equation (5.14) are reported in Table 5.1, in which the dependent variable is the estimate $\hat{\beta}_i^{LPP}$ from regression (5.6'). The results in columns 1 and 3 confirm that an individual location's geographical accessibility within the provincial network contributes to its provincial-level price convergence in both Northern China and Southern China. The results for regional convergence analysis in equation (5.15) are reported in Table 5.2, in which the dependent variable is the estimate $\hat{\beta}_i^{LPR}$ from equation (5.8'). The regional accessibility variable (i.e. $\ln(RA_i)$) is uncorrelated with the regional convergence speed both for rice markets (South) in column 1 and wheat markets (North) in column 3. These results indicate that rice markets (wheat markets) in South (North) China were not integrated as a whole as there is no evidence that one individual market's geographical accessibility within the region contributes to its regional price convergence. In columns 2 and 4 of Tables 5.1 and 5.2, I use the provincial (regional) potential demand for grain instead of provincial (regional) accessibility, but conclusions remain qualitatively identical.

Table 5.1 Provincial Integration or Fragmentation (1740-1820)

Dependent Variable: $\hat{\beta}_i^{LPP}$	Rice		Wheat	
	(1)	(2)	(3)	(4)
$\ln(PA_i)$	0.027		0.027	
	(0.0114)**		(0.0073)***	
$\ln(PPD_i)$		-0.0169		-0.012
		(0.004)***		(0.006)*
χ_i	yes	yes	yes	yes
Obs.	131	131	80	80
R^2	0.2383	0.2815	0.3651	0.3119

*Note: I omit reporting fixed effects, the constant. Robust standard errors provided in parentheses; ***, ** and * denote 1%, 5% and 10% significance level respectively*

Table 5.2 Regional Integration or Fragmentation (1740-1820)

Dependent Variable: $\hat{\beta}_i^{LPR}$	Rice		Wheat	
	(1)	(2)	(3)	(4)
$\ln(RA_i)$	-0.016		0.0066	
	(0.0155)		(0.0053)	
$\ln(RPD_i)$		0.004		-0.0018
		(0.0077)		(0.0038)
χ_i	yes	yes	yes	yes
Obs.	131	131	80	80
R^2	0.4029	0.3972	0.2123	0.2027

*Note: I omit reporting fixed effects and the constant. Robust standard errors provided in parentheses; ***, ** and * denote 1%, 5% and 10% significance level respectively*

The estimated change of ω_T^{PA} and ω_T^{RA} over time, based on equations (5.14) and (5.15) but using a 20-year rolling window, is reported in Figures 5.4 and 5.5 for South and North China, respectively. In both figures, solid circles (squares) represent statistical significance for $\hat{\omega}_T^{PA}$ ($\hat{\omega}_T^{RA}$) at the 5 percent level while hollow circles (squares) indicate statistically insignificant estimates. In Figure 5.4 for rice markets, provincial accessibility (in circle) only appears to statistically significantly correlate with provincial convergence around 1780 while regional accessibility (in square) is insignificant in virtually all periods. Since every point represents a 20-year window, these plots suggest that rice markets were only integrated within their respective provinces in Southern region during a 30-year period between 1755 and 1786 and there is no evidence to support a view that all the prefecture markets have been integrated as one unified market in South China.[43] From the 1790s onwards the correlation between provincial accessibility and price convergence disappears entirely, which coincides with the period of advanced market disintegration identified in our analysis in Section 5.3.1. The negative correlation around 1800 can be explained by the large-scale uprising the White Lotus Rebellion (1796-1804), which damaged the agricultural production in the grain surplus provinces (i.e. Sichuan and Hubei Province). Consequently, more long-distance grain transfer has been arranged by the state to recover the disaster area, which strengthens the price co-movement among the long distance rather than the short distance.

Figure 5.5 features the plots for wheat markets in North China, where similarly the correlation between provincial geographical determinants and

[43] Although there is one significant (i.e. solid) point for the regional level in Figure 5.4, it is negative, which still cannot support the existence of single unified market as the expected sign is positive to capture the positive relationship between trade cost and trade distance.

provincial price convergence (in circle) disappears at the end of the 18th century while there is only highly episodic evidence to support the existence of unified integrated market at the regional level (series in square). The provincial correlation was significant at the beginning but was insignificant the mid of 18th century. The disappearance of provincial integrated markets between 1760s and 1780s may be explained by the frequent military action during the mid-18th century. The impact of the military was much greater in Gansu of North China than in Coastal, Central, South, and Southwest China, because of Gansu's strategic location on the supply route to the garrisons occupying Central Asia. Continual military demands placed great stress on a fragile agrarian regime (Perdue, 1992).

Figure 5.4 Geographical Determinants and Convergence (South)

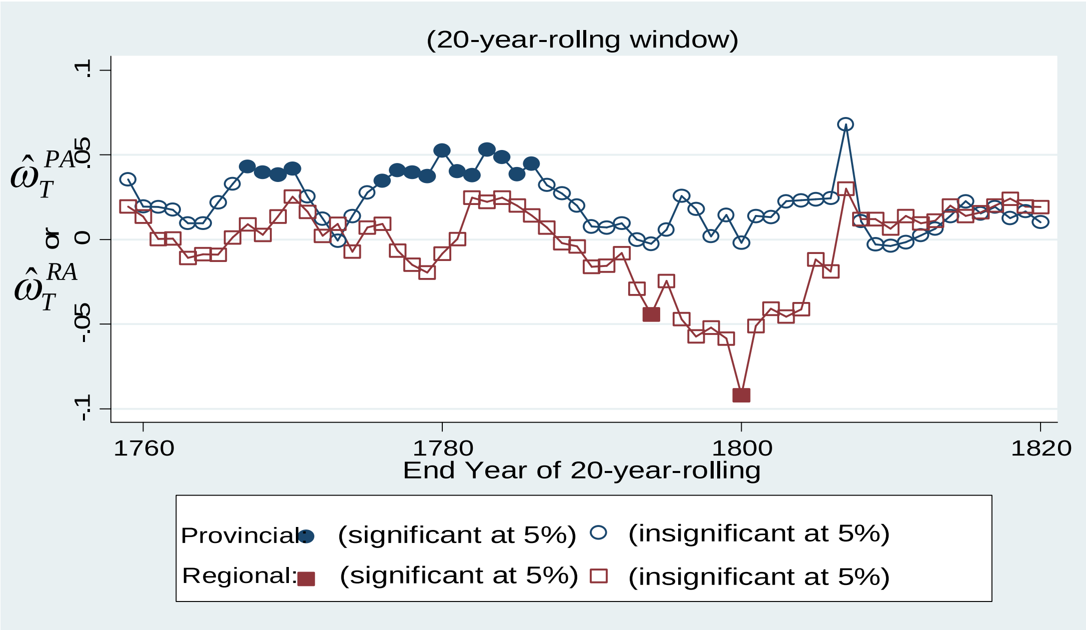
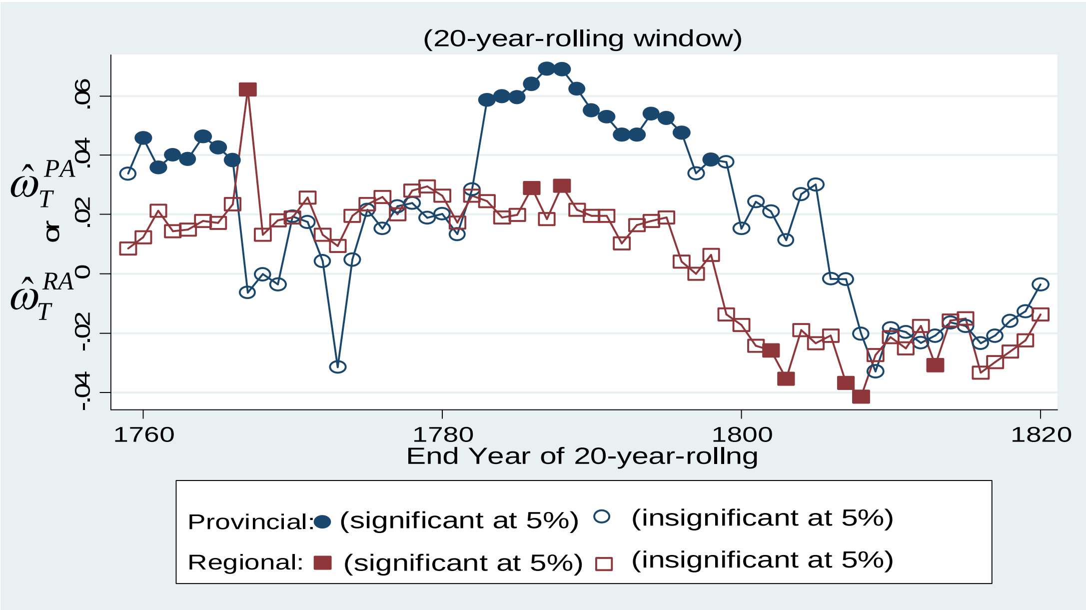


Figure 5.5 Geographical Determinants and Convergence (North)



Combining these results I would argue that there is strong evidence in favour of fragmented markets in both Southern and Northern China. There are two wider implications arising from these results: firstly, I need to redefine the relationship between the economic concept of market integration and the empirical cointegration test. Even though the results in Chapter 3 and Section 5.3.1 conclude that South China was *more* integrated, this does in no way imply that South China had a *unified* integrated market. It is possible that the high level of integration in Southern rice markets was mainly driven by short-distance within-province trade rather than long-distance inter-provincial trade. Figure 3.9 in Chapter 3, and Figures 4.2 and 4.3 in Chapter 4, confirmed that Southern market integration was apparently superior to that of the North for short-distance pairs. From this insight I can conclude more generally that the *extent* of integration in one market is not sufficient to judge whether this constitutes a *unified integrated* market or not. Secondly, my finding that South China's market was fragmented also sheds new light on the arguments regarding China's economic system on the eve of the Industrial Revolution. Many economic historians argue that China's unified stable political structure, in comparison to Europe's substantial and prolonged political fragmentation, should signify a distinct advantage in developing a unified integrated market. My results however suggest that China's market performance in its pre-modern period may have been significantly over-stated.

5.3.3 Physiographic or Political Boundaries?

In the previous section, my findings suggest that both Southern and Northern markets were integrated at the provincial level (for some sub-periods) but fragmented at the regional level. It is still possible that the inter-provincial fragmentation (or intra-provincial integration) observed was driven by physiographic boundaries. Qing China's provincial boundaries did not coincide but interlocked with the Skinner's physiographic boundaries, which allows me to conduct a natural experiment to identify the role of physiographic boundaries on the process of market disintegration and fragmentation. This section only focuses on the South rice markets.

I begin with analysis of heterogeneous price convergence to the macroregional level by modifying the regression (5.6') as follows:

$$\Delta LPS_{it} = \alpha_i + \beta_i^{LPS} LPS_{i,t-1} + \sum_{l=1}^{S_i} \delta_{i,l} \Delta LPS_{i,t-l} + \lambda_i^{S1} \overline{LPS_{t-1}^{S_i}} + \sum_{l=0}^{S_i} \lambda_{i,l}^{P2+l} \overline{\Delta LPS_{t-l}^{S_i}}$$
$$+ \sum_{C=1}^{11} \gamma_C M_C + \varepsilon_{i,t} \qquad (5.16)$$

where the relative log price level is defined as $LPS_{it} = \ln(p_{it} / \bar{S}_{St})$ and $\bar{S}_{St}$ is the respective macroregional average for prefecture i in time t (on average I have 13 prefectures per macroregion in Southern regions) adopting the Skinner classification. The dependent variable in equation (5.16) is the first difference of this relative log-price level and the sum on the right-hand side represents lags of this difference included to capture the short-run behavior. If an individual price series in location i converges to its macroregional average, then β_i^{LPS} will be negative significant. Under the null of no convergence, β_i^{LPS} is equal to zero.

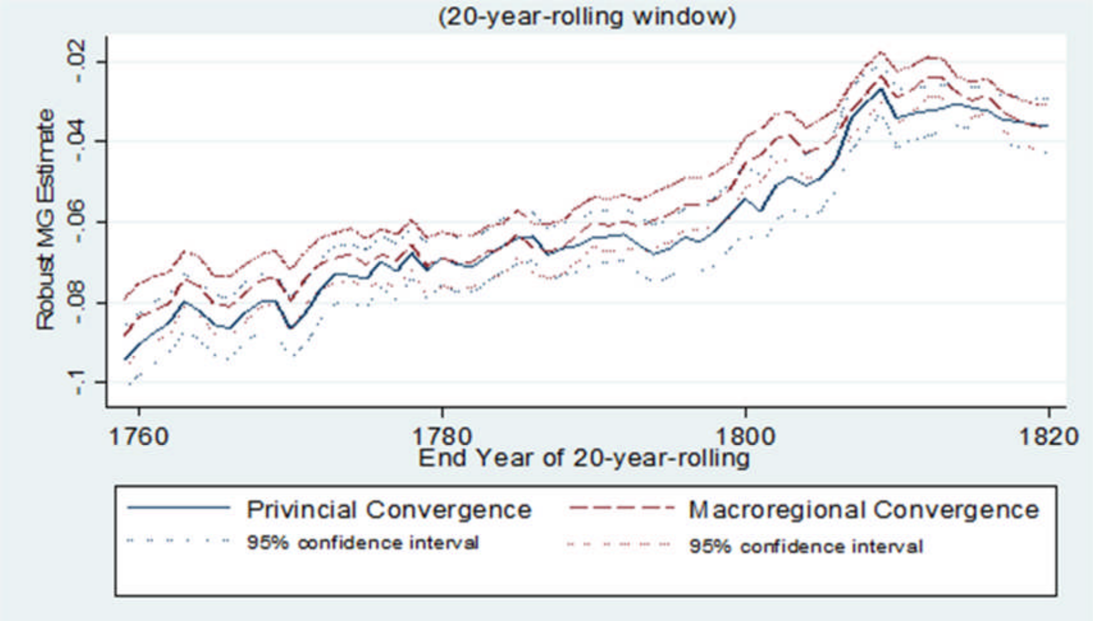
In (5.16), α_i captures prefecture-level time-invariant heterogeneity which will help explain price differentials across diverse locations within Southern China. $\overline{LPS_{t-1}^{S_i}}$ and $\overline{\Delta LPS_{t-1}^{S_i}}$ are the macroregional averages of $LPS_{i,t-1}$ and $\Delta LPS_{i,t-l}$ respectively, which capture the unobserved common factors driving price convergence. I include centered seasonal dummies M_c to capture the effect of heterogeneous harvest seasons across China's different climatic areas. The above empirical equation yields a total of N heterogeneous convergence coefficients and I report the Mean Group estimate of this set of coefficients:

$$\hat{\beta}_{MG}^{LPS} = (\Sigma w_i \hat{\beta}_i^{LPS}) / N \qquad (5.17)$$

where w_i represents a set of prefecture-specific weights applied in the computation of the average to reduce the impact of outliers.

Figure 5.6 plot the (Common Correlated Effects) Mean Group estimates of the 20-year rolling window for provincial convergence and macroregional convergence in South China respectively – both results account for cross-section dependence. The first observation is that both the provincial and macroregional convergence estimates follow an upward and similar trend over all time periods, which implies within-macroregional markets became less integrated over the entire period. This finding confirms that South China experienced a process of market disintegration. Although provincial boundaries did not follow the Skinner's physiographic boundaries, there was a large proportion of overlap between these two spatial distributions (see Figure 4.1 in Chapter 4). The second feature of Figure 5.6 is that, in the time dimension, the extent of price convergence at the macroregional level was similar but somewhat less than that at the provincial level, which could be driven by the spatial overlap between these two classifications. Until now, it is unclear whether provincial or physiographic borders contributed most to the fragmentation of Southern markets.

Figure 5.6 Macroregional/Provincial Convergence (South Rice)



In analogy to the network analysis conducted in Section 5.3.2, I construct a geographical variable for macroregional accessibility of prefecture *i*, SA_i, defined as the sum of postal route distances to all other prefectures within the same macroregion. I use the following cross-section regressions to investigate whether macroregional convergence is significantly correlated with macroregional accessibility:

$$\hat{\beta}_i^{LPS} = \alpha + \omega^{SA} \ln(SA_i) + \kappa_i + \varepsilon_i \qquad (5.18)$$

where the dependent variable is the macroregional convergence estimate for each prefecture from equation (5.16) for the entire 81-year period; κ_i denotes macroregion dummies, which account for unobserved heterogeneity across macroregions. If ω^{SA} is positive significant, it favours the hypothesis that there was a single *unified integrated macroregional market* to drive the observed macroregional convergence.

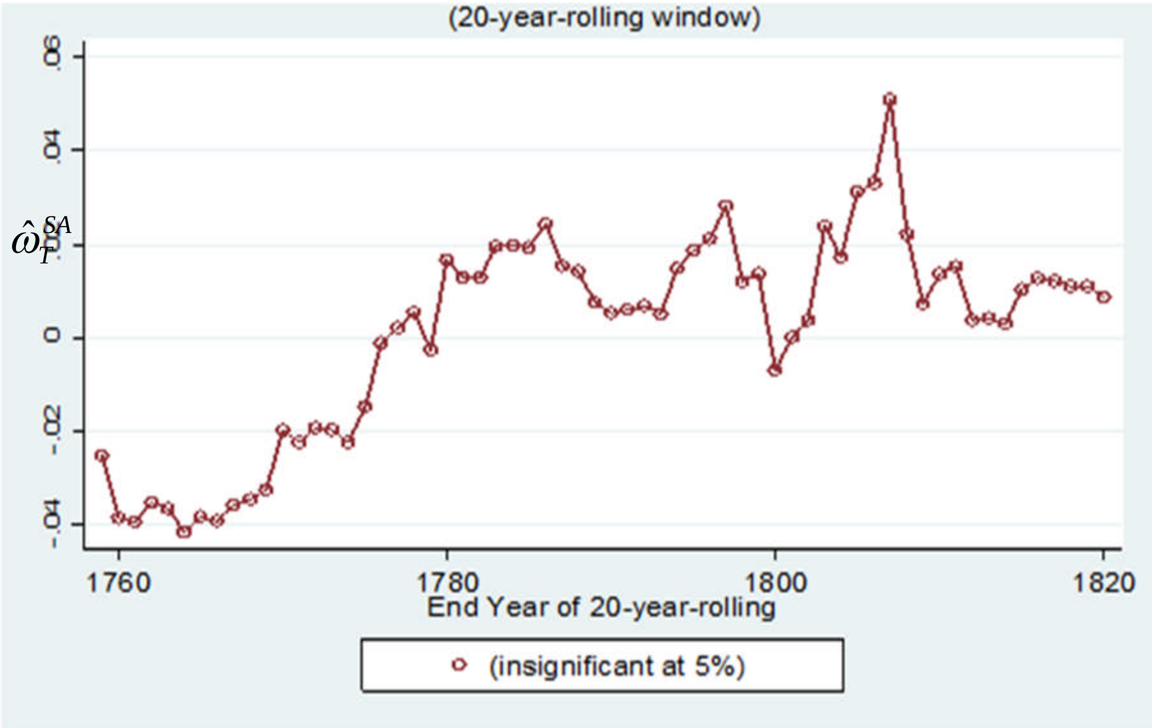
First, I am interested in the results for the *entire* time period, compared with those for provincial convergence. The results for the provincial convergence analysis are reported of columns 1 and 2 in Table 5.3, while the results for the macroregional convergence are in columns 3 and 4. Based on Figure 2.4(b) in Section 2.5.6, Agr_i denotes crop area dummies for prefecture i to capture the impact of heterogeneous climate and harvest time, which is added in each model. In columns 1 and 2, controlling for provincial fixed effects, macroregional fixed effects and cropping pattern fixed effects, provincial accessibility $\ln(PA)_i$ is still significant at the 10% level, which confirms that an individual location's geographical accessibility within the provincial network contributes to its provincial-level price convergence in Southern China. However, $\hat{\beta}_i^{LPS}$ is insignificant in columns 3 and 4. Although in Figure 5.6, the average macroregional convergence was comparable with the average provincial convergence, the individual macroregional convergence was not determined by geographical accessibility within the macroregional network. The contradiction implies that the similarity between provincial and macroregional convergence was driven by their spatial overlap, and that (political) provincial borders rather than physiographic borders were the dominant factor in market fragmentation of Southern China. The change of ω_T^{SA} over time, based on equations (5.18) but using a 20-year rolling window, is reported in Figures 5.7. The consistent statistical insignificance of ω_T^{SA} suggests that Southern prefectures were not integrated as a unified market at the macroregion level.

Table 5.3 Fragmentation: Geography or Institutions (only South, 1740-1820)

Dependent Variable:	$\hat{\beta}_i^{LPR}$		$\hat{\beta}_i^{LPS}$	
	(1)	(2)	(3)	(4)
$\ln(PA_i)$	0.023	0.021		
	(0.012)*	(0.0125)*		
$\ln(SAi)$			0.012	0.015
			(0.011)	(0.014)
Pro.	yes	yes	No	yes
Ski.	No	yes	yes	yes
Agr.	yes	yes	yes	yes
Obs.	131	131	131	131
R^2	0.283	0.315	0.242	0.295

Note: I omit reporting fixed effects and the constant. Robust standard errors provided in parentheses; ***, ** and * denote 1%, 5% and 10% significance level respectively

Figure 5.7 Macroregional Determinants and Convergence (South)



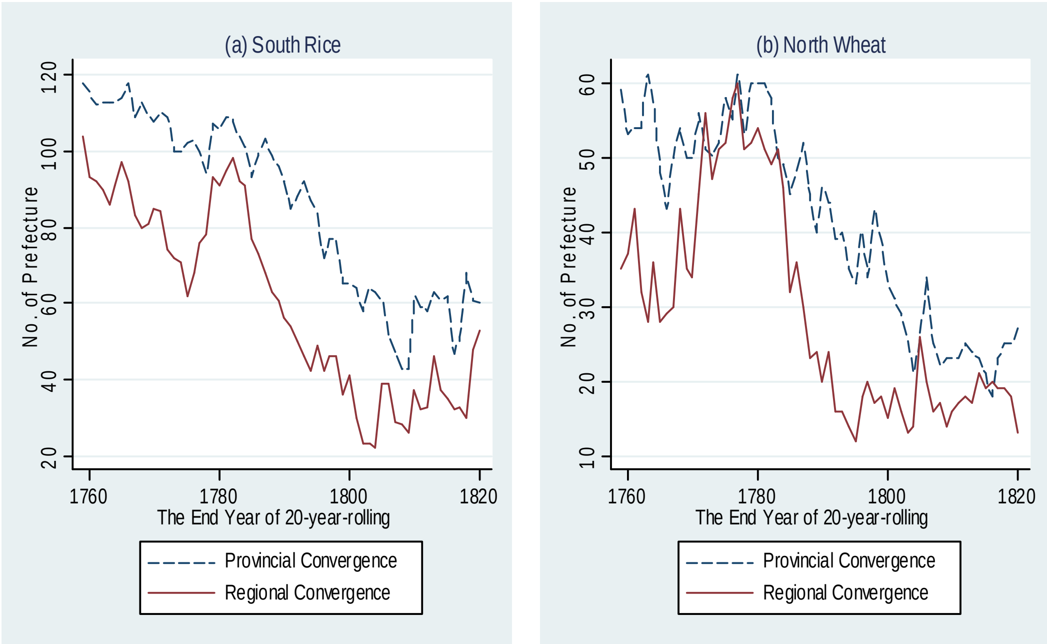
5.3.4 Robustness Check

In this section, I carried out two robust checks to lend support to the quantitative conclusion that China's markets were undergoing disintegration during the given time period.

<u>Number of Prefectures with Significant Convergence</u>

First, in Figure 5.8, I report the number of statistically significant (at the 5% level) prefectural convergence coefficients (i.e. $\hat{\beta}_i^{LPP}$ or $\hat{\beta}_i^{LPR}$) with a 20-year rolling window for regression (5.6') and (5.8'). It is expected that prices in fewer prefectures would significantly converge to the provincial (or regional) average price if markets became more and more disintegrated at the provincial (or regional) level. Since there are more prefectures in the sample for South China, the number of prefectures required for significant convergence is larger for the South than the North. There are two common features across both regions in Figure 5.8. First, the number of significant prefectures for provincial and regional convergence decreased over time, which convincingly supports the view that China's markets after the 1740s witnessed a process of disintegration. Second, more prefectures statistically significantly converged to the provincial rather than the regional mean price. This finding confirms that China's markets were more integrated at the provincial level.

Figure 5.8 Number of Prefecture with Significant Convergence



<u>Additional Common Factor</u>

Following Pesaran *et al.*(2013), in addition to the cross-section averages for the rice price in levels and first differences, I add the mean provincial and regional *wheat* price (in lagged levels and first differences according to the lag structure of the variable of interest) in the models for rice prices in (5.6') and (5.8') to further capture the unobserved common factors:

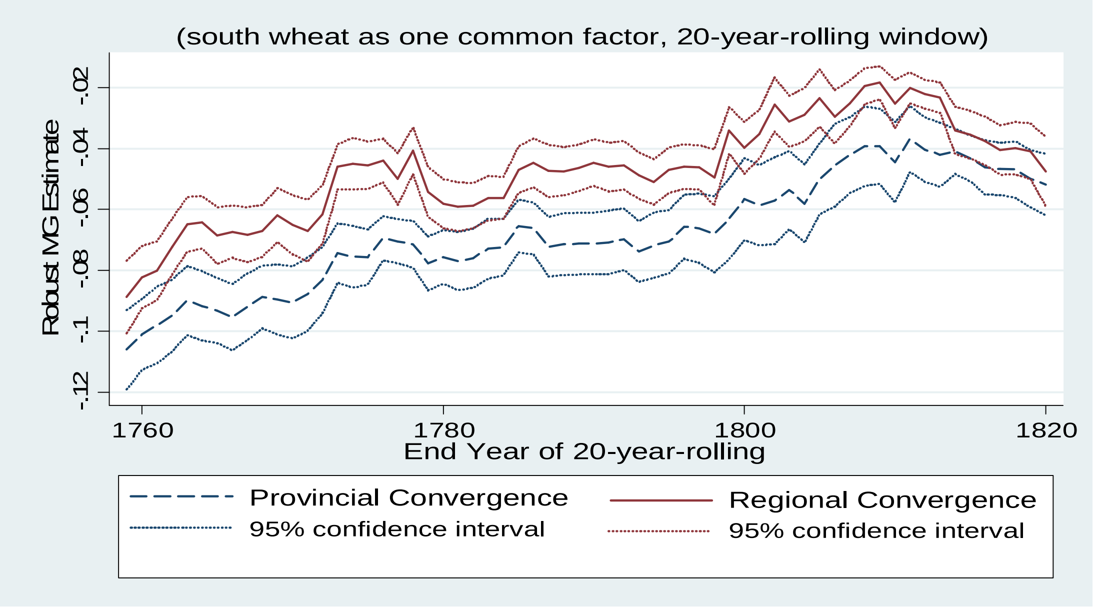
$$\Delta LPP_{it} = \alpha_i + \beta_i^{LPP} LPP_{i,t-1} + \sum_{l=1}^{p_i} \delta_{i,l} \Delta LPP_{i,t-l} + \lambda_i^{P1} \overline{LPP_{t-1}^{P_i}} + \sum_{l=0}^{p_i} \lambda_{i,l}^{P2+l} \overline{\Delta LPP_{t-l}^{P_i}}$$

$$+ \sum_{C=1}^{11} \gamma_C M_C + \underbrace{\sum_{l=1}^{p_i} \delta_{i,l} \Delta LPPw_{i,t-l} + \lambda_i^{P1} \overline{LPPw_{t-1}^{P_i}} + \sum_{l=0}^{p_i} \lambda_{i,l}^{P2+l} \overline{\Delta LPPw_{t-l}^{P_i}}}_{\text{additional unobserved common factors (constructed using wheat prices)}} + \varepsilon_{i,t} \qquad (5.19)$$

$$\Delta LPR_{it} = \alpha_i + \beta_i^{LPP} LPR_{i,t-1} + \sum_{l=1}^{p_i} \delta_{i,l} \Delta LPR_{i,t-l} + \lambda_i^{R1} \overline{LPR_{t-1}^{R_i}} + \sum_{l=0}^{p_i} \lambda_{i,l}^{R2+l} \overline{\Delta LPR_{t-l}^{R_i}}$$
$$+ \sum_{C=1}^{11} \gamma_C M_C + + \sum_{l=1}^{p_i} \delta_{i,l} \Delta LPRw_{i,t-l} + \lambda_i^{R1} \overline{LPRw_{t-1}^{R_i}} + \sum_{l=0}^{p_i} \lambda_{i,l}^{R2+l} \overline{\Delta LPRw_{t-l}^{R_i}} + \varepsilon_{i,t} \quad (5.20)$$

The basic idea in regressions (5.19) and (5.20) is to exploit additional information across the same prefectures over the same time series (i.e. wheat price) in order to capture the unobserved common factors. The common shocks driving rice prices are also affecting wheat prices in the South, and the methodology applied here exploits this commonality. This method requires prefectural data for rice as well as wheat prices in the same period. This additional data set was already used in Section 4.4.5 and comprises 77 prefectures in Southern China. The Mean Group estimate based on the estimator of regression (5.19) and (5.20) is reported graphically with a 20-year rolling window in Figure 5.9. These findings further confirm that, in South China, provincial convergence is faster than regional convergence in all periods investigated while both provincial and regional markets became *less* integrated over time.

Figure 5.9 Provincial/Regional Convergence with Additional Common Factor (only South)



5.4 Why Did Markets Decline?

To the best of my knowledge this study is the first to identify and quantify the disintegration process of Chinese grain markets during the 18th century. There is however a small literature that qualitatively or quantitatively analyses the decline of market efficiency in Qing Dynasty China during this period. Huang (2002) argues that the seemingly advanced market conditions in the Yangtze Delta during the pre-modern era were driven by a deterioration of the land-labor ratio, accompanied by lower capital intensity per unit of labor and lower returns per workday, which is described as 'involutionary growth'. During the 18th century, the cultivation of sweet potatoes sustained population growth in China as a cheap substitute for grain among the poor who did not possess land for crop cultivation (Chen, 2003; Jia, 2012). The popularity of sweet potato can on one hand be considered as a signal of dramatic demographic pressure on the Qing China.

On the other hand, to supply sufficient food for a fast-growing population, overuse of irrigation and excessive land reclamation had led to serious soil erosion and environmental degradation, which affected the grain output as well as river transportability (Chen, 2003; Gong, 1993; Zhang and Hui, 2006; Zhou, 2006). The popularity of sweet potato in the valleys and hillsides was another main contributor of soil erosion. Although sweet potato is extremely drought-resistant and grows quite easily, its roots dry up the soil and cause serious soil erosion and river siltation (Zhang and Hui, 2006).

It is quite likely that the unprecedented population growth as well as the deterioration of river transportability drove down the volumes of grains traded, which affected the grain market performance. In the following I consider a number of alternative hypotheses which have been advanced in this literature and submit them to some empirical testing.

5.4.1 Population Growth?

This section tests the statistic correlation between population growth and the change of provincial price convergence, and attempts to identify whether population growth was the driving force behind market disintegration. Rising local grain demand from an increasing population would substantially reduce the exportable grain volumes available from grain-surplus prefectures such that trade grain volumes would shrink over time. If this hypothesis were correct, we would expect a negative correlation between prefectural population growth and the provincial or regional grain price convergence term, especially for surplus prefectures (i.e. grain export prefectures). To test this hypothesis in the case of provincial convergence I adopt the following regression model:

$$\hat{\beta}_{i,1801-20}^{LPP} - \hat{\beta}_{i,1740-59}^{LPP} = \tau(PoPD_{i,1820} - PoPD_{i,1776}) + \chi_i + \varepsilon_i \qquad (5.21)$$

where $\hat{\beta}_{i,1801-20}^{LPP}$ and $\hat{\beta}_{i,1740-59}^{LPP}$ are provincial convergence estimates from the regression (5.6') in Section 5.2.2, and $PoPD_{i,1820}$ and $PoPD_{i,1776}$ is the prefectural population density in year 1820 and 1776, where the former are selected so as to match the available data for the latter. All results are reported in Table 5.4. There is no statistically significant evidence that population growth was positively correlated with a shift in price convergence over time. For Northern China, the signs are even negative. In Columns 3 and 6, the coefficients for the sample of grain surplus prefectures are still insignificant. In general, I cannot find support for the hypothesis that population growth drove down the extent of market integration.

Table 5.4 Population Density Growth and Market Disintegration

Dependent Variable: $\hat{\beta}_{i,1801-20}^{LPP} - \hat{\beta}_{i,1740-59}^{LPP}$	South Rice			North Wheat		
	all	deficit	surplus	all	deficit	surplus
	(1)	(2)	(3)	(4)	(5)	(6)
$PoPD_{i,1820} - PoPD_{i,1776}$	0.0004	0.0002	0.0012	-0.0004	-0.0006	-0.0002
	(0.0003)	(0.0003)	(0.0013)	(0.0004)	(0.0004)	(0.0005)
χ_i	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	117	38	60	70	23	35
R^2	0.2143	0.3906	0.1565	0.3981	0.1816	0.1699

Note: We omit reporting fixed effects and the constant. Robust standard errors provided in parentheses; ***, ** and * denote 1%, 5% and 10% significance level, respectively

5.4.2 Trade Cost Determinants

The finding of market disintegration implies that trade costs experienced an upward trend. The following analysis focuses on the determinants of trade costs and how this relationship varied over time. Trade cost (T) between markets i and j can be divided into two parts: variable cost (i.e. distance-related cost) and fixed cost (i.e. distance-unrelated cost). Distance-related costs (V) are related to the distance travelled (e.g. transport cost, information cost) and distance-unrelated cost (F) are other costs not related to distance, including storage cost, loading cost or costs related to a border effect.

$$T_{ij} = V_{ij} + F_{ij} \qquad (5.22)$$

If there exists a long-run trade link between two prefectures i and j (integrated market pair), according to the law of one price, total trade cost T_{ij} between two prefectures for a homogeneous commodity in period t equals their price differential:

$$T_{ij,\,t} = P_{i(h)t} - P_{j(l)t}, \text{ where } P_{i(h)t} > P_{j(l)t} \qquad (5.23)$$

where subscript h (or l) in the parentheses identifies the market with the higher (lower) price in each pair. In equation (5.22) above, distance-related costs V_{ij} equal cost per kilometre (C) multiplied by distance in kilometres (Dis_{ij}) between i and j, i.e.,

$$V_{ij} = C \times Dis_{ij} \qquad (5.24)$$

Combining (5.22) and (5.24) results in

$T_{ij} = C\times Dis_{ij} + F_{ij}$ (5.25)

In equation (5.25), C is the parameter representing the relationship that describes how trade cost T_{ij} increases with changes in the distance Dis_{ij} between market pairs, i.e. $C=\Delta T_{ij} / \Delta Dis_{ij}$. In regression (5.26) below, the dependent variable $T_{ij,t}$ is defined as the price differential of the same grain commodity in the same period, i.e. $T_{ij,t}= P_{i(h)t} - P_{j(l)t}$, where I impose that convention that $P_{i(h)t} > P_{j(l)t}$ in each pair ij to assure positive T Regression (5.26) empirically examines the determinants of trade cost only for the cointegrated prefecture pairs determined in Chapter 4 since cointegration indicates a long-run trade link between the two markets. Thus

$$\ln(T_{ij,t}) = \beta_0 + \beta_1 \ln(Dis)_{ij} + \beta_2 River_{ij} \times \ln(Dis)_{ij} + \beta_3 \ln(\sum_{m=1}^{11} P_{i(h),t-m}/11) + \beta_4 \ln(\sum_{m=1}^{11} P_{j(l),t-m}/11)$$
$$+\beta_5(\Delta P_{i(h),t-1}/P_{i(h),t-1}) + \beta_6(\Delta P_{j(l),t-1}/P_{j(l),t-1}) + \sum_{k=2}^{12}\theta_k M_k + \theta_{i^*j^*} + u_{ij,t} \qquad (5.26)$$

Similar to regression in Section 4.4.2, Dis_{ij} is the postal route distance between i and j ; $River_{ij}$ is a dummy variable equal to 1 if two prefectures have access to the same grain river; the aim of the interaction term $River_{ij} \times Dis_{ij}$ is to provide insights into the relative distance-related cost of land versus river transport; M_k captures monthly seasonality while $\theta_{i^*j^*}$ captures the seasonality across different cropping patterns. The $\sum_{m=1}^{11} P_{i(h),t-m}/11$ and $\sum_{m=1}^{11} P_{j(l),t-m}/11$ terms are the moving average price of the past 11 months[44], which capture the *past* price level for the high and low price prefectures, respectively so as to allow me to focus on the trade cost determinants in the current time period; to avoid endogeneity bias, the lag of price

[44] To deal with the missing value issue, I set the moving average as the missing value if there are more than 4 missing values in the past 11 months.

change ratios $(\Delta P_{i(h),t-1} / P_{i(h),t-1})$ and $(\Delta P_{j(l),t-1} / P_{j(l),t-1})$ are included to capture short run local shocks on the high- and low-price prefecture, respectively. To avoid bias from heterogeneity in the relationship over time, the regression is run separately for each year. For the short run analysis, the moving average of past price and the lag of price change ratio capture the unobserved heterogeneity across prefectures such that I do not add prefecture fixed effects in regression (5.26).

Regression (5.26) can be rearranged as follows:

$$\ln(T_{ij,t}) = \beta_0 + (\beta_1 + \beta_2 River_{ij}) \times \ln(Dis)_{ij} + \beta_3 \ln(\sum_{m=1}^{11} P_{i(h),t-m} / 11) + \beta_4 \ln(\sum_{m=1}^{11} P_{j(l),t-m} / 11)$$
$$+ \beta_5 (\Delta P_{i(h),t-1} / P_{i(h),t-1}) + \beta_6 (\Delta P_{j(l),t-1} / P_{j(l),t-1}) + \sum_{k=2}^{12} \theta_k M_k + \theta_{i*j*} + u_{ij,t} \quad (5.27)$$

where ($\hat{\beta}_1$ + $\hat{\beta}_2$ $\times River_{ij}$) represents the elasticity of trade cost $T_{ij,t}$ on the distance Dis_{ij}, i.e.,

$$\hat{\beta}_1 + \hat{\beta}_2 \times River_{ij} = (\Delta \mathrm{T}_{ij} / \mathrm{T}_{ij}) / (\Delta \mathrm{Dis}_{ij} / \mathrm{Dis}_{ij}) = (\Delta \mathrm{T}_{ij} / \Delta \mathrm{Dis}_{ij}) \times (\mathrm{Dis}_{ij} / \mathrm{T}_{ij}) \quad (5.28)$$

Substitute $C = \Delta \mathrm{T}_{ij} / \Delta \mathrm{Dis}_{ij}$ into equation (5.28) to yield

$$\hat{\beta}_1 + \hat{\beta}_2 \times River_{ij} = C \times (\mathrm{Dis}_{ij} / \mathrm{T}_{ij}) = (C \times \mathrm{Dis}_{ij}) / \mathrm{T}_{ij} = (\mathrm{T}_{ij} - \mathrm{F}_{ij}) / \mathrm{T}_{ij} \quad (5.29)$$

Equation (5.29) implies that the sum of the coefficients $\hat{\beta}_1 + \hat{\beta}_2 \times River_{ij}$ indicate the proportion of total trade cost which accrues to distance-related cost. The larger $\hat{\beta}_1 + \hat{\beta}_2 \times River_{ij}$ the larger is the share of distance-related cost in the total trade cost. If $\hat{\beta}_1 + \hat{\beta}_2 \times River_{ij} = 0$, there are at least two alternative but opposite interpretations: 1) C=0 such that the distance-related cost is equal to 0, which implies that the transport system is highly developed; 2) C>0 but the denominator T_{ij} approaches infinity, which implies that markets are highly disintegrated.

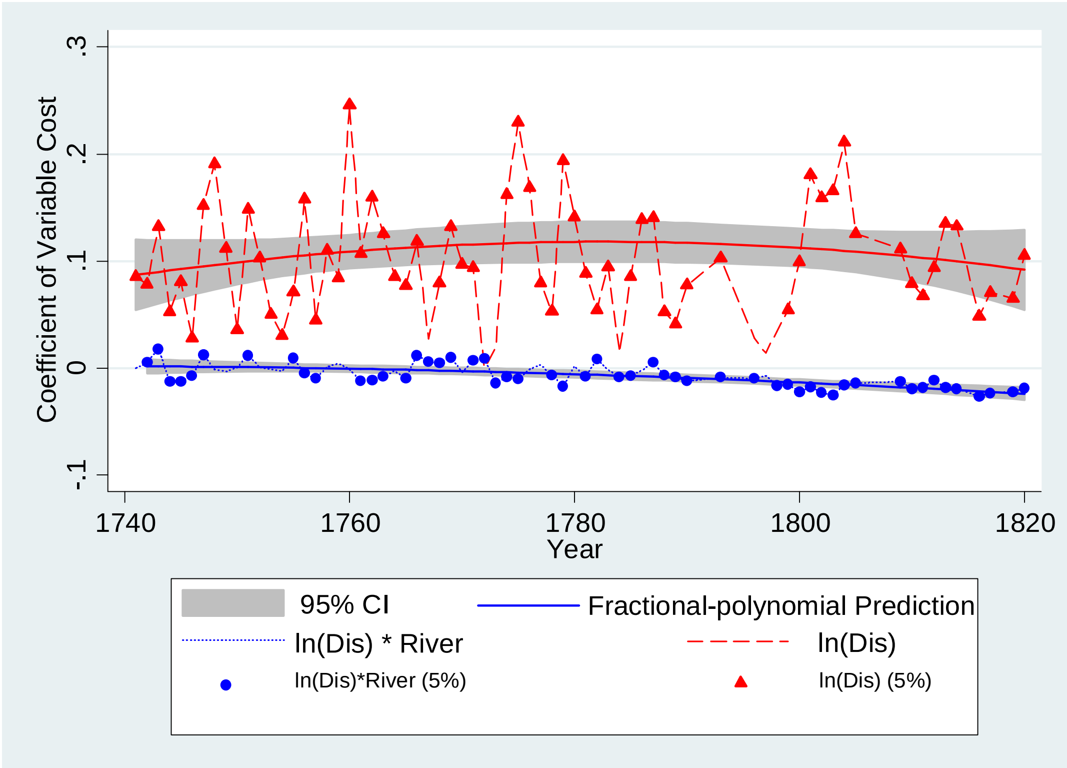
Figure 5.10 reports the annual coefficients for $\hat{\beta}_1$ and $\hat{\beta}_2$ where solid circles represent significant $\hat{\beta}_2$ (for $\ln(Dis)_{ij} \times \text{River}_{ij}$) at the 5% level. Although most $\hat{\beta}_2$ are significant, the magnitudes are small compared with the $\hat{\beta}_1$ (for $\ln(Dis)_{ij}$). This result suggests that river transport played a significant but small role in reducing trade cost. The small impact of river on the trade cost implies that the deterioration of river transportability during the sample period cannot be the main driving force of market decline. Since the magnitudes of $\hat{\beta}_2$ are small, the share of distance-related cost (i.e. $(C\times \text{Dis}_{ij}) / T_{ij}$) is mainly determined by $\hat{\beta}_1$. From 1741 to 1820, most of $\hat{\beta}_1$ estimates deviate around 0.1 between 0 and 0.2 except for occasional spikes. This implies that 10% of total trade cost is accounted for by distance (i.e. distance-related cost) in any given period. The results in Section 5.3.1 indicate that Southern China experienced market disintegration over time, which implies that the average T_{ij} increased over time. Thus, the stable ratio of variable to total trade cost suggests that distance-related cost ($C\times \text{Dis}_{ij}$) *increased proportionally* with T_{ij}.

If distance-related cost is only able to explain 10% of total trade cost, this implies that around 90% of trade cost was attributed to the distance-unrelated costs. In equation (5.30), distance-unrelated cost is defined as being made up three components: distance-unrelated cost related to provincial borders (i.e. institutional barriers), distance-unrelated cost related to the Skinner macroregion borders (i.e.

natural barrier) and an unknown distance-unrelated cost component which may relate to bureaucratic (in)efficiency or some other factors which cannot be observed.

$$T_{ij} = C\times Dis_{ij} + F_{ij,pro} + F_{ij,ski} + F_{ij,unknow} \qquad (5.30)$$

Figure 5.10 Distance-related Cost Determinants



I re-define my regression model in (5.26) and add dummy variables to capture the fixed border effects and analyse their relative proportion in total trade cost. Pro_{ij} =1 if there is a provincial border on the postal route between a pair of prefectures; Ski_{ij} =1 if there is a Skinner macroregion border between the same two prefectures. To capture potential heterogeneity in distance-related cost, the distance terms $\ln(Dis)_{ij}$ and its interaction term $River_{ij}\times \ln(Dis)_{ij}$ are further interacted with a series of distance group dummies. This yields

$$\ln(T_{ij,t}) = \beta_0 + \sum_{k=1}^{8}\lambda_k \times Dis\_G_{ij,k} \times \ln(Dis)_{ij} + \sum_{k=1}^{8}\omega_k \times Dis\_G_{ij,k} \times River_{ij} \times \ln(Dis)_{ij} + \beta_p \mathrm{Pr}o + \beta_s Ski$$
$$+\beta_1 \ln(\sum_{m=1}^{11} P_{i(h),t-m}/11) + \beta_2 \ln(\sum_{m=1}^{11} P_{j(l),t-m}/11) + \beta_3(\Delta P_{i(h),t-1}/P_{i(h),t-1}) + \beta_4(\Delta P_{j(l),t-1}/P_{j(l),t-1})$$
$$+\sum_{k=2}^{12}\theta_k M_k + \theta_{i^*j^*} + u_{ij,t}$$

(5.31)

$$Dis\_G_{ij,k} = \begin{cases} 1 & \text{if } (k\text{-}1)\times 200km < Dis_{ij} \leq k\times 200km \quad (k=1,2,\ldots 9) \\ 0 & \text{if otherwise} \end{cases}$$

In regression (5.31), $\hat{\beta}_p$ and $\hat{\beta}_s$ are the elasticites of trade cost with respect to the border dummies, i.e.,

$\hat{\beta}_p = (\Delta T_{ij} / T_{ij}) / (\Delta Pro_{ij}) = (\Delta T_{ij} / \Delta Pro_{ij}) / T_{ij}$ (5.32)

$\hat{\beta}_s = (\Delta T_{ij} / T_{ij}) / (\Delta Ski_{ij}) = (\Delta T_{ij} / \Delta Ski_{ij}) / T_{ij}$ (5.33)

In equation (5.30) above, $F_{ij,pro}$ is the parameter representing how trade cost changes by the appearance of a provincial border, i.e. $\Delta T_{ij} / \Delta Pro_{ij}$, while, similarly, $F_{ij,ski}$ is defined as $\Delta T_{ij} / \Delta Ski_{ij}$ such that $\hat{\beta}_p$ ($\hat{\beta}_s$) in equation (5.34) ((5.35)) express the cost share of a provincial (physiographic) border:

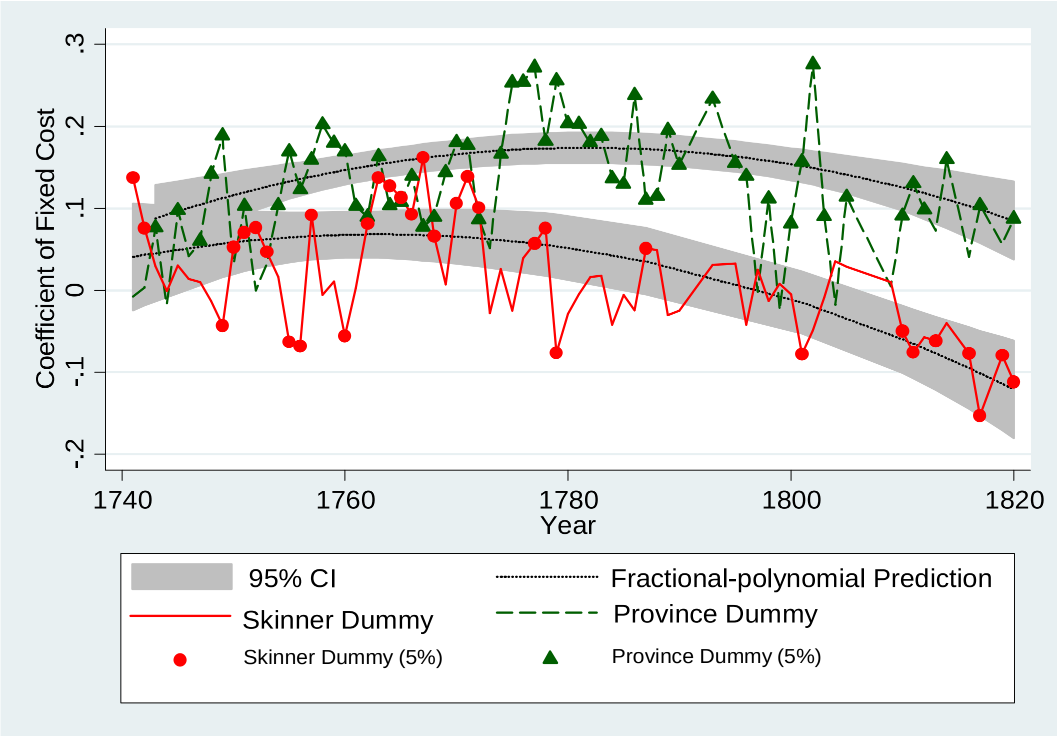
$\hat{\beta}_p = F_{ij,pro} / T_{ij}$ (5.34)

$\hat{\beta}_s = F_{ij,ski} / T_{ij}$ (5.35)

Figure 5.11 reports the annual estimates of β_p and β_s from 1741 to 1820. The solid triangle points indicate a statistically significant $\hat{\beta}_p$ at the 5% level. The $\hat{\beta}_p$ generally fall between 0.1 and 0.3 following a concave trend (fractional-polynomial prediction). This range implies that provincial borders explain 10-30% of total trade cost for *inter*-provincial trade. Since T_{ij} is assumed to increase over the whole period (due to the empirical finding of market disintegration), the increasing trend of $\hat{\beta}_p$ (i.e. $F_{ij,pro}$ / T_{ij}) before 1780 suggests that $F_{ij,pro}$ grew even *faster* than T_{ij}, while the decreasing trend after 1780 indicates that $F_{ij,pro}$ grew slower than T_{ij}. The provincial border effect thus played a significant role in the observed market disintegration until 1780. However, after 1780, its impact is ambiguous.

In terms of the physiographic border effect, $\hat{\beta}_s$ shows a marginally decreasing trend and its magnitudes are always smaller than $\hat{\beta}_p$. It appears that the trade cost impact of geographic barriers is significantly lower than the influence of (political) provincial borders. Before 1780, the proportion of trade cost explained by physiographic borders moved steadily between 0 and 20%. However, after 1780, the significance of $\hat{\beta}_s$ vanishes, which indicates that only a tiny share of trade cost was related to physiographic barriers. In the final 10 years this parameter became significant again but negative, which is difficult to explain and may be driven by the presence of highly fragmented markets.

Figure 5.11 Distance-unrelated Cost Determinants



Adding up the estimated annual coefficients in Figures 5.10 and 5.11, even the sum of the maximum estimates for distance-related cost, capturing both provincial and physiographic border effects, would only explain about 50% of total trade cost T_{ij}. This means that on average at least 50% of trade cost comes from unobserved distance-unrelated costs. Over the entire sample period, the stable ratio of distance-related cost to total trade cost (i.e. $\hat{\beta}_1 + \hat{\beta}_2 \times River$) suggests that distance-related cost was *increasing* until 1820, which is one plausible cause of market fragmentation. However, the importance of distance-related cost (including transport cost) has been overestimated in previous work since it was only able to explain around 10% of the price differentials. The impact of river transport on trade cost is statistically significant but not dominant. The provincial border effect played a significant role on market disintegration until 1780. However, after 1780, the decreasing trend of $\hat{\beta}_p$ and the insignificant $\hat{\beta}_s$ unambiguously suggest that unknown distance-unrelated cost were the main driving force behind the increasing trade cost T_{ij}. What constituted these unknown distance-unrelated costs? What happened in 1780 to trigger this pattern observed in the results? Most historians suggest that 1780 was the end of the most prosperous period of the Qianlong regime. It is possible that increasing bureaucratic inefficiency and a decrease of central power held at the imperial court in Beijing constitute the unknown distance-unrelated cost on grain trade. In order to be able to investigate this hypothesis it is necessary to create a link between China's grain market efficiency and the bureaucratic efficiency and power of the Qing State, which is beyond the scope of the present thesis. All of the above questions however deserve more attention in future research.

5.5 Conclusions

This chapter analyses the extent of dynamic market integration and patterns of market fragmentation during the prime of the Qing China, using monthly rice and wheat price data across 211 prefectures between 1740 and 1820. Applying novel panel time series and conventional cross-section methods, this chapter provides a dynamic comparison between rice markets in Southern China and wheat markets in Northern China. The empirics of this chapter were motivated through a simple theoretical model extended with a common factor structure, which allows me to capture the distorting impact of regional or local shocks on the analysis of market integration by relaxing the assumption of 'cross-section independence' in price series across prefectures. Combined with the theoretical model, panel cointegration methods building on Pesaran (2006, 2007) are exploited to investigate heterogeneous convergence to a provincial or regional average. This approach also allows me to quantify the statistical correlations between heterogeneous price convergence and geographic proximity, which provides a new and unique method to characterise the observed patterns of market fragmentation. The substantial time series dimension of my data further allows me to analyse price convergence in models with a 20-year rolling window to provide a dynamic observation of market evolution and safeguard against the biasing impact of structural breaks.

My results suggest that both Southern and Northern China experienced continuous market disintegration and fragmentation over the sample period, and that the pattern of market fragmentation was along political provincial rather than physiographic borders. These findings provide a convincing argument that Qing Dynasty markets were not fully integrated as a single unified market even during its economic golden era, which challenge the recent suggestions that China possessed a well-functioning market on the eve of western industrialization. Given this conclusion, we may need to reconsider the role of the market and market support institutions in the process of industrialization. The failure of pre-modern China to initiate industrialization may be due to its lack of well-functioning markets. My results further imply that the role of transport cost in determining market efficiency has been overstated in previous research and that we need to re-consider the widespread claims for causality between transport cost reduction and economic growth. In addition, my findings suggest that the *extent* of price convergence in a collection of locations (e.g. a region like Southern China) is insufficient to conclude whether the market constituted a *unified integrated* market or not.

This chapter identifies and quantifies China's market decline but also triggers another important question: how to explain China's market decline during its prosperous period. Using some simple regressions, I do not find any evidence to support that demographic pressure or the deterioration of river transport were the main driving forces behind the observed market decline. The combination of results in Chapters 4 and 5 indicate that Qing China's grain market was fragmented along provincial borders, which reflects the influential intervention by the Qing bureaucracy. In the analysis of short-run trade cost determinants, however, the provincial border effect was only able to explain 30% of trade cost while at least 50% of total trade is attributed to unknown distance-unrelated cost. Since the regression models arguable capture most of the geographical determinants, it is possible that the unexplained trade cost share still accrues to the impact of institutions. All the empirical results support, however indirectly, my hypothesis stated in Section 2.4.2 that "well-functioning" markets could not take root under the highly centralized polity of Qing Dynasty China since market regulation and food security rather than revenue creation were the primary concerns of the emperors.

Chapter 6
Conclusions

6.1 Summaries of Findings

This thesis is the first attempt to challenges the conventional wisdom that China possessed unified integrated market on the eve of western industralization, which uses archival data on grain prices covering the most prosperous episode (1740-1820) to identify the determinants of market evolution as well as the true extent of China's unified market in this pre-modern period.

By the late 18th century, the industrial revolution began to shake England, and then eventually transform the Europe. Because of Industrialization, for the first time, humanity would be sprung from the Malthusian trap and experience sustained growth in prosperity. Most of literature discussing the origin of the Great Divergence narrows down to the specific question of why the industrialization first emerged in Europe. The debate over China's failure to industrialize during the 19th century has been centred on the question of 'integrated markets' (whether prices co-move across localities reflecting marketization driven by demand and supply) as a necessary precondition for industrialisation. The unified politico-bureaucratic system and relative ethno-linguistic homogeneity of Qing Dynasty China vis-à-vis Western Europe are frequently cited as environmental factors conducive to the development of an integrated market network in Imperial China. Both the recent historical and economic literatures on this question agree that China was characterised by integrated markets on the eve of industrialisation in Europe (Pomeranz, 2000; Shiue and Keller, 2007).

Using unique historical grain price data combined with data for the postal route network, grain waterway network and physiographical distribution, this thesis seeks to provide evidence for the view that integration across prefectures and regions of Qing China was characterized by considerable heterogeneity My empirical analysis first confirms the close relationship between market integration (price cointegration) and geographic proximity. However, I show that political borders played a more important role for market integration than physical geography, which adds support to literature arguing for the supremacy of institutions over geography in the deep determinants of development. I then employ novel panel time series methods to investigate the evolving process of market integration over time in an empirical framework which further allows for common shocks (e.g., widespread drought) and local spillover effects (e.g., localised flooding). My findings again question the prevailing consensus in the literature by indicating a lengthy process of market disintegration with fragmentation determined by political structure during the 18th century: by 1820 China's markets were fragmented and the unified market hypothesis is thus seriously in doubt. China's market efficiency on the eve of Western industrialisation has been grossly overstated, and was heavily influenced by its bureaucratic system rather than the geographical determinants.

My results suggest that we may re-consider the role of market efficiency on industrialization. However, my empirical results trigger and discuss another question: why were markets not integrated in Qing China even though its political institutions were unified and integrated? The answer to this question may not just help us to understand pre-modern China's economic mode, but also provide insight into China's fall in economic status during the Great Divergence. In this research, my empirical results cannot support the hypothesis that demographic pressure or river transportability deterioration led to market decline. It is quite possible that institutions produced the main driving force. Without direct evidence, this thesis suggests the absence of formal property right institutions blocked the development of the modern market mechanism under the unified political regime present in China, and the grain market performance was thus mainly driven by the state engagement and intervention.

6.2 Limitation of this Thesis

The first limitation of this thesis is the unbalance missing value in the grain price data, although its reliability and comparability have been discussed in Chapter 3. It is always possible that my results are driven by the missing values. The good side is that my quantitative conclusions of market decline are still robust during the most prosperous period (i.e. 1750-1770) with the lowest proportion of missing value. It is still convincing to claim that China's grain market started to decline during its "golden" era of the mid-Qing. In Chapter 4, I used the cointegration estimator of each pair to construct the cross-section model identifying the determinants of market integration, with which I have to impost the assumption of independence across pairs. Obviously, this assumption is not reasonable since the real markets always possess complicated spatial link with each other. On the other hand, I do not observe direct empirical link between "grain protectionism" and provincial border barrier.

In Chapter 5, despite the panel cointegration method that allow me to relax the assumption of “cross-section independence” with a common factor framework including global shocks and local spill-over effects, it is not able to distinguish between global shocks and the local spatial dependence of grain prices. The panel cointegration method I used only allows me to test the panel price convergence with imposed structure (e.g. province or macroregion). It is unclear which forces drove market decline behind the provincial borders during this stable and prosperous period in a politically unified economy. It is possible that the identified political border effects were driven by the official or merchants’ network.

6.3 Implications for Further Research

The rich data used in this thesis is not only able to shed new light on history, but also identify links between the past and today, which would give us more insights into the unified framework including China’s historical decline and contemporary rise.

In terms of spatial analysis, adopting advanced spatial econometric method (Bailey *et al.*, 2013) I am able to distinguish between global shocks (e.g. a nationwide drought) and the local spatial dependence using the grain price data, a distinction thus far ignored in the empirical analysis of market integration. The pattern revealed by the data can then be tested against more hypotheses for the determinants of market integration, e.g. China’s institutional development and/or external weather shocks (enabled by detailed information already digitised). This investigation will allow me to identify which factors limited China’s market performance in the 18th century.

Most literature agreed that the reduction of transport cost played a progressive role to drive the economic growth in United States and Europe. "Reduction in the cost of carriage has enabled specialization and division of labour on a national inter-national basis to replace the relatively self-sufficient economics that predominated in the Western world two centuries ago" (North, 1958, p.537, cited from Shiue (2002)). In the early 1990s, China embarked on an ambitious initiative to build and upgrade its transportation infrastructure, particularly its highway system. From a low base, spending on transportation infrastructure has grown at 15% a year since 1990 to about $200 billion in 2007 (Baum-Snow *et al.*, 2012). This huge investment has created renewed debate over how much infrastructure contributes to economic growth. On the one hand, the empirical analysis of this important question faces serious difficulties in identifying a causal link and its magnitude in the face of 'reverse causality' (richer regions/countries build more roads; road construction projects first target locations with the greatest potential for development). In this thesis, I digitized archival maps of the national postal network to provide a more accurate representation of trading routes during the Qing Dynasty period. Information on these trading routes can now act as an 'instrumental variable' for today's transport infrastructure in the empirical analysis of the infrastructure-growth nexus in modern-day China. On the other hand, this thesis provides convincing argument that the role of transport cost on the market evolution in pre-modern China has been overstated. Thus, it behoves us to go back to the history to identify which factors limit the impact of transport costs, which could supply valuable information for policy makers for their decisions to invest in transportation infrastructure.

During the process of globalization with technological advances and formal trade tariff reductions, market segmentation continues to exist. Political and administrative borders have long been considered as a major source of trade costs in most of trade literature. China's contemporary domestic market was fragmented by provincial borders. Chinese provinces' greater involvement in international trade went hand in hand with a decrease in inter-provincial trade flow intensity between 1987 and 1997 (Poncet, 2001, 2003, and 2005). Zhu *et al.* (2005) suggest that China's rapid export expansion is produced by its severe market segmentations which produce higher trade cost for private firms to explore home market than oversea market. Young (2000) argues that China's gradual reform allow local officials' rent-seeking through the protection of local industries, which consequently led to the market fragmentation. It is ambiguous whether the empirically identified "provincial border" is a temporary or permanent product of China's decentralization reform. China's bureaucratic framework remained comparatively stable over the past 40 years. With the basic political structures and social arrangements displaying substantial continuity since the Qing Dynasty, it is possible to connect these historical institutional formations to "protectionism" observed in today's China.

Acemoglu and Robinson (2012) explain the entire humankind history by dividing the world into "inclusive" and "extractive" institutions. Nations gain prosperity when institutions are "inclusive" and pluralistic, encompassing property rights and creating incentives for investment. Nations fail when institutions are "extractive", protecting the interests of the elite against new entry from competitors. Before the 19th century, while Europe's intensive inter-state competition predetermined the evolution of inclusive institutions, China's imperial political structure was a centralized and isolated unitary state consisted of extractive institutions. Although without direct empirical evidence, my results support the hypothesis that China’s “extractive” institutions limited the evolution of modern market mechanism, which further implies the importance of “institutional change” for triggering modern economic growth. The identification of link between institution and economic performance in history would tell us more about how history affects today and what we need to do in the future.

Bibliography

Acemoglu, Daron, Simon Johnson, and James A. Robinson, 2001, “The Colonial Origins of Comparative Development: An Empirical Investigation,” *American Economic Review*, Vol. 91, pp.1369–1401

Acemoglu, Daron, Simon Johnson, and James A. Robinson., 2002, "Reversal of fortune: Geography and institutions in the making of the modern world income distribution." *The Quarterly Journal of Economics*, Vol. 117(4): pp.1231-1294

Acemoglu, Daron, and Simon Johnson, 2004, “Unbundling Institutions,” Journal of Political Economy, Vol. (113): pp.949–995

Acemoglu, Daron, Simon Johnson, and James Robinson, 2005, "The rise of Europe: Atlantic trade, institutional change, and economic growth", *American economic review*, Vol. 95(3): pp.546-579

Acemoglu, Daron, James A. Robinson, and Dan Woren, 2012, *Why nations fail: the origins of power, prosperity, and poverty*. Vol. 4. New York: Crown Business

Ai, Chunrong and Edward C. Norton (2003), “Interaction Terms in Logit and Probit Models”, *Economics Letters*, Vol.80, pp.123-129

Allen, Robert C. 2009. “Agricultural Productivity and Rural Incomes in England and the Yangtze Delta”, Economic History Review, Vol. 62 (3), pp. 525-550

Allen, Robert, 2012, “Technology and the Great Divergence”, Explorations in Economic History, Vol. 49 (1), pp.1-16

Allen, Robert C., Jean-Pascal Bassino, Debin Ma, Christine Moll-Murata, and Jan Luiten van Zanden. 2011. “Wages, Prices, and Living Standards in China, 1738–1925: In Comparison with Europe, Japan, and India.” *Economic History Review* 64: 8–38

Andrabi, Tahir, and Michael Kuehlwein, 2010, "Railways and Price Convergence in British India." *The Journal of Economic History*, Vol. 70(2): pp. 351-377.

Bai, Jushan, 2009, “Panel Data Models with Interactive Fixed Effects”, *Econometrica*, Vol. 77(4), pp.1229-1279

Bai, Jushan and Serena Ng, 2002. "Determining the Number of Factors in Approximate Factor Models," *Econometrica, Vol. 70(1), pp.191-221*

Bai, Jushan and Serena. Ng, 2004, “A Panic Attack on the Unit Roots and Cointegration”, *Econometrica, Vol. 72(4), pp.1127-1277*

Bai, Ying, and James Kai-sing Kung, 2014, "Diffusing Useful Knowledge while Spreading God’s Message: Protestantism and Economic Prosperity in China, 1840–1920", *Journal of the European Economic Association (forthcoming)*

Banerjee, Abhijit, and Lakshmi Iyer, 2005, “History, Institutions and Economic Performance: The Legacy of Colonial Land Tenure Systems in India,” *American Economic Review*, Vol. 95: pp.1190–1213

Barrett, C., 2001. “Measuring integration and efficiency in international agricultural markets”, *Review of Agricultural Economics*, Vol. 23, pp.19–32.

Baten, Joerg, Ma, Debin, Morgan, Stephen and Wang, Qing, 2010. “Evolution of Living Standards and Human Capital in China in the 18-20th Centuries: Evidences from Real Wages, Age-heaping, and Anthropometrics”, *Explorations in Economic History*, Vol. 47 (3), pp.347-59.

Bailey, N., S. Holly and H. Pesaran, 2013, “Modelling Spatial Dependence with Pairwise Correlation”, unpublished mimeo

Baum-Snow, N., L. Brandt, J. V. Henderson, M. A. Turner and Q. Zhang, 2012, “Roads, Railroads and Decentralization of Chinese Cities”, unpublished mimeo

Bernard, Andrew B & Jones, Charles I, 1996. "Productivity across Industries and Countries: Time Series Theory and Evidence," *The Review of Economics and Statistics*, Vol. 78(1), pp.135-46

Blaut, James M., 1993, *"The colonizer’s model of the world: Geographical Diffusionism and Eurocentric History”*, Guilford Press

Blaydes, Lisa, and Eric Chaney, 2013, "The Feudal Revolution and Europe's Rise: Political Divergence of the Christian West and the Muslim World before 1500 CE." *American Political Science Review* Vol. 107(1): pp.16-34

Bol, Peter K., 2007, "The China historical geographic information system (CHGIS): Choices faced, lessons learned." *Conference on Historical Maps and GIS, Nagoya University*

Bogart, Dan, 2011, "Did the Glorious Revolution contribute to the transport revolution? Evidence from investment in roads and rivers 1." *The Economic History Review,* Vol. 64(4): 1073-1112

Brandt, Loren, Debin Ma, and Thomas G. Rawski, 2014, "From Divergence to Convergence: Reevaluating the History behind China's Economic Boom", *Journal of Economic Literature*, Vol. 52(1), pp.45-123

Brandt, Loren.,1989, *Commercialization and Agricultural Development: Central and Eastern China, 1870-1937*. Cambridge University Press

Brenner, Robert, and Christopher Isett., 2002, "England's divergence from China's Yangzi Delta: Property relations, microeconomics, and patterns of development." *The Journal of Asian Studies* Vol. 61(2): pp.609-662

Broadberry, S. N. and Gupta, Bishnupriya, 2006, **"***The early modern great divergence: wages, prices and economic development in Europe and Asia, 1500-1800"***,** *Economic History Review*, Vol. LIX(1), pp 2-31

Buck, John Lossing , 1937, *Land Utilization in China: A Study of 16786 Farmers in 168 Localities and 38256 Farm Families in Twenty Two Provinces in China, 1929-1933*, Shanghai: University of Nanking

Cai, Xiaojuan, 2005, "Study and Realization of Digitization for China Postal Album in Qing Dynasty" (Daqing Youzheng Yutu de Shuzihua Yanjiu yu Shixian), Modern Technology of Library and Information Services (Xiandai Tushu Qingbao Jishu), Vol 129, pp51-55

Cao, Shuji. 2000. *Zhongguo Renkou Shi (History of Population in China)*. Volume 5. Shanghai: Fudan University Press.

Chen, Chunsheng and Liu, Zhiwei, 2010, "Gongfu, Shichang yu Wuzhi Shenghuo – Shilun Shiba Shiji Meizhou Baiyin Liuru yu Zhongguo Shehui Bianqian zhi Guanxi (Tribute, Market and Substantial Life – A discussion of the relation between Silver Inflow from America in the 18th century and Social Change in China)", *Qinghua Daxue Xuebao (Journal of Tsinghua University),* Vol. 25(5), pp.65-81

Chen, Rui, 2003, "Qingdai Zhongqi Huizhou Shanqu Shengtai Huanjing E'hua Zhuangkuang Yanjiu-Yi Pengmin Yingshan Huodong Wei Zhongxin

(Research on the Deterioration of Ecological Environment of Huizhou Mountain Areas in the Middle Period of Qing Dynasty)”, *Anhui Shixue (Historical Research in Anhui)*, Vol. 6(14)

Chen, Zhiqing, 2001, “Lishi Shiqi Huanghe Xiayou de Yuni, Juekou Gaidao Jiqi Yu Renlei Huodong de Guanxi (The Deposition, Breach, and Diversion in the Lower Yellow River and Their Relationships with Human Activities during the Historical Period)”, *Dili Kexue Jinzhan (Progress in Geography)*, Vo1 20(1), pp.44-49

Chilosi, D., Murphy, T. E., Studer, R., & Tunçer, A. C., 2013, “Europe's many integrations: Geography and grain markets, 1620–1913”, *Explorations in Economic History*, Vol. 5*0*(1), pp. 46-68.

Chuan, Han-sheng, and Richard A. Kraus, 1975, *Mid–Ch’ing Rice Markets and Trade: An Essay in Price History.* Cambridge, MA:Harvard University Press.

Chudik, A., M. H. Pesaran, E. Tosetti (2011), "Weak and Strong Cross Section Dependence and Estimationof Large Panels", *Econometrics Journal*, Vol. 14, pp.45-90.

Clark, Gregory, 2002, “Markets and Economic Growth, The Grain Market of Medieval England,” manuscript, University of California-Davis

Clark, Gregory. 2008, *A farewell to alms: a brief economic history of the world*. Princeton University Press

Clark, Gregory., 2010, “The macroeconomic aggregates for England, 1209–2008”, in Alexander J. Field (ed.) *Research in Economic History, Vol. 27,* pp.51-140

Clark, Gregory, and Robert C. Feenstra., 2003, "Technology in the Great Divergence", *NBER Chapters*, pp.277-322.

Coffman, D’Maris, Adrian Leonard and Larry Neal, 2013, *Questioning Credible Commitment: Perspectives on the Rise of Financial Capitalism,* Cambridge: Cambridge University Press

Coleman, Andrew, 2007, “The Pitfalls of Estimating Transaction Costs from Price Data: Evidence from Tran-Atlantic Gold-Point Arbitrage, 1886-1905”, *Explorations in Economic History*, Vol. 44, pp.387-410

Crook, Frederick W., 1999, “An Analysis of China’s Food Grain Security Policy”, In *Agriculture in China and OECD Countries: Past Policies and Future Challenges*., pp.55-74, OECD

Deaton, Angus. 1999. "Commodity Prices and Growth in Africa." *Journal of Economic Perspectives*, Vol. 13(3), pp.23–40.

Deaton, Angus, and Guy Laroque, 1996, "Competitive Storage and Commodity Price Dynamics", *Journal of Political Economy*, Vol. 104 (5), pp.896-923

Dell, Melissa, 2008, "*The Mining Mita*: Explaining Institutional Persistence", mimeo, MIT

Deng, Yibin, 1994, "Qingdai Qianqi Neilu Liangshi Yunshuliang Ji Bianhua Qushi – Guanyu Qingdai Liangshi Yunshu Yanjiu Zhier (Domestic Grain Trade Volume and its Growth in Early Qing –Qing Grain Transport Analysis No2)", *Zhongguo Jingjishi Yanjiu (China Economics History Research),* No 3

Deng, Yibin, 1995, "Qingdai Qianqi de liangshi Yunxiao he Shichang (The Food Transport, Trade and Market in the Early Period of the Qing Dynasty)", *History Research (Lishi Yanjiu),* No.4

Diamond, Jared, 1997, *Guns, germs, and steel: the fates of human societies,* NY: WW Norton & Company

Dickey, David and Wayne A. Fuller, 1979, "Distribution of the Estimates for Autoregressive Time Series with a Unit Root." *Journal of the American Statistical Association*, Vol. 74, pp.427-431.

Dincecco, Mark, and Massimiliano Gaetano Onorato, 2013, "Military Conflict and the Economic Rise of Urban Europe", IMT Lucca Eic Working Paper, Series No.7

Dodgen, Randall A., 1991, "Hydraulic Evolution and Dynastic Decline: The Yellow River Conservancy, 1796-1855." *Late Imperial China*, Vol. 12(2): pp.36-63.

Donaldson, Dave. 2010, "*Railroads of the Raj: Estimating the impact of transportation infrastructure"*, No. w16487. National Bureau of Economic Research

Duan, Wei, 2009, Fu, Linxiang, 2009, Qingdai Hubei, Hunan Liangsheng de Xingcheng(The Division of the Imperial Examinations and Provincial Administrations: the Formation of the Provinces of Hubei and Hunan in Qing Dynasty), Qingshi Yanjiu (Studies in Qing History), No.2, May, pp.23-31

Dunstan, Helen, 1996, *Conflicting Counsels to Confuse the Age: A Documentary Study of Political Economy in Qing China, 1644-1840,* Ann Arbor: Center for Chinese Studies, University of Michigan

Dunstan, Helen, 2006, *State or merchant?: Political Economy and Political Process in 1740s China*, Harvard University Council on East Asian

Eastman, Lloyd, 1988, "*Family, Fields, and Ancestors: Constancy and Change in China's Social and Economic History 1550-1949*", Oxford University Press

Eberherdt, Markus and Francis Teal, 2013, "Structural Change and Cross-Country Growth Empirics", *World Bank Economic Review*, forthcoming

Eberherdt, Markus, Christian Helmers and Hubert Strauss, 2013, "Do Spillovers matter when estimating private returns to R&D?", *The Review of Economics and Statistics*, Vol. 95(2)

Editorial Committee of Irrigation History of the Yellow River, 1982, Huanghe Shuili Shi Shuyao (A Concise Narrative of Irrigation History of the Yellow River), China Irrigation Press (Zhongguo Shuili Chubanshe).

Ejrnæs, M., and Persson, K.G., 2000, "Market Integration and Transport Costs in France 1825–1903: A Threshold Error Correction Approach to the Law of One Price" *Explorations in Economic History*, 37, pp. 149–173

Elvin, Mark, 1973, *The pattern of the Chinese past: A social and economic interpretation*, Stanford University Press

Engerman, Stanley L., and Kenneth L. Sokoloff., 2000, *Factor endowments, inequality, and paths of development among new world economics*. No. w9259. National Bureau of Economic Research

Engle, Robert F., and Clive W. J. Granger. 1987. "Co-Integration and Error Correction: Representation, Estimation, and Testing", *Econometrica*, Vol. 55(2), pp.251–76.

Engel, Charles and John H. Rogers, 1996, "*How Wide is the Border*?", The American Economic Review, Vol. 86 (5), pp. 1112-1125

Evans, Laurence (1984), "Junks, Rice, and Empire: Civil Logistics and the Mandate from Heaven", *Historical Reflections*, Vol. 11(3), pp.271-313.

Fackler, Paul and Barry Goodwin, 2001. "Spatial Price Analysis" In Handbook of Agricultural Economics, volume 1, edited by B. Gardner and G. Rausser. Elsevier Science B.V. pp.971-1024.

Fan, I-chun, 1993, "Long-distance Trade and Market Integration in the Ming-Ch'ing period, 1400-1850", PhD Dissertation, Stanford University, 1993

Fan, C.,S., and Xiaogdong Wei (2006), “The Law of One Price: Evidence From the Transitional Economy of China”, *The Review of Economics and Statistics*, Vol. 88 (4), pp.682-697

Fang, Xing, and James H. Cole., 1989, "Why the Sprouts of Capitalism Were Delayed in China." *Late Imperial China*, Vol. 10(2), pp.106-138.

Fang, Xing, Shi Qi, Jian Rui, and Wang Shixin. 2000. “The Growth of Commodity Circulation and the Rise of Merchant Organisations.” *Chinese Capitalism, 1522–1840*, ed. Xu Dixin and Wu Chengming, pp.165–83. New York: St.Martin’s Press. (Orig. pub. in Chinese 1985.

Fang, Ying and Yang Zhao, 2011, “Xunzhao Zhidu de Gongju Bianliang: Guji Chanquan Baohu dui Zhongguo Jingji Zengzhang de Gongxian (Looking for Instruments for Institutions: Estimating the Impact of Property Rights Protection on Chinese Economic Performance)”, *Jingji Yanjiu (Economic Research Journal)*, Vol.5, pp138-148

Federico, Giovanni., 2007, "Market integration and market efficiency: the case of 19th century Italy." *Explorations in Economic History* Vol. 44(2): pp.293-316

Federico, Giovanni., 2011, “When did European markets integrate?”, *European Review of Economic History*, Vol. 15, pp.93–12

Federico, Giovanni., 2012, “How Much do We Know about Market Integration in Europe?”, *Economic History Review*, Vol. 65, pp.470-497

Federico, G. and Persson, K. G., 2007, “Market Integration and Convergence in the World Wheat Market, 1800-2000”. In Hatton, O’Rourke, and Taylor, editors, The new comparative economic history: essays in honour of J. Williamson, Cambridge, Mass. MIT Press.

Ferguson, Niall., 2011, *Civilization, the West and the Rest*, London: Allen Lane

Frank, Andre Gunder. 1998, *Global Economy in the Asian Age. Berkeley*, University of California Press

Fu, Linxiang, 2008, Jiangnan, Huguang, Shannxi Fensheng Guocheng yu Qingchu Zhidu de Bianhua (The Partition of Jiangnan, Huguang and Shaanxi Provinces and the Change of Provincial System at the beginning of the Qing Dynasty), *Zhongguo Lishi Dili Luncong (Journal of Chinese Historical Geography)*, Vol. 23 (2), pp.118-126

Fu, Linxiang, 2009, Qingdai Jiangsu Jiansheng Wenti Xintan (A New Study on the Establishment of Jiangsu Province in the Qing Dynasty), Qingshi Yanjiu (Studies in Qing History), No.2, May, pp.23-31

Galor, Oded, and David N. Weil., 2000, "Population, technology, and growth: From Malthusian stagnation to the demographic transition and beyond." *American Economic Review*, Vol. 90(4), pp.806-828.

Glaeser, Edward L., and Andrei Shleifer, 2002, "Legal origins", *The Quarterly Journal of Economics,* Vol. 117(4): pp. 1193-1229

Glaeser , E . L, LaPorta , R, Lopez de Silanes , F, and Shleifer , A , 2004 , “Do Institutions Cause Growth?”, *Journal of Economic Growth* , Vol. 9 , pp. 271-303

Goldberg, Pinelopi. K. and Frank Verboven, 2005, “Market Integration and Convergence to the Law of One Price: Evidence from the European car Market”, *Journal of International Economics*, Vol. 65, pp.49-73

Gong, Shengsheng. 1993. “Qingdai Lianghu Diqu Renkou Yali Xia de Shengtai Erhua yiji Duiche (Under Huge Population Pressure: Ecological Environment Deterioration and Related Policy in Hunan and Hubei areas in the Middle Period of Qing Dynasty)”, *Zhongguo Lishi Dili luncong (Forum of Geographical History in China),* Vol. 1, pp.69-94.

Gong, Shengsheng. 1995. “18 shiji Liang Hu liangjia shikong tezheng yanjiu (Research on the temporal and special characteristics of grain prices in Hunan and Hubei during the eighteenth century)”, *Zhongguo nongshi (Agricultural History of China),* Vol. 14(1), pp.48-59.

Gong, G., Ge, Q., and Xu, K., 1996, “Influence of Climatic Changes on Agriculture”, In Zhang, P. (ed.), *Historical Climatic Changes in China*, Shandong Science and Technology Press, Jinan, pp. 406–425

Goodwin, B. K. 1992, "Multivariate Cointegration Tests and the Law of One Price in International Wheat Markets." *Review of Agriculture Economics*, Vol. 14, pp.117-24.

Granger, C. W. J. 1986, "Developments in the Study of Cointegrated Economic Variables." *Oxford Bulletin of Economics and Statistics*. Vol. 48, pp.213-28.

Granger, C.W.J. 1969, "Investigating causal relations by econometric models and cross-spectral methods", *Econometrica*, Vol. 37, pp.424--438.

Greif, Avner, 1993, "Contract enforceability and economic institutions in early trade: The Maghribi traders' coalition." *The American Economic Review*, Vol. 83(3): pp.525-548.

Greif, Avner, and Guido Tabellini., 2010, "Cultural and institutional bifurcation: China and Europe compared", *The American Economic Review: Papers & Proceedings*, Vol. 100(2), pp.135-140.

Guy, R. K., 2010, *Qing governors and their provinces: the evolution of territorial administration in China, 1644-1796*, University of Washington Press.

Hanson, W. G., 1959, "How Accessibility Shapes Land Use", *Journal of the American Institute of Planners*, Vol. 25, pp.73-76

Hamilton, Lawrence C. 1992. "How Robust is Robust Regression?", *Stata Technical Bulletin*, Vol. 1(2)

Heinemeyer, Hans Christian, Max-Stephan Schulze, and Nikolaus Wolf, 2008, "Endogenous borders?: the effects of new borders on trade in Central Europe 1885-1933". No. 2246. CESifo working paper

Hoffman, Philip T., 2011, "Prices, the military revolution, and western Europe's comparative advantage in violence", *The Economic History Review*, Vol. 64 (s1): pp.39-59.

Hsu, J. L., and B. K. Goodwin. 1993, "Dynamic Relationships in the Market for Ocean Grain Freighting." Paper presented at AAEA Summer Meetings, Orlando FL

Huang, Philip C. C. 2002, "Development or Involution in Eighteenth-Century Britain and China?", *The Journal of Asian Studies*, Vol. 61(2): pp.501–38

Hung, Ho-fung., 2008, "Agricultural revolution and elite reproduction in Qing China: The transition to capitalism debate revisited", *American Sociological Review*, Vol. 73(4): pp. 569-588.

Im, Kyung.S. , M. Hashem Pesaran and Yongcheol Shin, 2002, "Testing for Unit Roots in Heterogeneous Panels", *Journal of Econometrics*, Vol. 115(1), pp.53-74

Isham, Jonathan, and Daniel Kaufmann, 1999, "The forgotten rationale for policy reform: the productivity of investment projects", *The Quarterly Journal of Economics*, Vol. 114(1): pp.149-184.

Jacks, D. S., 2005, “Intra- and international commodity market integration in the Atlantic economy, 1800–1913”, *Explorations in Economic History*, 42 (2005), pp. 381–413.

Jacks, David S., and Krishna Pendakur., 2010, "Global trade and the maritime transport revolution." *The Review of Economics and Statistics*, Vol. 92(4) : pp.745-755.

Jia, Ruixue, 2012, “Weather Shocks, Sweet Potatoes and Peasant Revolts in Historical China”, Working Paper

Juselius, Katarina, 2006, “*Cointegrated VAR Model: Methodology and Applications*”, Oxford University Press

Kamarck, Andrew M., 1976, *The Tropics and Economic Development*, John Hopkins University Press, Baltimore, MD

Keller, Wolfgang and Carol H. Shiue. 2007a, “The Origins of Spatial Interaction: Evidence from Chinese Rice Markets, 1742-1795,” *Journal of Econometrics*, Vol. 140(1): pp.304-332.

Keller, W and Shiue, C, 2007b, “Market Integration and Economic Development: A Long-Run Comparison”, *Review of Development Economics*, Vol. 11, No. 1, pp. 107-123, February 2007

Kremer, M., 1993, “Population growth and technological change: one million BC to 1990”, *The Quarterly Journal of Economics*, Vol. 108(3), pp. 681-716

Kwiatkowski, D., Phillips, P. C., Schmidt, P., and Shin, Y, 1992. “Testing the Null Hypothesis of Stationarity against the Alternative of A Unit Root: How Sure Are We that Economic Time Series Have a Unit Root?”. *Journal of econometrics*,Vol. *54*(1): pp.159-178.

Landes, David S., 2006, "Why Europe and the West? Why Not China?", *The Journal of Economic Perspectives*, pp. 3-22.

Lee, Kevin, Pesaran. M and Smith, Ron, 1997, “Growth and Convergence in a Multi-Country Empirical Stochastic Solow Model”, *Journal of Applied Econometrics*, Vol. 12, pp.357-392

Levin, A. and Lin, C. F. (1992). “Unit Root Test in Panel Data: Asymptotic and Finite Sample Properties”, University of California at San Diego, Discussion Paper No.92-93.

Li, Bozhong, 1998, *Agricultural development in Jiangnan, 1620-1850*, New York: St. Martin's

Li, Bozhong, 2000a, *Jiangnan de Zaoqi Kongyehua 1550–1850 (The early industrialization in Jiangnan 1550–1850)*, Beijing: Publishing Press of Social Science Materials

Li, Lillian M. 1992. “Grain Prices in Zhili Province, 1736–1911: A Preliminary Study.” In Thomas G. Rawski and Lillian Li, eds, *Chinese History in Economic Perspective*, pp.69–99. Los Angeles: University of California Press.

Li, Lillian M., 2000b, “Integration and Disintegration in North China’s Grain Markets, 1738-1911”, *Economic History Association,* Vol. 60(3), pp. 665-699

Li, Lillian M., and Alison Dray-Novey, 1999, "Guarding Beijing's food security in the Qing dynasty: state, market, and police." *The Journal of Asian Studies*, Vol. 58(4): pp. 992-1032.

Li, Rongsheng, 2009, “Qingdai (1645-1911) Meinian Liuru Zhongguo Baiyin Shuliang de Chubu Guji (Estimating the Yearly Amount of Silver Inflow during the China Dynasty in China (1645-1911)”, *Renwen Ji Shehui kexue Qikan (Journal of Humanities and Social Sciences)*, Vol. 5(2), pp.31-58

Lin, J. Y., 1995, “The Needham Puzzle: Why the Industrial Revolution did not Originate in China”, *Economic development and Cultural Change*, Vol. 43(2), pp.269-92.

Lin, J. Y., 2008, “The Needham puzzle, the Weber question, and China's miracle: Long-term performance since the Sung dynasty”, *China Economic Journal*, Vol. 1(1), pp.63-95

Liu, Cuirong, 1980, “Qingdai Cangchu Zhidu Wending Gongneng Zhi Jianyan (Institutions and its Stability of Granary System during the Qing Dynasty)”, Jingji Lunwen (Economic Papers), Vol. 8(1): pp.1-29

Liu, Guanglin, 2012, “Song China’s Water Transport Revisted: A Study of The 1077 Commercial Tax Data”, *Pacific Economic Review*, Vol. 17(1), pp.57-85

Liu, Peilin, 2000, “Changjiang Liuyu Lishi Hongshui de Zhouqi Dilixue Yanjiu (The Cyclic Geography Study on the Historical Floods in the Yangtze River)”, *Dili Kexue Jinzhan (Advance in Earth Sciences)*, Vol 15(5), pp.503-507

Lu, Feng and Kaixiang Peng, 2006, “A research on China’s long term rice prices (1644-2000)”, *Frontiers of Economics in China*, Vol. 4, pp.465-520

Lucas, Robert E., 1999, "The Industrial Revolution: Past and Future", Mimeo, Department of Economics, University of Chicago

Lufrano, Richard, 2013, "Minding the Minders: Overseeing the Brokerage System in Qing China", *Late Imperial China*, Vol. 34(1), pp.67-107.

Ma, Debin, 2004, "Growth, Institutions and Knowledge: a Review and Reflection on the Historiography of 18th–20th Century China", *Australian Economic History Review*,Vol. 44(3), pp.259-277

Ma, Debin, 2006, “Law and Commerce in Traditional China: An Institutional Perspective on the ‘Great Divergence’”, *Keizai-shirin* **(***The Hosei University Economic Review***)**, Vol. 73 (4), pp.69-96

Ma, Debin, 2008, “Economic Growth in the Lower Yangzi Region of China in 1911–1937: a quantitative and historical perspective.” *The Journal of Economic History*, Vol. 68(2), pp.385–392

Ma, Debin. 2011, "Rock, Scissors, Paper: the Problem of Incentives and Information in Traditional Chinese State and the Origin of Great Divergence", Working Paper

Ma, Debin, 2012, "Political Institutions and Long-run Economic Trajectory: Some Lessons from Two Millennia of Chinese Civilization", CEPR Discussion Papers, No. 8791

MacKinnon, James G. (1991), “Critical Values for Cointegration Tests.” In *Long-Run Economic Relationships, Readings in Cointegration*, R. Engle and C.W.J. Granger, (eds)., New York: Oxford University Press.

Maddala, G.S and Shaowen Wu, 1999, “A Comparative Study of Unit Root Tests with Panel Data and A New Simple Test”, *Oxford Bulletin of Economics and Statistics*, Special Issue, pp.631-652

Maddison, Angus, 1998, *Development Centre Studies Chinese Economic Performance in the Long Run*, OECD Publishing.

Mankiw, N. G., D. Romer and D. N. Weil (1992), “A contribution to the empirics of economic growth”, *Quarterly Journal of Economics*, Vol. 107, pp.407-37

Mann, Susan, 1987, *Local merchants and the Chinese bureaucracy, 1750-1950*. Stanford University Press

Marks, Robert B., 1991, “Rice Prices, Food Supply, and Market Structure in Eighteenth-Century South China”, *Late Imperial China*, Vol. 12(2), pp.64-116

Marks, Robert B., 1998. *Tigers, Rice, Silk, and Silt: Environment and Economy in Late Imperial South China*, Cambridge: Cambridge University Press.

Marks, Robert B. and Chunsheng Chen, 1995, “Price Inflation and Its Social, Economic, and Climatic Context in Guangdong Province, 1707-1800”, *T'oung Pao,* Second Series, Vol. 81, Fasc. 1/3, pp. 109-152

McCallum, J., 1995. “National Borders Matter: Canada–US Regional Trade Patterns”, *The American Economic Review*, Vol. 85 (3), pp.615–623.

Mokyr, Joel.,1990, *The lever of riches: Technological creativity and economic progress*. Oxford University Press

Mokyr, Joel., 2009, “*The Enlightened Economy: An Economic History of Britain 1700-1850*”, Yale University Press

Morgan, Stephen L., 2004. “Economic Growth and the Biological Standard of Living in China, 1880-1930”, *Economics and Human Biology*, Vol. 2(2), pp.197-218.

Naquin, Susan, and Evelyn S. Rawski. 1987, *Chinese Society in the Eighteenth Century*. New Haven: Yale University Press

Needham, J., 1969, *The Grand Titration: Science and Society in East and West*, Routledge

North, Douglass., 1958, "Ocean Freight Rates and Economic Development 1730-1913." *The Journal of Economic History*, Vol. 18(4) : pp.537-555.

North, Douglass C., and Robert P. Thomas, 1973, *“The Rise of the Western World: A New Economic History”*, New York: Cambridge University Press

North, Douglas C., 1981, *Structure and Change in Economic History*, W.W. Norton & Company, New York

North, Douglass C.,1990, “*Institutions, Institutional Change and Economic Performance*”, Cambridge: Cambridge University Press

North, Douglass C., and Barry R. Weingast, 1989, "Constitutions and commitment: the evolution of institutions governing public choice in seventeenth-century England." *The Journal of Economic History*, Vol. 49(4), pp. 803-832.

Norton, C. Norton, Hua Wang and Chunrong Ai, 2004, “Computing Interaction Effects and Standard Errors in Logit and Probit Models”, *The Stata Journal*, Vol.4(2), pp.154-167

Nunn, Nathan, 2009, “*The importance of history for economic development”*, No. w14899. National Bureau of Economic Research

Parsley, David C., and Shang-Jin Wei, 2001, "Explaining the border effect: the role of exchange rate variability, shipping costs, and geography." *Journal of International Economics* Vol. 55(1): pp.87-105.

Parsley, David, and Shang-Jin Wei, 2003, “How Big and Heterogeneous are the Effects of Currency Arrangements on Goods Market Integration: a Price Based Approach?”, Vanderbilt University working Paper

Parthasarathi, Prasanan., 1998, “Rethinking Wages and Competitiveness in the Eighteenth Century: Britain and South India.” *Past & Present*, Vol(158), pp.79-109

Perdue,C. Peter, 1992, "The Qing State and the Gansu Grain Market, 1739-1864", In Chinese History in Economic Perspective, edited by Thomas G. Rawski and Lillian M. Li, 35-68. Berkeley and Los Angeles: University of California Press, 1992

Perkins, D.H., 1967,"Government as an Obstacle to Industrialization: The Case of Nineteenth-Century China," *Journal of Economic History*, Vol. 26(4): pp. 478-492.

Perkins, D.H., 1969, *Agricultural development in China, 1368-1968*, Edinburgh: Edinburgh University Press and Chicago: Aldine Publishing Company

Persson, Karl-Gunnar. 1999. “*Grain Markets in Europe, 1500–1900, Integration and Deregulation”*. Cambridge: Cambridge University Press

Peng, Kaixiang. 2006, *Qingdai yilai de liangjia: lishixue de jieshi yu zaijieshi (The grain price since Qing Dynasty: the Explanation and Re-explanation of History)*, Shanghai: Shanghai Renmin Press

Pesaran, M. H.,2006. “Estimation and inference in large heterogeneous panels with cross section dependence”, *Econometrica*, Vol. 74(4), pp.967-1012.

Pesaran, M. H., 2007. “A simple panel unit root test in the presence of cross-section dependence”, *Journal of Applied Econometrics*, Vol. 22(2), pp.265-312.

Pesaran, M. H. and R. Smith, 1995, “Estimating long-run relationships from dynamic heterogenous panels”, *Journal of Econometrics*, Vol. 68, pp.79-113.

Pesaran, M. H., L. V. Smith and Takashi Yamagata, 2013, “Panel Unit Root Tests in the Presence of a Multifactor Error Structure”, *Journal of Econometrics*, Vol. 175(2), pp. 94-115

Pohlman, John T. and Dennis W. Leitner, 2003, “A Comparison of Ordinary Least Squares and Logistic Regression”, *The Ohio Journal of Science*, Vol.103(5), pp.118-125

Poncet, Sandra, 2001, “Is China Disintegrating? The Magnitude of Chinese Province’s Domestic and International Border Effects”, Working Papers 200221, CERDI

Poncet, Sandra, 2003, “Domestic Market Fragmentation and Economic Growth in China?”, ERSA conference papers ersa03l117, European Regional Science Association

Poncet, Sandra, 2005, “A Fragmented China: Measure and Determinants of Chinese Domestic Market Disintegration”, Review of International Economics, Wiley Blackwell, Vol. 13(3), pp.409-430.

Pomeranz, Kenneth, 2000, *The Great Divergence: China, Europe, and the Making of the Modern World Economy*. Princeton, NJ: Princeton University Press.

Rappaport, Jordan, and Jeffrey D. Sachs, 2003, “The United States as a Coastal Nation,” Journal of Economic Growth, Vol. 8 (2003), pp.5–46

Rawski, E. S., and Naquin, S., 1987, *Chinese society in the eighteenth century*, New Haven.

Rawski, Thomas G., 1989, *Economic Growth in Pre-War China*. University of California Press, Berkeley

Rodrik, Dani, Arvind Subramanian, and Francesco Trebbi, 2004, "Institutions Rule: the Primacy of Institutions over Geography and Integration in Economic Development." *Journal of economic growth*, Vol. 9(2): pp.131-165

Rodrik, Dani, 2012, “Unconditional Convergence in Manufacturing”, forthcoming in the *Quarterly Journal of Economics*

Rosenthal, Jean-Laurent, and Roy Bin Wong, 2011, Before and Beyond Divergence: The Politics of Economic Change in China and Europe, Harvard University Pres

Rowe, William T. 1984. *Hankow. Commerce and Society in a Chinese City, 1796–1889*. Stanford:Stanford University Press

Rowe, William. T., 1993, "State and Market in Mid-Qing Economic Thought: The Case of Chen Hongmou (1696-1771), *Études chinoises*, vol. XII, n° 1

Rowe, William T., 2011, "Introduction: The Significance of the Qianlong-Jiaqing Transition in Qing History." *Late Imperial China*, Vol. 32(2): pp.74-88.

Sachs, Jeffrey D., and Pia Malaney, 2002, "The Economic and Social Burden of Malaria," *Nature*, 415, pp.680–685

Sachs, Jeffrey D., Andrew D. Mellinger and John L. Gallup, 2001, "The Geography of Poverty and Wealth," *Scientific American*, 284, pp.70–76

Sachs, Jeffrey D., and Andrew M. Warner, 2001, "The curse of natural resources", *European economic review* Vol. 45(4): pp.827-838

Sachs, Jeffrey D. 2003, "*Institutions don't rule: direct effects of geography on per capita income*". No. w9490. National Bureau of Economic Research

Sands, Barbara, and Ramon H. Myers, 1986, "The spatial approach to Chinese history: a test." *The Journal of Asian Studies*, Vol. 45(4): pp.721-743.

Shimbel, A., 1953, "Structural Parameters of Communication Networks", *Bulletin of Mathematical Biophysics*, Vol. 15, pp.501-507

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

Shiue, Carol H. 2004, "Local Granaries and Central Government Disaster Relief, Moral Hazard and Intergovernmental Finance in 18th and 19th Century China", *Journal of Economic History*, Vol. 64(1): pp.100-124

Shiue, C and W. Keller, 2005, "Markets in China and Europe on the Eve of the Industrial Revolution", Working Paper

Shiue, Carol H., and Wolfgang Keller, 2007, "Markets in China and Europe on the Eve of the Industrial Revolution", *American Economic Review*, vol. 97(4), pages 1189-1216

Skinner, G. William, 1964, “Marketing and Social Structure in Rural China”, The *Journal of Asian Studies*, Vol.24

Skinner, G William., 1977a, “Regional urbanization in nineteenth-century China”, *The city in late imperial China*, pp.211-249

Skinner, G. William, 1977b, "Cities and the Hierarchy of Local Systems", *The city in late imperial China*, pp.275-351.

Skinner, G. William, Mark Henderson and Zumou Yue, 2007, “A Note Regarding the Physiographic and Socioeconomic Macroregions of China”, China Historical GIS Project, Harvard and Fudan Universities.

Studer, Roman, 2008, “India and the Great Divergence: Assessing the Efficiency of Grain Markets in Eighteenth- and Nineteenth- Century India”, *The Journal of Economic History*, Vol. 68, p394-437

Studer, Roman, 2009, “Does Trade Explain Europe’s Rise? Geography, Market Size and Economic Development”, Economic History Working Papers 27877, London School of Economics and Political Science, Department of Economic History

Sng, Tuan-hwee., 2014, "Size and dynastic decline: The principal-agent problem in late Imperial China 1700-1850", *Explorations in Economic History (forthcoming)*

Tan, Li, 2013, "Market-Supporting Institutions, Gild Organisations, and the Industrial Revolution: A Comparative View." *Australian Economic History Review*, Vol. 53(3): pp. 221-246

Tsai, Weipin., 2013, "Breaking the Ice: The Establishment of Overland Winter Postal Routes in the late Qing China." *Modern Asian Studies*, Vol. 47: pp. 1749-1781.

Van Zanden, Jan Luiten, Eltjo Buringh, and Maarten Bosker, 2012, "The rise and decline of European parliaments, 1188–1789", *The Economic History Review*, Vol. 65(3): pp. 835-861.

Wang, Shaowu, Ye, Jinlin and Daoyi Gong, 1998, “Zhongguo Xiaobingqi de Qihou (Climate in China During the Little Ice Age)”, *Disiji Yanjiu (Quaternary Sciences)*, Vol.1, pp.54-64

Wang, Yeh-Chien, 1978, “Qingdai de liangshi chenbao shidu (The Grain Reporting System in Qing Dynasty)”, *Gugong Jikan (The Quarterly Journal of the Palace Museum)*, Vol. 13 (1), pp.53-66

Wang, Yeh-Chien. 1986. “Food Supply in Eighteenth Century Fukien.” *Late Imperial China*, Vol. 7(2), pp.80-117

Wang, Yeh-Chien, 1989, “Food Supply and Grain Prices in the Yangzi Delta in the eighteenth Century”, The Second Conference on Modern Chinese History, Vol. 3(2), Academia Sinica: pp. 423-462

Wang, Yeh-Chien. 1990. “Food Supply and Grain Prices in the Yangzi Delta in the Eighteenth Century.” In Yung-san Lee and Ts’iu-jung Liu, eds, *China’s Market Economy in Transition*. Taipei: Institute of Economics, Academia Sinica. Reprinted in the Vol 3 of the collected works of Wang Yeh-Chien, pp.323-58.

Wang, Yeh-Chien, 1992, "The Secular Trend of Rice Prices in the Yangzi Delta, 1638-1935", In Thomas G. Rawski and Lillian Li, eds, *Chinese History in Economic Perspective*., pp.35-68. Berkeley and Los Angeles: University of California Press

Watson, Andrew, 1972. *Transport in transition: The evolution of traditional shipping in China*, Ann Arbor, MI: University of Michigan

Wei, Shangjin, 1996, Intra-national versus International Trade: How Stubborn Are Nations in Global Integration? NBER Working Paper 5531, April.

Wen, Guanzhong, 2005, “Zhongguo de Jiangyu Bianhua yu Zouchu Rongben Shehui de Chongdong (Changes in China’s Territory and its Impulse to Come out of the Agrarian Trap: An Economic Geography Approach)”, *Jingji Xue Jikan (China Economic Quaterly)*, Vol. 4(2), pp. 519-540

Wiens, Herold J., 1955, “Riverine and Costal Junks in China’s Commerce”, *Economic Geography*, Vol. 31(3), pp.248-264

Will, Pierre-Etienne, and Roy Bin Wong, 1991, *"Nourish the people: the state civilian granary system in China, 1650-1850."* Michigan monographs in Chinese studies (USA)

Wilson, W.W., 1981, "Factors Affecting Post Harvest Changes in Grain Prices Received by North Dakota Producers", Agricultural Economics Report No. 146, Department of Agricultural Economics, North Dakota State University

Wong, R. Bin, 2004, “The Role of the Chinese State in Long-distance Commerce”, Working Paper No. 05/04

Wong, R. Bin, and Peter Perdue, 1992, “Grain Markets and Food Supplies in 18th Century Hunan.” In Thomas G. Rawski and Lillian Li, eds, *Chinese History in Economic Perspective*, pp 126–44. Los Angeles: University of California Press

Wolf, Nikolaus, 2005, "Path dependent border effects: the case of Poland’s reunification (1918–1939)." *Explorations in Economic History,* vol.42.3 : pp.414-438.

Wu, Chengming, 1985, *Chinese capitalism and domestic markets*, Beijing, China’s Social Science Press, 1985

Wu, Chengming, 1985, *Chinese capitalism and domestic markets*, Bejing, China’s Social Science Press

Xu, Dixin, and Wu Chengming, 1985, “*Chinese Capitalism 1522-1840”* in "Zhongguo zibenzhuyi de mengya (The sprouts of capitalism in China). Beijing: Zhongguo shehui kexue chubanshe 2000."

Yao, Yang, 2003, “Gaoshuiping Xianjing- Li Yuese Zhi Mi Zai Kaocha (The High Equilibrium Trap- The Needham Paradox Revisited)”, *Jingji Yanjiu (Economic Research Journal),* Vol.1, pp71-79

Yan, Se and Liu, Cong, 2011, “Shiba shiji zhongguo nanbeifang shichang zhenghe chengdu de bijiao(The North-South Market Integration Comparison in China of the 18^{th} century)”, *Jingji Yanjiu (Economic Research)*, Vol. 12, pp.124-137

Yin, Y., Miao, Q., and Tien, G., 2003, *Climatic Change and Regional Sustainable Development: A Case Study in the Changjiang Delta Region of China*, Kexue (Science), Beijing.

Young, Alwyn., 2000, "The razor's edge: Distortions and incremental reform in the People's Republic of China." *The Quarterly Journal of Economics,* Vol. 115(4), pp.1091-1135

Zhang, D. D., Zhang, J., Lee, H. F., and He, Y. Q., 2007, “Climate change and war frequency in Eastern China over the last millennium”, *Human Ecology*, Vol.35(4), pp.403-414

Zhang, Xianwen and Fuping Hui, 2006, “Qingdai Zhongqi Shandi Zhongzhi Yumi Yinfa de Shuitu Liushi jiqi E’zhi Cuoshi (Soil Erosion because of Extensive Corn Planting on Mountain Country and Restraining Measures in China From Middle to Late in Qing Dynasty), *Zhongguo Nongshi (Agricultural History of China)*, Vol. 25(3), pp.13-21

Zhao, Hongjun, 2009, “Li Yuese Zhi Mi: Jingji Xuejia Ying Jieshou Xinjie Haishi Xinjie? (The Needham Puzzle: Should Economists Accept Old Hypotheses or New Ones?)”, *Jingjixue Jikan (China Economic Quarterly)*, Vol. 8 (4), pp1615-1646

Zhou, Bangjun, 2006, “Qingdai Sichuan Tudi Kaifa yu Huanjing Bianqian – Yi Shuitu Liushi Wenti Wei Zhongxin (Land Reclamation and Environmental Changes in Sichuan during the Qing Dynasty: Focusing on the Problem of Soil Erosion”, *Xi’an Jiaotong Daxue Xuebao (Shehui Kexue Ban) (Journal of Southwest Jiaotong University (Social Science))*, Vol. 7(3)

Zhou, Zhenhe, 1996, Quanya Xiangru haishi Shanchuan Xingbian—Lishi shang Xingzheng quyu Huajie de Liangda Yuanze (Following the Natural Boundaries or not? Two Basic Principles of Political Boundaries Dividing), Zhongguo Fangyu (China’s Regions), Vol. 5(6)

Zhu Xiwei, Ji Xiangrong and Luo Deming, 2005, Guonei Shichang Fenge yu Zhongguo de Chukou Maoyi Kuozhang (Market Segmentation and the Expansion of China’s Export), *Jingji Yanjiu (Economic Research)*, Vol. 12, pp. 68-75

Appendix A Data Information

A.1 Unit Root Test Results

Table A.1.1 ADF Unit Root Test Results (South China)

Prefecture	p-value		Prefecture	p-value	
	With Drift	No Drift		With Drift	No Drift
Anqing	0.4463	0.7753	Pingyue	0.0005	0.5204
Chizhou	0.6420	0.7991	Shiqian	0.0000	0.6292
Chuzhou	0.2256	0.6186	Sinan	0.3864	0.8326
Fengyang	0.7049	0.6662	Sizhou	0.0060	0.5793
Guangde	0.3875	0.7208	Dading	0.1964	0.3703
Hezhou	0.1058	0.3935	Tongren	0.0000	0.5035
Huizhou	0.0616	0.6165	Xingyi	0.3720	0.1830
Liu'an	0.8168	0.5990	Zhenyuan	0.0000	0.8848
Luzhou	0.5093	0.7305	Zunyi	0.0000	0.3572
Ningguo	0.3879	0.7663	Guilin	0.0021	0.8551
Sizhou	0.5075	0.7300	Liuzhou	0.0013	0.7738
Taiping	0.1348	0.5773	Nanning	0.0010	0.8344
Yingzhou	0.7536	0.6894	Pingle	0.0034	0.8350
Changzhou	0.0705	0.8056	Qingyuan	0.1217	0.8878
Haizhou	0.5030	0.8107	Sicheng	0.1752	0.7055
Huai'an	0.1273	0.7418	Si'en	0.3092	0.5088
Jiangning	0.1869	0.8602	Taipingfu	0.0011	0.7808
Songjiang	0.0750	0.8647	Wuzhou	0.0013	0.6607
Suzhou	0.0267	0.7476	Xunzhou	0.0025	0.8457
Taicang	0.0498	0.8878	Yulin	0.0010	0.8424
Tongzhou	0.1224	0.7657	Zhen'an	0.0013	0.8301
Yangzhou	0.0195	0.7583	Anlu	0.4823	0.7612
Zhenjiang	0.0437	0.7132	De'an	0.5106	0.7968
Fuzhou	0.0000	0.6383	Hanyang	0.5570	0.8516
Ganzhou	0.0001	0.5746	Huangzhou	0.5475	0.7043
Guangxin	0.0000	0.5959	Jingzhoufu	0.1488	0.5866
Ji'an	0.0410	0.7412	Shinan	0.4569	0.6628
Jianchang	0.0001	0.7668	Wuchang	0.4451	0.8473
Jiujiang	0.0011	0.5372	Xiangyang	0.4647	0.9196
Linjiang	0.1116	0.8865	Yichang	0.5636	0.7468
Nan'an	0.0001	0.6222	Yunyang	0.6185	0.8154
Nanchang	0.0177	0.8618	Baoqing	0.0030	0.7892
Nankang	0.0000	0.7402	Changde	0.6978	0.9528

Table A.1.2 ADF Unit Root Test Results (South China)

Prefecture	*p-value*		Prefecture	*p-value*	
	With Drift	No Drift		With Drift	No Drift
Ningdu	0.0418	0.8133	Changsha	0.3282	0.8445
Raozhou	0.0000	0.6628	Chenzhou	0.7939	0.8779
Ruizhou	0.0023	0.7540	Chenzhoufu	0.3367	0.8004
Yuanzhou	0.0193	0.8503	Guiyang	0.0480	0.7048
Fuzhou	0.0007	0.8512	Hengzhou	0.8821	0.8590
Funing	0.0767	0.8645	Jingzhou	0.5618	0.9042
Jianning	0.0073	0.7562	Lizhou	0.4304	0.9163
Longyan	0.0096	0.9588	Yongshun	0.0953	0.7754
Quanzhou	0.0040	0.8121	Yongzhou	0.0005	0.9016
Shaowu	0.4609	0.5598	Yuezhou	0.0277	0.9455
Tingzhou	0.0004	0.9135	Yuanzhou	0.0131	0.7860
Xinghua	0.0008	0.9345	Baoning	0.4817	0.9322
Yanping	0.0822	0.6153	Chengdu	0.0709	0.7849
Yongchun	0.0025	0.7615	Zhongqing	0.4141	0.6666
Zhangzhou	0.0211	0.9287	Jiading	0.3170	0.6971
Taiwan	0.0000	0.5921	Kuizhou	0.2492	0.9122
Chaozhou	0.0001	0.8257	Long'an	0.3204	0.7443
Gaozhou	0.0188	0.7102	Ningyuan	0.2639	0.9536
Guangzhou	0.0317	0.8315	Shunqing	0.2946	0.8569
Huizhou	0.0020	0.8878	Tongchuan	0.5787	0.7770
Jiayingzhou	0.0022	0.8816	Xuzhou	0.0948	0.8820
Leizhou	0.0469	0.6517	Yazhou	0.5847	0.7159
Lianzhou	0.0014	0.7784	Hangzhou	0.0033	0.6685
Lianzhoufu	0.0211	0.7946	Huzhou	0.0090	0.6222
Luoding	0.0033	0.8217	Jiaxing	0.0036	0.6470
Nanxiong	0.0439	0.8532	Jinhua	0.0014	0.5592
Qiongzhou	0.0009	0.8030	Quzhou	0.0002	0.5929
Shaozhou	0.0000	0.7819	Ningbo	0.0001	0.6659
Zhaoqing	0.0072	0.8506	Shaoxing	0.0129	0.7736
Anshun	0.2270	0.5285	Taizhou	0.0009	0.6448
Duyun	0.0000	0.5690	Wenzhou	0.0001	0.6506
Guiyang	0.3179	0.4819	Yanzhou	0.0011	0.6227
Liping	0.2547	0.7732			

Table A.1.3 ADF Unit Root Test Results (North China)

Prefecture	*p-value*		Prefecture	*p-value*	
	With Drift	No Drift		With Drift	No Drift
An'xi	0.1853	0.5450	Jinan	0.5308	0.7621
Ganzhou	0.0728	0.6882	Laizhou	0.0655	0.7029
Gongchang	0.0481	0.5045	Qingzhou	0.1170	0.8012
Jiezhou	0.0168	0.6808	Tai'an	0.1296	0.6702
Lanzhou	0.0373	0.7115	Wuding	0.3332	0.8540
Liangzhou	0.0522	0.5711	Yanzhou	0.7189	0.7090
Ningxia	0.0577	0.5167	Yizhou	0.6412	0.5265
Pingliang	0.0095	0.6499	Baode	0.5454	0.7622
Qinzhou	0.1510	0.6310	Daizhou	0.4008	0.8569
Qingyang	0.0516	0.7167	Datong	0.1886	0.9101
Suzhou	0.0006	0.5558	Fenzhou	0.0342	0.7734
Xi'ning	0.1222	0.6469	Jiangzhou	0.0000	0.7457
Chenzhou	0.0000	0.2174	Jiezhou	0.0012	0.6727
Guangzhou	0.0002	0.2076	Liaozhou	0.0057	0.8861
Guide	0.0001	0.5177	Lu'an	0.0007	0.8632
Henanfu	0.0028	0.1589	Ningwu	0.6055	0.8002
Huaiqing	0.0003	0.4062	Pingding	0.1968	0.9599
Kaifeng	0.0041	0.4575	Pingyang	0.0007	0.7825
Nanyang	0.0002	0.3665	Puzhou	0.0006	0.7587
Ruzhou	0.0042	0.5457	Qinzhou	0.0039	0.8257
Runing	0.0001	0.1011	Shuoping	0.5531	0.9687
Shanzhou	0.0000	0.2857	Taiyuan	0.1414	0.9305
Weihui	0.0186	0.3733	Xizhou	0.0049	0.6593
Xuzhou	0.0000	0.2868	Xinzhou	0.0645	0.8496
Zhangde	0.1968	0.3434	Zezhou	0.0259	0.8073
Binzhou	0.1363	0.7329	Baoding	0.7968	0.4827
Fengxiang	0.4397	0.7205	Daming	0.2132	0.8139
Fuzhou	0.0721	0.6571	Dingzhou	0.0068	0.6217
Hanzhong	0.1910	0.7385	Hejian	0.0961	0.4756
Qianzhou	0.1956	0.8169	Jizhou	0.6011	0.4675
Shangzhou	0.2525	0.7170	Guangpingfu	0.2974	0.6729
Suide	0.1552	0.7101	Shenzhou	0.0593	0.4679
Tongzhou	0.2192	0.6934	Shunde	0.4160	0.6406
Xi'an	0.1339	0.5497	Tianjin	0.2687	0.4636
Xing'an	0.4926	0.7211	Xuanhua	0.0017	0.5394
Yan'an	0.5773	0.8354	Yizhou	0.0735	0.7693
Yulin	0.6489	0.8230	Yongping	0.5433	0.7746
Caozhou	0.6539	0.6541	Zhaozhou	0.8686	0.7181
Dengzhou	0.2787	0.8248	Zhengding	0.3515	0.5254
Dongchang	0.5045	0.7358	Zunhuazhou	0.8103	0.4095

Table A.1.4 KPSS Unit Root Test Results (South China)							
	LM-Stat.		LM-Stat.		LM-Stat.		LM-Stat.
Anqing	0.0762	Ningdu	0.1902	Pingyue	0.2114	Changsha	0.4175
Chizhou	0.1552	Raozhou	0.0978	Shiqian	0.0486	Chenzhou	0.6441
Chuzhou	0.1467	Ruizhou	0.0677	Sinan	0.2275	Chenzhoufu	0.7109
Fengyang	0.1784	Yuanzhou	0.1449	Sizhou	0.0583	Guiyang	0.2651
Guangde	0.1712	Fuzhou	0.2355	Dading	0.3603	Hengzhou	0.4704
Hezhou	0.1927	Funing	0.0969	Tongren	0.1902	Jingzhou	0.6162
Huizhou	0.2257	Jianning	0.2078	Xingyi	0.1682	Lizhou	0.6700
Liu'an	0.3334	Longyan	0.2870	Zhenyuan	0.2051	Yongshun	0.5793
Luzhou	0.0972	Quanzhou	0.0963	Zunyi	0.3175	Yongzhou	0.1563
Ningguo	0.3026	Shaowu	0.1243	Guilin	0.2079	Yuezhou	0.5490
Sizhou	0.1660	Tingzhou	0.3231	Liuzhou	0.1547	Yuanzhou	0.4349
Taiping	0.1325	Xinghua	0.0904	Nanning	0.2039	Baoning	0.3786
Yingzhou	0.1967	Yanping	0.2145	Pingle	0.2578	Chengdu	0.4572
Changzhou	0.2013	Yongchun	0.3899	Qingyuan	0.1858	Zhongqing	0.3951
Haizhou	0.5103	Zhangzhou	0.1027	Sicheng	0.5618	Jiading	0.4595
Huai'an	0.2412	Taiwan	0.0937	Si'en	0.4049	Kuizhou	0.4324
Jiangning	0.1846	Chaozhou	0.5204	Taipingfu	0.1414	Long'an	0.4681
Songjiang	0.2718	Gaozhou	0.3227	Wuzhou	0.1482	Ningyuan	0.4996
Suzhou	0.2409	Guangzhou	0.1634	Xunzhou	0.1738	Shunqing	0.3828
Taicang	0.2622	Huizhou	0.1755	Yulin	0.2254	Tongchuan	0.3606
Tongzhou	0.1641	Jiayingzhou	0.3453	Zhen'an	0.0680	Xuzhou	0.7395
Yangzhou	0.1799	Leizhou	0.3367	Anlu	0.1812	Yazhou	0.4566
Zhenjiang	0.2696	Lianzhou	0.3308	De'an	0.1050	Hangzhou	0.3041
Fuzhou	0.0496	Lianzhoufu	0.1460	Hanyang	0.1529	Huzhou	0.2218
Ganzhou	0.0675	Luoding	0.2660	Huangzhou	0.1532	Jiaxing	0.2251
Guangxin	0.0841	Nanxiong	0.1802	Jingzhoufu	0.2467	Jinhua	0.3091
Ji'an	0.1245	Qiongzhou	0.1845	Shinan	0.4039	Quzhou	0.1563
Jianchang	0.1015	Shaozhou	0.1811	Wuchang	0.1961	Ningbo	0.1914
Jiujiang	0.0981	Zhaoqing	0.1810	Xiangyang	0.3814	Shaoxing	0.1253
Linjiang	0.1207	Anshun	0.1594	Yichang	0.2476	Taizhou	0.3802
Nan'an	0.2085	Duyun	0.3816	Yunyang	0.3176	Wenzhou	0.1638
Nanchang	0.0722	Guiyang	0.2517	Baoqing	0.4770	Yanzhou	0.3693
Nankang	0.0664	Liping	0.3735	Changde	0.6918		

Note: The null hypothesis for KPSS test is that the series is stationary. Constant and linear trend are inclueded in the KPSS test of this table. The asymptotic critical values for 1%, 5% and 10% level are 0.216, 0.146 and 0.119 respectively.

Table A.1.5 KPSS Unit Root Test Results (North China)			
	LM-Stat.		LM-Stat.
An'xi	0.3136	Jinan	0.3243
Ganzhou	0.2657	Laizhou	0.3147
Gongchang	0.1740	Qingzhou	0.1623
Jiezhou	0.1032	Tai'an	0.2122
Lanzhou	0.1856	Wuding	0.3904
Liangzhou	0.1979	Yanzhou	0.2343
Ningxia	0.1896	Yizhou	0.2902
Pingliang	0.2740	Baode	0.1259
Qinzhou	0.2355	Daizhou	0.1243
Qingyang	0.2368	Datong	0.1172
Suzhou	0.1635	Fenzhou	0.1569
Xi'ning	0.1957	Jiangzhou	0.1327
Chenzhou	0.0920	Jiezhou	0.1159
Guangzhou	0.2352	Liaozhou	0.1918
Guide	0.2594	Lu'an	0.1667
Henanfu	0.1226	Ningwu	0.2476
Huaiqing	0.1100	Pingding	0.4683
Kaifeng	0.1304	Pingyang	0.1733
Nanyang	0.1183	Puzhou	0.1946
Ruzhou	0.1159	Qinzhou	0.3324
Runing	0.1537	Shuoping	0.1576
Shanzhou	0.0783	Taiyuan	0.1688
Weihui	0.0956	Xizhou	0.2729
Xuzhou	0.1446	Xinzhou	0.2034
Zhangde	0.1915	Zezhou	0.1326
Binzhou	0.1184	Baoding	0.2644
Fengxiang	0.1034	Daming	0.0986
Fuzhou	0.2176	Dingzhou	0.0965
Hanzhong	0.1313	Hejian	0.2927
Qianzhou	0.1294	Jizhou	0.3667
Shangzhou	0.4255	Guangpingfu	0.1051
Suide	0.4043	Shenzhou	0.0989
Tongzhou	0.2873	Shunde	0.1382
Xi'an	0.2161	Tianjin	0.1089
Xing'an	0.3373	Xuanhua	0.1133
Yan'an	0.2639	Yizhou	0.4156
Yulin	0.2099	Yongping	0.1546
Caozhou	0.2484	Zhaozhou	0.1562
Dengzhou	0.3799	Zhengding	0.5049
Dongchang	0.4103	Zunhuazhou	0.4083

Note: The null hypothesis for KPSS test is that the series is stationary. Constant and linear trend are inclueded in the KPSS test of this table. The asymptotic critical values for 1%, 5% and 10% level are 0.216, 0.146 and 0.119 respectively.

A.2 Name of Prefectures in the Grain Price Data

South China (rice, 131 prefectures)

Anhui Province:

Anqing, Chizhou, Chuzhou, Fengyang, Guangde, Hezhou, Huizhou, Liu'an, Luzhou, Ningguo, Sizhou, Taiping, Yingzhou;

Jiangsu Province:

Changzhou, Haizhou, Huai'an, Jiangning, Songjiang, Suzhou, Taicang, Tongzhou, Yangzhou, Zhenjiang;

Jiangxi Province:

Ganzhou, Guangxin, Ji'an, Jianchang, Jiujiang, Linjiang, Nan'an, Nanchang, Nankang, Ningdu, Raozhou, Ruizhou, Yuanzhou;

Fujian Province:

Fuzhou, Funing, Jianning, Longyan, Quanzhou, Shaowu, Tingzhou, Xinghua, Yanping, Yongchun, Zhangzhou, Taiwan;

Guangdong Province:

Chaozhou, Gaozhou, Guangzhou, Huizhou, Jiayingzhou, Leizhou, Lianzhou, Lianzhou Fu, Luoding, Nanxiong, Qiongzhou, Shaozhou, Zhaoqing;

Guizhou Province:

Anshan, Duyun, Guiyang, Liping, Pingyue, Shiqian, Sinan, Sizhou, Dading, Tongren, Xingyi, Zhenyuan, Zunyi;

Guangxi Province:

Guilin, Liuzhou, Nanning, Pingle, Qingyuan, Sicheng, Si'en, Taiping Fu, Wuzhou, Xunzhou, Yulin, Zhen'an;

Hubei Province:

Anlu, De'an, Hanyang, Huangzhou, Jingzhou Fu, Shinan, Wuchang, Xiangyang, Yichang, Yunyang;

Hunan Province:

Baoqing, Changde, Changsha, Chenzhou, Chenzhou Fu, Guiyang, Hengzhou, Jingzhou, Lizhou, Yongshun, Yongzhou, Yuezhou, Yuanzhou

Sichuan Province:

Baoning, Chengdu, Chongqing, Jiading, Kuizhou, Long'an, Ningyuan, Shunqing, Tongchuan, Xuzhou, Yazhou;

Zhejiang Province:

Hangzhou, Huzhou, Jiaxing, Jinhua, Quzhou, Ningbo, Shaoxing, Taizhou, Wenzhou, Yanzhou.

North China (wheat, 80 prefectures)

Gansu Province:

Anxi, Ganzhou, Gongchang, Jiezhou, Lanzhou, Liangzhou, Ningxia, Pingliang, Qinzhou, Qingyang, Suzhou, Xi'ning;

Henan Province:

Chenzhou, Guangzhou, Guide, Henan Fu, Huaiqing, Kaifeng, Nanyang, Ruzhou, Runing, Shanzhou, Weihui, Xuzhou, Zhangde;

Shann'xi Province:

Binzhou, Fengxiang, Fuzhou, Hanzhong, Qianzhou, Shangzhou, Suide, Tongzhou, Xi'an, Xing'an, Yan'an, Yulin;

Shandong Province:

Caozhou, Dengzhou, Dongchang, Ji'nan, Laizhou, Qingzhou, Tai'an, Wuding, Yanzhou, Yizhou;

Shanxi Province:

Baode, Daizhou, Datong, Fenzhou, Jiangzhou, Jiezhou, Liaozhou, Lu'an, Ningwu, Pingding, Pingyang, Puzhou, Qinzhou, Shuoping, Taiyuan, Xizhou, Xinzhou, Zezhou;

Zhili Province:

Baoding, Daming, Dingzhou, Hejian, Jizhou, Guangping Fu, Shenzhou, Shunde, Tianjin, Xuanhua, Yizhou, Yongping, Zhaozhou, Zhengding, Zunhuazhou

A.3 Monthly Price Change Frequency

To observe whether the grain price changed monthly, I construct a dummy variable (i.e. the price change dummy) for each prefecture in each month. Let

(Price Change Dummy)$_{i,t}$ = 1 if $P_{i,t} - P_{i,t-1} \neq 0$;

= 0 if $P_{i,t} - P_{i,t-1} = 0$

The mean of (Price Change Dummy)$_{i,t}$ indicates the percentage of prefectures that experienced a price change in a given period. The mean of this Price Change Dummy (i.e. MPCD) is given from Table A.2 to Table A.5 by time period and province for each region respectively. Firstly, these tables show that quite a large number of prefectures witnessed monthly price changes. Secondly, the MPCD is related to the harvest time. In Southern rice regions, the largest MPCD occurs around September while the largest MPCD for the North wheat always happened in July. Third, evidence in Tables A.2 and A.5 shows that the frequency of price change decreases over time, which may be due to a declining efficiency of the price report system. Fourthly, in Tables A.2 and A.5, the frequency of price changes is similar across provinces, which avoids the possibility that differential price report efficiency across provinces drives the empirical results.

Table A.2 Monthly Price Change Frequency (South)

		1740-1820	1740-1759	1760-1779	1780-1799	1800-1820
Jan	MPCD	0.5543	0.6624	0.5728	0.4882	0.4679
	Obs.	7465	1973	2174	1743	1575
Fed	MPCD	0.5456	0.688	0.5494	0.4717	0.4426
	Obs.	7418	1955	2208	1660	1595
Mar	MPCD	0.6475	0.76	0.6835	0.5478	0.5624
	Obs.	7574	1998	2262	1641	1673
Apr	MPCD	0.7406	0.822	0.7674	0.6704	0.6694
	Obs.	7453	2015	2266	1499	1673
May	MPCD	0.7541	0.8295	0.7696	0.7123	0.6817
	Obs.	7375	1982	2222	1512	1659
Jun	MPCD	0.7206	0.8107	0.7247	0.6254	**0.6919**
	Obs.	7311	2013	2187	1527	1584
Jul	MPCD	0.699	0.782	0.7231	0.5872	0.6585
	Obs.	7263	2041	2207	1410	1605
Aug	MPCD	0.7624	0.8422	0.8156	0.7246	0.6189
	Obs.	7160	2028	2212	1322	1598
Sep	MPCD	**0.7937**	**0.8573**	**0.8362**	**0.7727**	0.6761
	Obs.	7226	1997	2180	1434	1615
Oct	MPCD	0.7511	0.8308	0.7858	0.7095	0.6486
	Obs.	7341	2045	2106	1494	1696
Nov	MPCD	0.6844	0.7875	0.7342	0.5831	0.5906
	Obs.	7479	2104	2088	1648	1639
Dec	MPCD	0.6181	0.7321	0.6354	0.5237	0.5471
	Obs.	7639	2128	2164	1810	1537

MPCD is defined as the mean of Price Change Dummy, which indicates the percentage of prefectures that experienced a price change in a given period; Price Change Dummy =1 if $P_{i,t} - P_{i,t-1} \neq 0$*; otherwise, Price Change Dummy=0*

Table A.3 Monthly Price Change Frequency by Provinces (South, 1740-1820)

		Anhui	Jiangsu	Jiangxi	Fujian	Guangdong	Guizhou	Guangxi	Hubei	Hunan	Sichuan
Jan	MPCD	0.657	0.7183	0.551	0.5846	0.6762	0.316	0.5037	0.5768	0.4670	0.5331
	Obs.	846	639	646	792	803	810	818	612	895	604
Fed	MPCD	0.636	0.6831	0.6087	0.5836	0.6589	0.3142	0.4432	0.55	0.4935	0.5152
	Obs.	819	650	621	819	818	783	837	620	859	592
Mar	MPCD	0.672	0.745	0.7768	0.6769	0.6809	0.5325	0.561	0.6592	0.6505	0.5431
	Obs.	793	651	654	845	843	830	852	628	887	591
Apr	MPCD	0.74	0.7523	0.7979	0.7071	0.7816	0.7953	0.7461	0.7171	0.7909	0.5279
	Obs.	712	642	653	823	838	816	839	640	880	610
May	MPCD	0.704	0.724	0.8365	0.7376	0.7533	0.8347	0.786	0.7297	0.8344	0.5438
	Obs.	778	634	624	747	827	829	827	640	864	605
Jun	MPCD	0.713	0.7415	0.7877	0.6865	0.7427	0.7291	0.7045	0.6629	0.7721	0.6396
	Obs.	859	650	636	724	793	816	802	620	856	555
Jul	MPCD	0.735	0.7463	0.8437	0.6867	0.7609	0.607	0.6297	0.6754	0.6800	0.6181
	Obs.	857	670	646	750	824	748	786	610	822	550
Aug	MPCD	0.763	0.804	0.9293	0.7975	0.7783	0.6395	0.7475	0.7561	0.7927	0.6045
	Obs.	813	648	651	726	812	749	788	574	820	579
Sep	MPCD	0.857	0.8316	0.855	0.7133	0.6865	0.8964	0.7146	0.8102	0.8859	0.6667
	Obs.	848	677	600	729	820	753	792	569	859	579
Oct	MPCD	0.867	0.8714	0.7048	0.6625	0.6727	0.8141	0.7403	0.779	0.7986	0.5454
	Obs.	854	669	586	726	819	791	828	620	854	594
Nov	MPCD	0.805	0.8519	0.648	0.681	0.7271	0.6214	0.7265	0.6476	0.6234	0.4485
	Obs.	857	655	642	765	883	774	852	630	839	582
Dec	MPCD	0.69	0.7843	0.6207	0.6564	0.7715	0.4315	0.6268	0.589	0.5243	0.4673
	Obs.	896	640	667	783	871	825	852	640	883	582

MPCD is defined as the mean of Price Change Dummy, which indicates the percentage of prefectures that experienced a price change in a given period;

Price Change Dummy =1 if $P_{i,t} - P_{i,t-1} \neq 0$*; otherwise, Price Change Dummy=0*

Table A.4 Monthly Price Change Frequency (North)

		1740-1820	1740-1759	1760-1779	1780-1799	1800-1820
Jan	MPCD	0.5972	0.7894	0.6704	0.445	0.4707
	Obs.	4774	1111	1426	1218	939
Fed	MPCD	0.6046	0.7656	0.6301	0.5387	0.4934
	Obs.	4909	1122	1414	1227	1066
Mar	MPCD	0.6714	0.8054	0.7144	0.5698	0.608
	Obs.	4957	1141	1432	1225	1079
Apr	MPCD	0.7037	0.815	0.7375	0.6257	0.6441
	Obs.	5090	1211	1436	1197	1166
May	MPCD	0.6947	0.829	0.7134	0.6245	0.6147
	Obs.	5047	1187	1483	1124	1173
Jun	MPCD	0.7723	0.886	0.8033	0.6867	0.7236
	Obs.	4852	1123	1480	1098	1071
Jul	MPCD	**0.8061**	**0.9337**	**0.8681**	**0.7498**	**0.6691**
	Obs.	4750	1101	1456	1019	1094
Aug	MPCD	0.7493	0.9048	0.8225	0.6103	0.6211
	Obs.	4679	1145	1459	934	1061
Sep	MPCD	0.6679	0.8118	0.7537	0.5143	0.5538
	Obs.	4730	1148	1470	945	1087
Oct	MPCD	0.6274	0.8301	0.7006	0.496	0.4692
	Obs.	4826	1130	1436	1012	1168
Nov	MPCD	0.612	0.789	0.6867	0.4335	0.5221
	Obs.	4868	1123	1465	1068	1132
Dec	MPCD	0.5953	0.7876	0.657	0.4438	0.4847
	Obs.	4981	1191	1452	1183	1075

MPCD is defined as the mean of Price Change Dummy, which indicates the percentage of prefectures that experienced a price change in a given period; Price Change Dummy =1 if $P_{i,t} - P_{i,t-1} \neq 0$; otherwise, Price Change Dummy=0

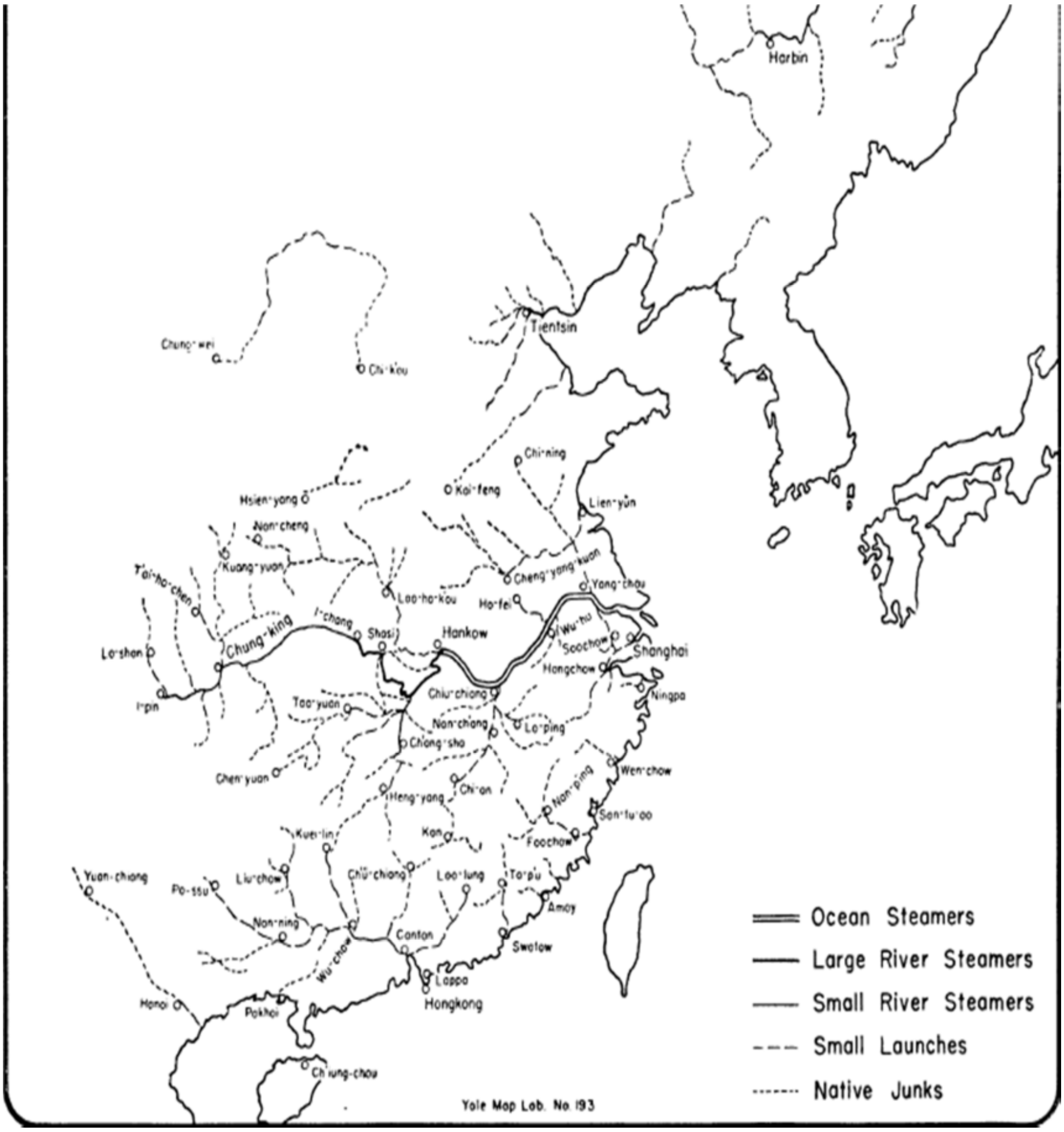
Table A.5 Monthly Price Change Frequency by Provinces (North, 1740-1820)

		Gansu	Henan	Shann'xi	Shandong	Shanxi	Zhili
Jan	MPCD	0.6881	0.5069	0.7039	0.6601	0.466	0.641
	Obs.	776	724	770	609	1193	702
Fed	MPCD	0.6276	0.5489	0.7166	0.6899	0.467	0.6785
	Obs.	768	756	794	587	1242	762
Mar	MPCD	0.6975	0.5922	0.7256	0.7592	0.5639	0.7878
	Obs.	767	797	820	598	1268	707
Apr	MPCD	0.7202	0.594	0.7552	0.7815	0.6226	0.8317
	Obs.	779	830	817	650	1301	713
May	MPCD	0.7487	0.5978	0.7422	0.7678	0.584	0.8146
	Obs.	752	803	803	633	1274	782
Jun	MPCD	0.7568	0.7895	0.8058	0.8789	0.6398	0.8491
	Obs.	728	803	762	644	1166	749
Jul	MPCD	0.7804	0.7456	0.8438	0.8845	0.7635	0.8559
	Obs.	756	794	762	632	1091	715
Aug	MPCD	0.7799	0.6278	0.7874	0.7194	0.7594	0.8234
	Obs.	804	763	762	613	1114	623
Sep	MPCD	0.7782	0.4928	0.7114	0.7389	0.6174	0.7036
	Obs.	816	763	731	628	1124	668
Oct	MPCD	0.7491	0.5137	0.6618	0.7045	0.5234	0.6681
	Obs.	821	765	748	660	1133	699
Nov	MPCD	0.7465	0.5019	0.6723	0.7203	0.4983	0.6096
	Obs.	785	777	772	622	1164	748
Dec	MPCD	0.7628	0.4919	0.6713	0.6625	0.4583	0.6145
	Obs.	780	799	785	646	1211	760

MPCD is defined as the mean of Price Change Dummy, which indicates the percentage of prefectures that experienced a price change in a given period; Price Change Dummy =1 if $P_{i,t} - P_{i,t-1} \neq 0$*; otherwise, Price Change Dummy=0*

A.4 River Network in Wien (1955)

Figure A.1 River Transportation Network



A.5 List of Grain River

Lv Shui, Xun He, Baishui Jiang, Diao He, Yellow River, Gun He, Yangchang He, Liu Jiang, Ba Jiang, Chishui He, Feng He, Daning He, Juan Shui, Xiong Xi, Xinan Xi(Da Xi), Sha Xi, Xi Xi, Shimen Gang, Dong He, Luan He, Yongding He, Majia He, Xinfeng Jiang, Liu Xi, Li Jiang, Gui Jiang, Lingqu, Ang Jiang, Hongshui Jiang, Baisha He, Gan Jiang, Jialing Jiang, Jin Shui, Bai He, Dan Shui, Tu He, Bei Jiang, Zhong Jiang, Dun Shui, Ju Shui, Qu Jiang, Fu Jiang, Nanliu Jiang, Mi Shui, Jin Shui, Wu Shui, Lei Shui, Qi Jiang, Songkan He, Fuling Jiang, Wu Jiang, Qing Jiang, Hudu He, Pen Shui, Baishigang, Bei Shui, Jin Jiang, Zhang Shui, Gong Shui, Mingde Shui, Baotang Shui, Long'an Shui, Le'an Jiang, Chang Jiang, Qin jiang(Ting Shui), Mei Xi, Qing Xi(Zheng Xi), Nanpu Xi, Xin'an Jiang, Hui He, Wo He, Qu He, Xi Shui, Hui Shui, Luo He, Fen Shui, Wei He, Luo Shui, Qiantang Jiang, Sheyang He, Feng Jiang, Ren He, Fuyi Shui, Shi He, Ying He, Rong Jiang, Yuan Jiang, Da Jiang, Zi Jiang, Xiang Jiang, Zhong Jiang, Tanglang Chuan, Yu Jiang, Lian Jiang, Bei Jiang, Dong Jiang, Xi Jiang, Han Jiang, Xiao Xi, Futun Xi, Jian Xi, Min Jiang, Anyang Jiang, Fuchun Jiang, Er Jiang, Ru He, Po Jiang, Tong Jiang, Qingyi Jiang, Nicha He, Ying He, Han Shui, Wei Shui, Ziya He, Huai He, Yun He, Yangtze River, Grand Canal

A.6 Name of Prefectures with Both Rice and Wheat Price

South China(rice and wheat, 77 prefectures)

Anhui Province:

Anqing, Chizhou, Chuzhou, Fengyang, Guangde, Hezhou, Huizhou, Liu’an, Luzhou, *Ningguo, Sizhou, Taiping, Yingzhou;*

Jiangsu Province:

Changzhou, Haizhou, Huai’an, Jiangning, Songjiang, Suzhou, Taicang, Tongzhou, Yangzhou, Zhenjiang;

Jiangxi Province:

Ganzhou, Guangxin, Ji’an, Jianchang, Jiujiang, Linjiang, Nan’an, Nanchang, Nankang, Ningdu, Raozhou, Ruizhou, Yuanzhou;

Fujian Province:

Fuzhou, Funing, Jianning, Longyan, Quanzhou, Shaowu, Tingzhou, Xinghua, Yanping, Yongchun, Zhangzhou, Taiwan;

Guangdong Province:

Chaozhou, Gaozhou, Guangzhou, Huizhou, Jiayingzhou, Leizhou, Lianzhou, Lianzhou Fu, Luoding, Nanxiong, Qiongzhou, Shaozhou, Zhaoqing;

Hubei Province:

Anlu, De’an, Hanyang, Huangzhou, Jingzhou Fu, Shinan, Wuchang, Xiangyang, Yichang, Yunyang;

<u>Hunan Province:</u>

Baoqing, Changde, Changsha, Chenzhou, Chenzhou Fu, Guiyang, Hengzhou, Jingzhou, Lizhou, Yongshun, Yongzhou, Yuezhou, Yuanzhou

<u>Sichuan Province:</u>

Baoning, Chengdu, Chongqing, Jiading, Kuizhou, Long’an, Ningyuan, Shunqing, Tongchuan, Xuzhou, Yazhou;

<u>Zhejiang Province:</u>

Hangzhou, Huzhou, Jiaxing, Jinhua, Quzhou, Ningbo, Shaoxing, Taizhou, Wenzhou, Yanzhou

Appendix B Robustness Checks

B.1 Probit Results for Market Determinants

The pattern of the results by probit model in Table B.1 is the same as the results in Table 4.2. First, it confirms that the impact of river transport on price cointegration in South China was heterogeneous by distance while it is insignificant in North China. Second, provincial border dominated the water transport on the market evolution.

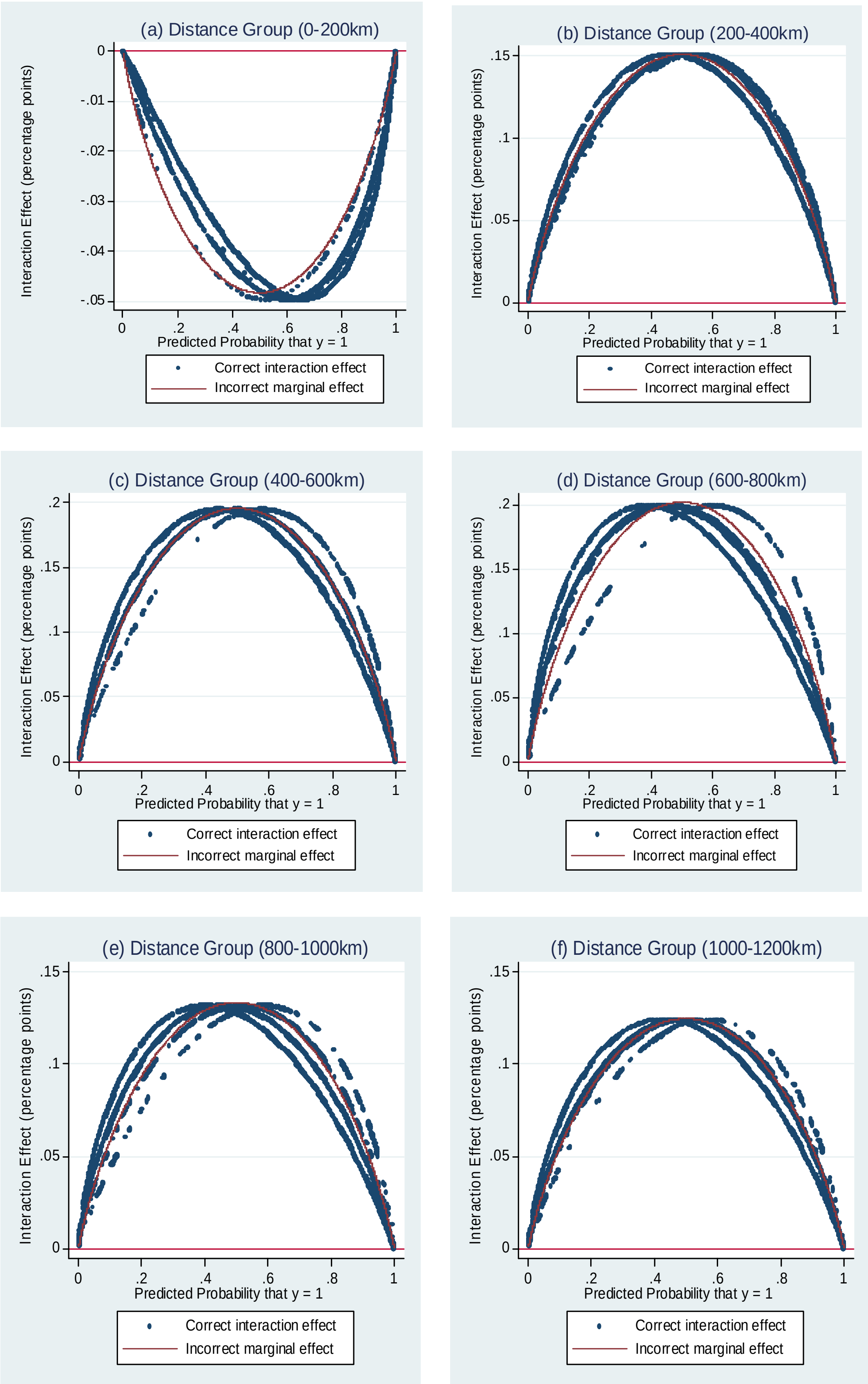
In column 3, to confirm the significance of these interaction terms, I calculated the re-corrected magnitude and statistical significance of the interaction effect for all interaction terms, following the re-derived formulas in Ai and Norton (2003) and Norton *et.al.* (2004). The re-corrected interaction effect for Probit model are given in Figure B.1 and these Z-statistics of significance are given in the Figure B.2, which confirm the Southern river transport affected the market integration heterogeneously. In Figure B.2, if the absolute value of Z-statistic for the given probability is below the critical value (i.e. the red line in the graph), it means the interaction term for the given probability is insignificant. For example, In Figure B.2 (a), all the points are between two critical red lines, which mean for any probability this interaction term is insignificant. Similarly, Figure B.2 (b) represents, for most of the given probabilities, the interaction term for the distance between 200 and 400 km is significant.

Table B.1 Market Integration, Geography and Institutions (Probit)

Dependent Variable: $C_{ij} = \{0,1\}$	South Rice (1)	North Wheat (2)	South Rice (3)	North Wheat (4)
$\ln(Dis_{i,j})$	-0.1694	-0.2586	-0.1292	-0.145
	(0.0373)***	(0.0522)***	(0.439)***	(0.063)**
$River_{ij}$	0.1433	0.0194	-0.4126	0.2738
	(0.0479)***	(0.0786)	(0.1695)**	(0.5044)
Pro_{ij}	1.0744	1.014	3.128	2.3
	(0.0747)***	(0.0689)***	(0.7273)***	(0.582)***
$Pro_{ij} \times \ln(Dis_{ij})$			-0.3396	-0.2149
			(0.121)***	(0.097)**
$\text{River}_{ij} \times Dis\_G_{ij,1(x\leq 200km)}$			-0.0061	0.029
			(0.2525)	(0.532)
$\text{River}_{ij} \times Dis\_G_{ij,2(200<x\leq 400km)}$			0.5376	-0.169
			(0.1944)***	(0.511)
$\text{River}_{ij} \times Dis\_G_{ij,3(400<x\leq 600km)}$			0.7051	-0.335
			(0.182)***	(0.511)
$\text{River}_{ij} \times Dis\_G_{ij,4(600<x\leq 800km)}$			0.807	-0.361
			(0.177)***	(0.508)
$\text{River}_{ij} \times Dis\_G_{ij,5(800<x\leq 1000km)}$			0.744	-0.377
			(0.174)***	(0.511)
$\text{River}_{ij} \times Dis\_G_{ij,6(1000<x\leq 1200km)}$			0.539	-0.107
			(0.175)***	(0.516)
$\text{River}_{ij} \times Dis\_G_{ij,7(1200<x\leq 1400km)}$			0.3004	-0.407
			(0.176)*	(0.532)
$\text{River}_{ij} \times Dis\_G_{ij,8(1400<x\leq 1600km)}$			0.113	-0.461
			(0.185)	(0.551)
$\text{River}_{ij} \times Dis\_G_{ij,9(1600<x\leq 1800km)}$			0.157	-0.888
			(0.197)	(0.603)
Marginal Effect				
$River_{ij}$	0.0307	0.0039	-0.0877	0.0549
	(0.0103)***	(0.0158)	(0.036)**	(0.101)
Pro_{ij}	0.23	0.2043	0.665	0.4613
	(0.0155)***	(0.0132)***	(0.154)***	(0.116)***
θ_i, θ_j and θ_{i*j*}	Yes	Yes	Yes	Yes
No. of Obs.	16,770	6314	16,770	6,314
Pseudo-R^2	0.4547	0.3734	0.4584	0.3757

Note: We omit reporting fixed effects, seasonality and the constant. Robust standard errors provided in parentheses; ***, ** and * denote 1%, 5% and 10% significance level, respectively

Figure B.1 Re-corrected Interaction Effect for Probit Model (Rice)



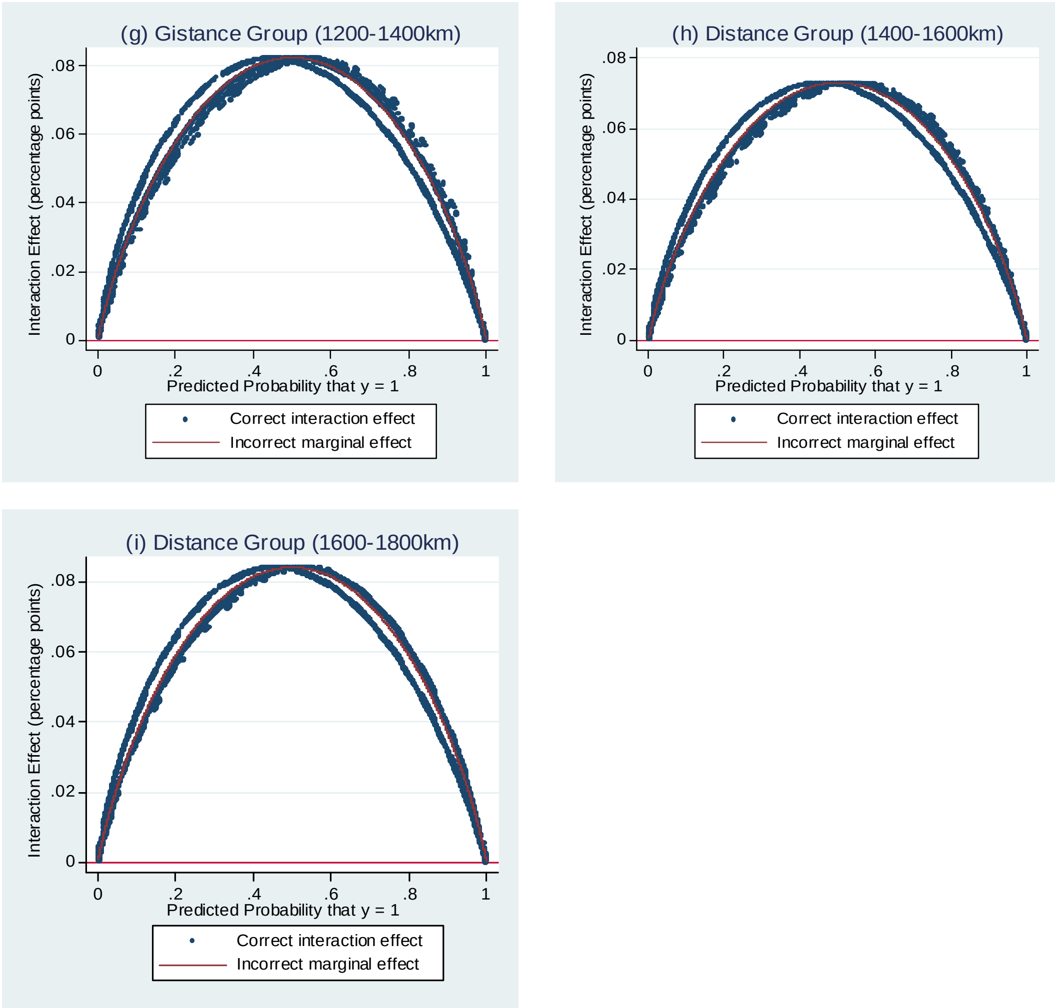
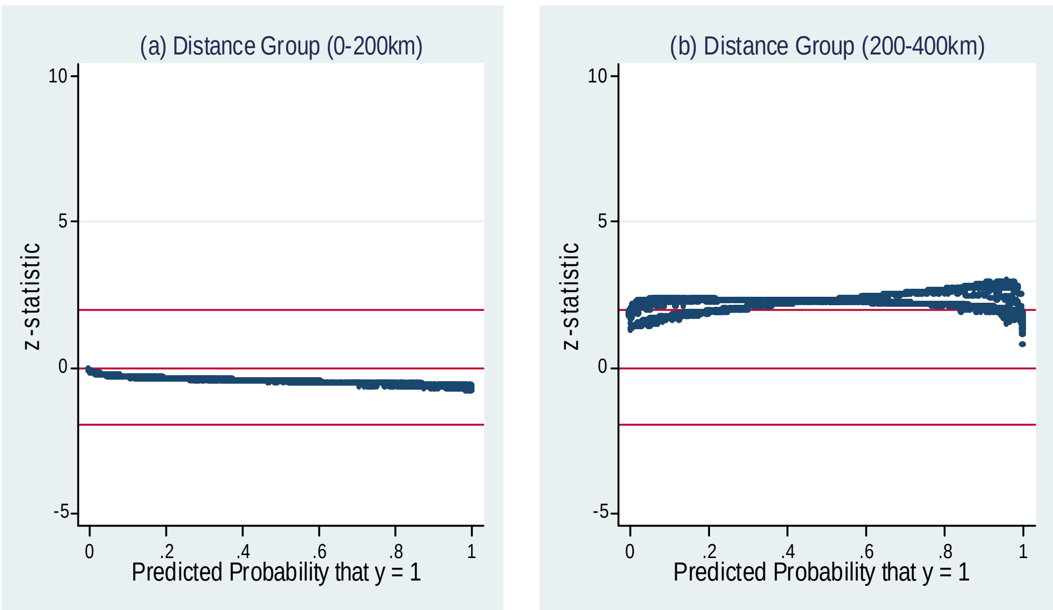
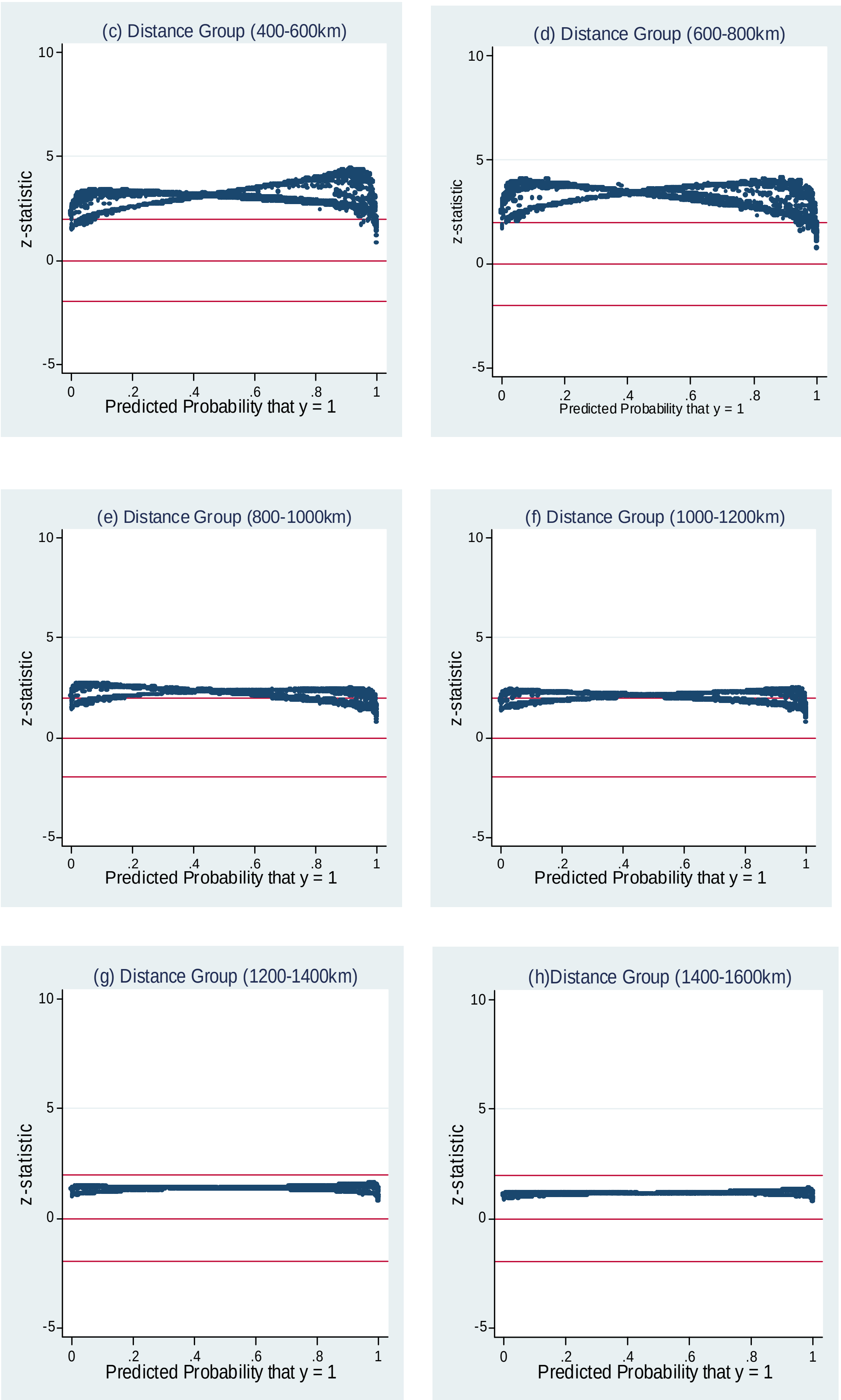
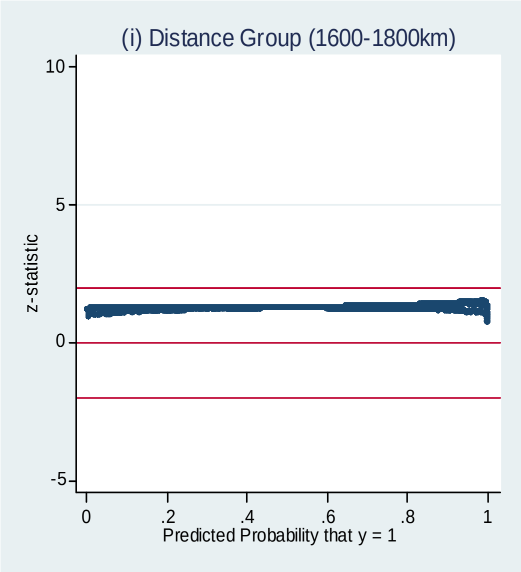


Figure B.2 Z-statistics of Interaction Effects for Probit Model (Rice)




(c) Distance Group (400-600km)
z-statistic
10
5
0
-5
0 .2 .4 .6 .8 1
Predicted Probability that y = 1
(d) Distance Group (600-800km)
z-statistic
10
5
0
-5
0 .2 .4 .6 .8 1
Predicted Probability that y = 1
(e) Distance Group (800-1000km)
z-statistic
10
5
0
-5
0 .2 .4 .6 .8 1
Predicted Probability that y = 1
(f) Distance Group (1000-1200km)
z-statistic
10
5
0
-5
0 .2 .4 .6 .8 1
Predicted Probability that y = 1
(g) Distance Group (1200-1400km)
z-statistic
10
5
0
-5
0 .2 .4 .6 .8 1
Predicted Probability that y = 1
(h)Distance Group (1400-1600km)
z-statistic
10
5
0
-5
0 .2 .4 .6 .8 1
Predicted Probability that y = 1



(i) Distance Group (1600-1800km)
z-statistic
10
5
0
-5
0
.2
.4
.6
.8
1
Predicted Probability that y = 1

B.2 Distance and Province Border Effect

In Table B.2 for Southern rice, obviously, the ratio of cointegrated pairs is much higher for the sample of pairs within the same province. For the distance group between 200 and 400*km*, both categories (within the same province or within different province) own the similar number of pairs, and the pairs within the same province still own the larger likelihood of cointegration. In Table B.3 for Northern wheat, the similar pattern was found. These results confirm that, controlling for distance, provincial border still has an impact on reducing the cointegration likelihood.

Table B.2 The Ratio of Cointegrated Pairwise by Post Distance Group (South Rice, 1740-1820)

	same province			different provinces		
Distance Group (km)	No. of Cointegrated Pairwise	No. of Pair	Ratio	No of Cointegrated Pairwise	No. of Pair	Ratio
	(1)	(2)	(1) / (2)	(3)	(4)	(3) / (4)
0-200	296	346	0.86	75	122	0.61
200-400	**459**	**600**	**0.77**	**409**	**632**	**0.65**
400-600	247	338	0.73	895	1428	0.63
600-800	86	124	0.69	1216	2076	0.59
800-1000	21	30	0.7	1231	2362	0.52
1000-1200	11	12	0.92	1043	2314	0.45
1200-1400		0		867	2158	0.4
1400-1600		0		609	1742	0.35
1600-1800		0		381	1280	0.3
>1800		0		330	1466	0.23

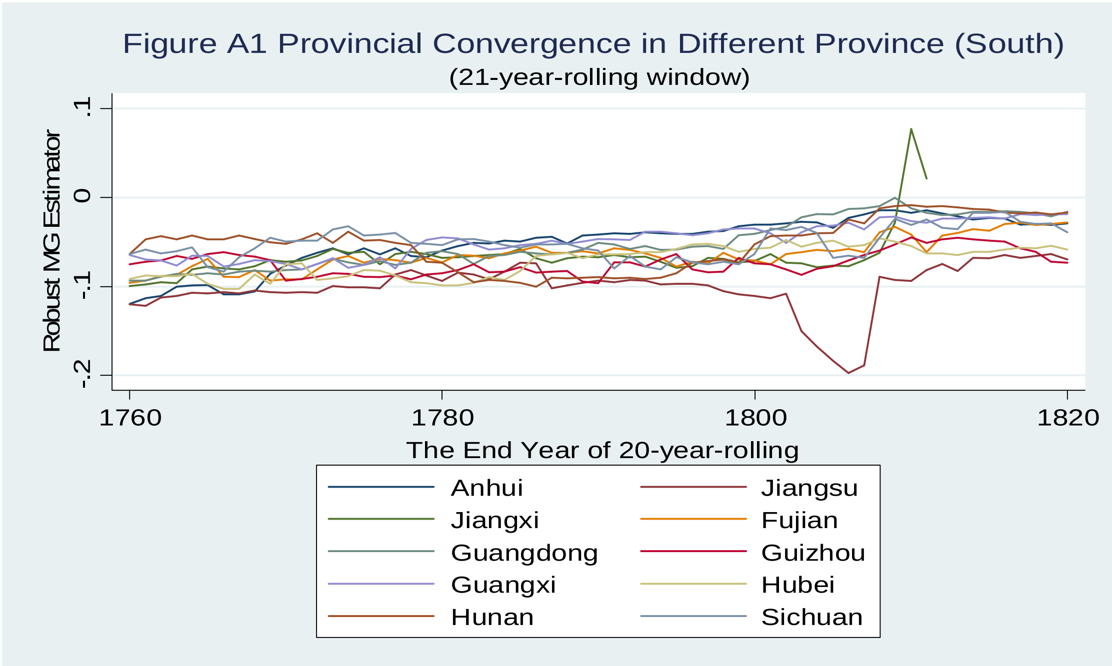
Table B.3 The Ratio of Cointegrated Pairwise by Post Distance Group (North Wheat, 1740-1820)

	same province			different provinces		
Distance Group (km)	No of Cointegrated Pairwise	No of Pairwise	Ratio	No of Cointegrated Pairwise	No of Pairwise	Ratio
	(1)	(2)	(1) / (2)	(3)	(4)	(3) / (4)
0-200	161	242	0.67	19	82	0.23
200-400	**272**	**432**	**0.63**	**132**	**524**	**0.25**
400-600	108	234	0.46	272	1092	0.25
600-800	25	68	0.37	238	1132	0.21
800-1000	11	26	0.42	176	870	0.2
1000-1200	2	16	0.13	102	572	0.18
1200-1400	1	6	0.17	47	348	0.14
1400-1600	0	2	0	32	238	0.13
1600-1800		0		31	164	0.19
>1800		0		52	272	0.19

B.3 Heterogeneous Provincial Convergence

I estimate the rolling robust Mean Group convergence coefficients for each province separately using regression (5.6'), in both the South and North China samples. The findings confirm that the trends in Figure B.3 are not driven by some extreme outlier province(s).

Figure B.3 Provincial Convergence in Different Province



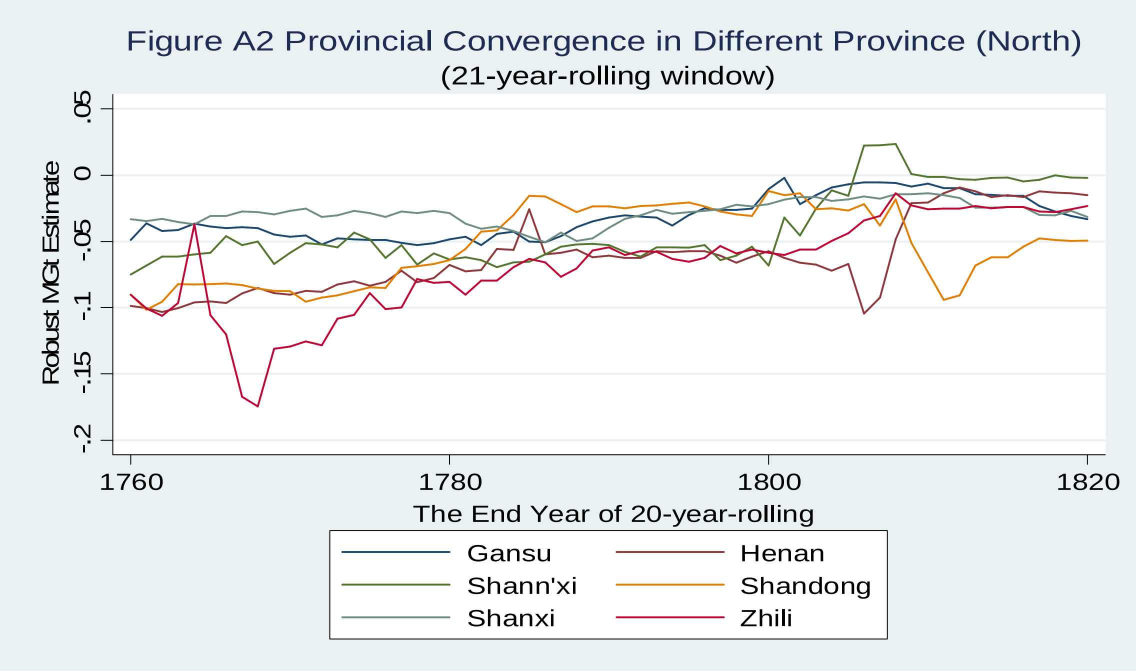


Figure A2 Provincial Convergence in Different Province (North)
(21-year-rolling window)
Robust MGt Estimate
.05
0
-.05
-.1
-.15
-.2
1760
1780
1800
1820
The End Year of 20-year-rolling
Gansu
Henan
Shann'xi
Shandong
Shanxi
Zhili

B.4 Cointegration Results with Sub-sample

Figure B.4 Share of Cointegrated Prefecture Paris by Distance

(Full Sample and Sub Sample)

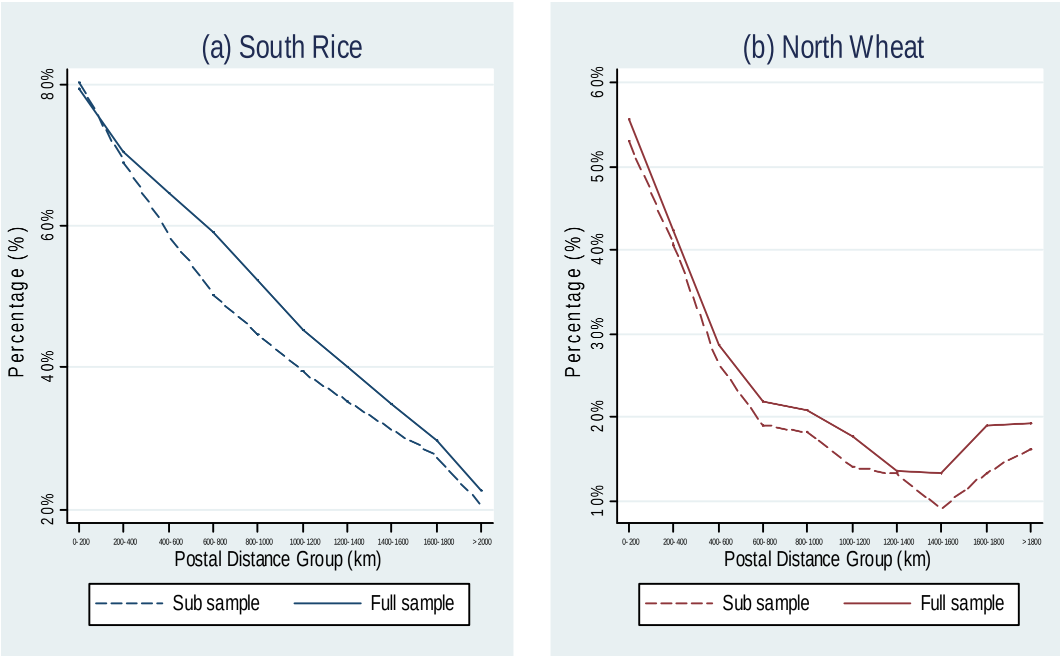


Table B.4 Market Integration, Geography and Institutions (OLS, subsample)

Dependent Variable: $C_{ij} = \{0,1\}$

	South Rice	North Wheat	South Rice	North Wheat
	(1)	(2)	(3)	(4)
$\ln(Dis_{i,j})$	-0.0393	-0.0474	-0.0479	0.0027
	(0.0084)***	(0.0156)***	(0.0104)***	(0.0177)
$River_{ij}$	0.014	0.0096	-0.091	-0.0677
	(0.012)	(0.0207)	(0.029)**	(0.0677)
Pro_{ij}	0.27	0.236	0.146	0.8802
	(0.0161)***	(0.0218)***	(0.138)***	(0.1718)***
$\ln(Pro_{ij}) \times ln(Dis_{ij})$			0.0225	-0.1076
			(0.023)	(0.0284)***
$River_{ij} \times Dis\_G_{1ij(x \leq 200km)}$			0.0264	0.165
			(0.0469)	(0.087)*
$River_{ij} \times Dis\_G_{2ij(200<x \leq 400km)}$			0.1	0.188
			(0.0349)***	(0.079)**
$River_{ij} \times Dis\_G_{3ij(400<x \leq 600km)}$			0.133	0.0655
			(0.0337)***	(0.0723)
$River_{ij} \times Dis\_G_{4ij(600<x \leq 800km)}$			0.14	0.0384
			(0.033)***	(0.0704)
$River_{ij} \times Dis\_G_{5ij(800<x \leq 1000km)}$			0.126	0.0354
			(0.0303)***	(0.0712)
$River_{ij} \times Dis\_G_{6ij(1000<x \leq 1200km)}$			0.111	0.0631
			(0.0299)***	(0.08)
$River_{ij} \times Dis\_G_{7ij(1200<x \leq 1400km)}$			0.099	0.0181
			(0.0307)**	(0.0736)
$River_{ij} \times Dis\_G_{8ij(1400<x \leq 1600km)}$			0.068	-0.0057
			(0.033)	(0.0711)
$River_{ij} \times Dis\_G_{9ij(1600<x \leq 1800km)})$			0.053	-0.079
			(0.0317)	(0.059)
θ_i	Yes	Yes	Yes	Yes
θ_j	Yes	Yes	Yes	Yes
$\theta_{i^*j^*}$	Yes	Yes	Yes	Yes
No. of Obs.	12,656	4160	12,656	4,160
R^2	0.474	0.3776	0.4756	0.3845

Note: We omit reporting fixed effects, seasonality and the constant. Robust standard errors provided in parentheses; ***, ** and * denote 1%, 5% and 10% significance level, respectively