Markets in China and Europe on the Eve of the Industrial Revolution

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August 2006

Abstract

An influential view on why industrialization began in Western Europe places a great deal of emphasis on how European allocative institutions were both necessary and sufficient conditions for modern growth. Western Europe's exceptionally well-functioning markets supported with a set of institutions led to more efficient resource use and provided far greater incentives to make investments needed to industrialize. This paper examines this hypothesis by comparing the actual performance of markets in terms of market integration in Western Europe and China, two regions of the world that were relatively advanced in the pre-industrial period, but would start to industrialize about 150 years apart. Using cointegration analysis on grain prices for about 250 markets from the 17th to the 19th century, the analysis covers economies that in total account for about two-fifths of the world's population in the mid-18th century. Our main findings include: first, the performance of markets in China and Western Europe overall was comparable in the late 18th century. Second, market performance in England was higher than in the Yangzi Delta region, and markets in England also performed better than in continental Western Europe. Third, the performance of markets in Western Europe improved between 1780 and 1830 in a dramatic and sudden fashion in comparison to what came before. Rather than being a key condition for subsequent growth, improvements in market performance and growth might have occurred simultaneously. The paper also compares the conditions and institutions that were underlying grain trade in the two regions; this provides the initial means to better understand what the advantages of England over China really were, and it adds to our knowledge on what institutions are necessary for industrialization and growth.

JEL: N10, O1, F1

We have benefited from comments and discussions with Derek Byerlee, Gregory Clark, Brad DeLong, Avinash Dixit, Michael Edelstein, Robert Evenson, Marcel Fafchamps, Avner Greif, Peter Hansen, Jean-Laurent Rosenthal, Vernon Ruttan, Max Stinchcombe, and David Weil, as well as many seminar participants. The comments by two referees of this journal, as well as by Robert Moffitt and Tim Besley as editors were particularly useful. We also thank Jörg Baten for the European weather data and Patrick Wild for the maps. Part of the paper was written while the first author was Visiting Scholar at the Russell Sage Foundation. We acknowledge generous financial support from the National Science Foundation under grant SES # 0453040.

1. Introduction

Recent interpretations of the Industrial Revolution suggest that it started around 1770 in Britain and spread to United States and Continental Western Europe by the mid-19th century.[1] The turning point of modern economic growth was a remarkable event because it was the first time in human history that per capita growth rates much above zero became sustainable over the long-run. How did a world of static expansion make its way to one of sustained increase in GDP per capita, and why did the Industrial Revolution start its spread from Western Europe and not elsewhere—in particular, China?

One influential view on the source of economic growth places a great deal of emphasis on how European allocative institutions are both necessary and sufficient conditions for modern growth. According to North and others, by 1700 Britain and the Netherlands had developed exceptionally well-functioning markets supported with a set of institutions—non-distortionary pricing systems, common law, and property rights—that would lead to more efficient resource use and provide far greater incentives to make investments that would raise income per capita (North and Weingast 1989, North 1981, North and Thomas 1973).[2] An outcome of that was that it facilitated the movement of goods across locations and furthered developments of industrial expansion.

An alternative view on growth, however, is that these allocative institutions are not necessary and sufficient for modern economic growth. Thus, China may have been as market-oriented as the leading areas in Western Europe, with similarly good institutions of allocative efficiency. Yet it did not experience an industrial revolution in the 18th century, possibly because it lacked, for example, institutions that support technical progress (Mokyr 1990, Landes 1969), which are different from the allocative institutions supporting market integration.

[1] The year 1770 is often chosen as the starting date of the Industrial Revolution because a number of key innovations, including the spinning jenny (1764), the water frame (1769), the steam engine (1774), and other inventions in the cotton industry as well as iron making were introduced around this time. See Maddison (1989) on international income comparisons in the last three centuries. Note that we distinguish Continental Western Europe from Western Europe, which includes Britain.

[2] These Western European institutions have successfully taken root in other countries as well in the last two centuries. The historical record of Europe attests to an expansion of influence and trade over long-distances (Chaswick and Hatton 2003, O'Rourke and Williamson 2000). Western European settlers, by bringing with them their heritage of institutions, in some cases created the basis of long-run growth in these countries (Banerjee and Iyer 2002, Acemoglu, Johnson, and Robinson 2001).

Moreover, it is generally held that the state has a critical influence in shaping these institutions. According to North (1981), the state has two faces. The state and associated institutions provide the legal framework that enables private contracts for economic transactions. At the same time, the state is an instrument for transferring resources from one group to another. According to this view, institutions are good if they both support private contracts and provide protection against expropriation from the state and other powerful groups. Interesting recent cross-country work by Acemoglu and Johnson (2005) has sought to establish which of these two functions is more critical for growth. Our detailed analysis of a single country, China, will enable us to see how North's paradigm can help us understand why China remained locked in the pre-industrial era when Western Europe took off.

Although a fair amount has been written on the rise of commerce and internal trade in China during the 18th century (e.g., Elvin 1973, Xu and Wu 2000), a quantitative assessment of the performance of markets in China in a comparative context is still lacking. This paper compares markets in China and Western Europe in terms of spatial market integration, using cointegration analysis with data on grain prices from the 17th to the 19th century. It is the first study, as far as we know, to provide a comprehensive comparison of markets across Europe and most of China in the pre-industrial era. This is particularly useful for investigating the fundamental determinants of growth, as these two regions were relatively advanced as of the mid-18th century, and yet would start industrializing about 150 years apart. A main goal of the paper is to determine whether European markets were already outperforming markets in China before the period of its industrialization, as implied by the currently influential view, or whether differences in performance of commodity markets are a more recent phenomenon.

Our analysis also sheds new light on a number of specific questions surrounding the industrial revolution. One is whether the industrial revolution was a uniquely British phenomenon, or whether the more advanced countries of Europe, such as France, as well as China and other non-Western areas of the world were equally plausible contenders (Crafts 1995, Pomeranz 2000, Goldstone 2002). Comparisons of relative living standards are only starting to emerge, but there is general agreement that within China, the

Yangzi Delta was one of the most developed areas.[3] In a prominent recent study, Pomeranz maintains that whatever advantages England had over the Yangzi Delta, it was not in its markets, and that more generally, "China comes closer the neoclassical ideal of a market economy than Europe" (Pomeranz 2000, 17). This paper distinguishes England from the rest of Western Europe, and compares it both to markets in the Yangzi Delta and in China overall.

We find that as late as 1780, markets in China were comparable to most of those in Western Europe. The performance of English markets at this time, however, was better than that found in the most advanced parts of Continental Western Europe, as well as in China. Furthermore, market integration in Continental Europe improved between 1780 and 1830, and the improvement occurred dramatically and suddenly in comparison to what came before. The finding of differences in market integration between England and the Western European continent may prove important, we think, for future research on what drives modern economic growth.

A comparison of the underlying mechanisms supporting trade in each region helps give qualitative support to our results. Even if the overall degree of market integration was comparable, what can we say, for example, about the quality of market regulation in China compared to that in Western Europe, or, differences in the transportation systems? Notwithstanding a number of important contributions (Pomeranz 2000, Huang 2002, and Wong 2002), little is know about the relative strengths and weaknesses of specific institutions in each country. The conditions and institutions that affected trade, such as the role of guilds and the provision and enforcement of property rights, not only differed in China and Western Europe, but they also played a major role in these economies in a broad sense. Thus, by probing deeper in this analysis of grain market integration, we may improve our understanding of what advantages England really had over China, and also narrow down the set of fundamental drivers that have been previously proposed as being crucial for economic growth.

This paper contributes to recent literature that emphasize the beneficial role of markets in allocating resources (Isham and Kaufman 1999), as well as the importance of institutions that provide the

[3] For living standard comparisons, see Allen et al. (2005), Allen (2002, 2001), as well as Bairoch (1975), pp. 3-17.

framework in which markets operate (Hall and Jones 1999; Rodrik, Subramanian, and Trebbi 2002). Another issue on which we can bring new evidence to bear is whether the sources of growth in Europe might have originated from a long process of development stretching back for many centuries (perhaps as far back as the year 1000), or emerged rather recently in the last couple of centuries. Because we follow the same economies over several centuries this reduces many important identification problems because persistent factors unique to Europe—such as geography, customs, intellectual and ethical tradition, or language—are held constant.

A better understanding of changing patterns in market performance around the first industrial revolution should provide a more complete picture of modern economic growth on many fronts as there are few explanations of growth that do not depend on the existence of, or have implications for the performance of commodity markets. More generally, the question of market functioning and the quality of market-supporting institutions is also important in furthering understanding of the origins of economic growth, how it can be sustained, and how it may be spread further across economies today.

2. Grain trade: Its basis in terms of geography, technology, and institutions

A comparison of trade and transport technology in China and Western Europe suggests that although the regions were geographically diverse, there were basic similarities in the means of moving grain and goods across land and sea in the pre-industrial era. Geographically, China’s rice growing area is located in the south and central part of the country, and wheat was grown in northern areas. The main trade routes were along the Yangzi River and its major tributaries, the Grand Canal, the Yellow River, as well as trade along the coast. In Western Europe, wheat was harvested throughout the area and widely traded, with waterways being an important means of transport as well. The rivers Vistula, Oder, and Elbe connected the grain-growing areas of Eastern Europe to the Hanseatic ports, while the Danube linked the Black Sea areas to Central Europe. The major rivers of Western Europe, the Rhine, Rhône, Seine, Loire, and the Thames, together with canals especially in the Netherlands, England, France and Germany supported an expanding network of trade.

In both continents, only rough estimates on the scale of the long-distance grain trade exist. The total on all major routes in China amounted to perhaps 2.6 million tons annually in the mid-Qing (Qing Dynasty, 1644-1911) (Xing et al. 2000, 170).[4] Assuming this would have been enough to feed 14 million people (Pomeranz 2000, 34), some 8% of national grain consumption was supplied via traded grain. The fraction of grain imports varied both across China and over time. For example, in the 18th century, the Yangzi Delta may have imported in a typical year about 25% of its rice consumption; Southern Zhejiang imported in one year, 1748, more than 50% of its rice consumption (Chuan and Kraus 1975, 62). Grain was exchanged for commodities such as cotton and cotton fabrics, silk and silk fabrics, tea and salt, all of which were also a significant share of internal trade. In Western Europe, by comparison, between the years 1550 and 1800, more than 80% of the total long-distance grain trade was the Baltic trade through the Danish Sound (Braudel 1982, 127). At its high point in the 1640s, an average of about 0.23 million tons was shipped per year, and close to 0.22 million tons was the maximum amount shipped per year on average in the 18th century (van Tielhof 2002, 49, 61).[5] Chinese long-distance grain trade was therefore larger than its Western European counterpart, perhaps by a factor of 10.[6]

The direct evidence on shipping speed for seagoing vessels is scarce, but what information is available indicates that the speeds were roughly comparable. The roundtrip from Southern Fujian to Zhapu in Zhejiang took about 8 days in the 1720's, including loading (Chuan and Kraus 1975, 61-62); this is about 6.8 miles per hour. For comparison, around the year 1580 Dutch merchant vessels traveled from Danzig to Amsterdam in 11 days or more (about 3.8 miles/hour), while the trip from Danzig to London could take as little as 9 days (about 5.4 miles/hour) (van Tielhof 2002, 158-159).

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[4] As conversion factors, we use a weight of 160 lbs for 1 *shi* of rice, and 2,200 lbs to one metric ton.

[5] Here we use the following conversion factors: one *last* = 30.1 hektoliter (van Tielhof 2002, 7), 100 liters of wheat = 79 kilograms, and 1 metric ton = 1,000 kilograms.

[6] It is also possible to compare the size of the waterway networks in China and Western Europe. Eight major European rivers—the Danube, Elbe, Rhine, Oder, Seine, Rhône, Loire, and Thames—together have a drainage area of 1,6 million square kilometers, which is less than the Yangzi River alone (1,8 million square kilometers). In terms of navigability, the Yangzi was far more important than the Yellow River, due to relatively high levels of silt in the latter. The size of China's inland waterway system (rivers and canals) in the mid-Qing is estimated to be about 50,000 kilometers (Xing et al. 2000, 167), whereas England and Wales's inland navigation system in 1780 was less than 3,500 kilometers long (Petersen 1995, 153). If one abstracts from the large areas in China's west where few people lived, the density of its waterway network was likely higher in China than in England.

The speed of river transport in England was comparable to that in the upper reaches and tributaries of the Yangzi and Yellow Rivers, while speeds on the Lower Yangzi and especially in the delta were likely higher. Average (round trip) inland waterway speeds in England around 1800 probably averaged between 0.7 to 1.1 miles/hour for river transport and up to 1.5 miles/hour when it was (mostly) canal traffic (based on Jackman 1962, 450, 725), not too different from the 1.0 miles per hour round trip speed for travel on the Yellow River in the vicinity of Luoyang, in Henan province (Evans 1984, 289). The most common Yangzi junk in Hubei had a roundtrip speed of up to 2.4 miles/hour (Worcester 1971, 380), and the speed of junks in the Yangzi Delta was typically far higher because they took advantage of the tidal currents in the lower Yangzi: a junk could travel at 11.5 miles per hour for up to 300 miles inland (Worcester 1971, 184).

Available information on other transport costs is scarce, but it suggests that freight costs in China and Western Europe were broadly comparable. In the Baltic trade during the early 18th century, the freight charge may have been around 40% of the price differential between Danzig and Amsterdam (van Tielhof 2002, 217). For China, estimates indicate that the real costs of transport were on average 25% of the grain shipped, and as much as 50% for more involved transports, such as that from the Yangzi Delta to Beijing through the Grand Canal (Evans 1984, 298-299).

What does a comparison of the relative costs of different modes of transport—by sea, by inland waterway, and overland—for a given weight and distance yield? Land transport in the late 18th century England was normally 2 to 4 times as expensive as waterway transport (Jackman 1962, Appendix 8); in China, land transport was between 1.5 to 5.5 times as expensive as waterway transport, depending on the ease of navigation of the waterway.[7] Inland waterway transport in China may have been about 2.7 times as expensive as transport by sea, while the corresponding factor in 18th century England was between 2 to 2.75 (Evans 1984, 294, and Petersen 1995, 150, respectively). Using the mid-point estimates and

[7] For the well-navigable Yangzi River, overland transport was between 3-5.5 times as expensive as waterway transport (Peking road transport is 5.5 times the costs on the Yangzi; Evans 1984, 293; and land transport in Hubei and Shanxi is 3-5 times as expensive as transport on the Yangzi; Perkins 1969, 120). For the less navigable Yellow River and Grand Canal, overland transport may have been only 1.5 times as costly (Evans 1984, 294).

normalizing the cost of sea transport to one, our estimates for the relative costs of sea versus inland waterway versus overland transport in China are 1: 2.7: 9.5, while the analogous figures for England are 1: 2.4: 7.1. Thus, while the scale of China's long-distance grain trade was larger than Western Europe's, overland transport may have been somewhat more expensive relative to water transport in China compared to Western Europe. Overall, these figures suggest that the efficacy of transport technologies did not differ too much between China and Western Europe in the 18th century.

Both public and private institutions that supported the grain trade in China. Below, we summarize some of the more notable ones for China, which may be less familiar to most readers.[8] First, the Qing state was a direct participant in the grain trade: about 15% of China's long-distance trade in the mid-Qing may have been official government shipments—primarily in form of tribute grain to Beijing and food for soldiers (Xing et al. 2000, 180). The state also influenced the grain trade indirectly, by gathering information about agricultural practices, harvest outcomes, and grain prices throughout the empire. The Qing state supported the grain trade by creating and maintaining transport routes, and by organizing local communities in the upkeep of transport routes. Some 10% of its total revenues were devoted to public projects, which included flood control and passageability of major routes. (Naquin and Rawski 1987, 23; Myers and Wang 2002, 597). Finally, the Qing Code, the formal legal framework of Qing China, protected private property and hence trade through its articles against theft, sale of property belonging to others, as well as trespassing.

It also appears that a reasonably effective court system existed and official arbitration of property disputes was available, even to the poor. There does not appear to have been much of a contradiction between customary laws and the official legal framework. Customary practice was judged within the official laws, and conversely, private written contracts were enforced in the ruling of the Qing courts when disputes arose. The emphasis of the Qing Code, however, was on maintaining public order by

[8] Additional details and comparisons with Europe can be found in the appendix on the journal's website (denoted Web Appendix), as well as in Shiue and Keller (2006).

providing incentives for lawful behavior through the threat of punishment rather than on reconciling conflicts among private economic interests.

Although formal Qing laws took a relatively *laissez faire* approach to the daily affairs of trade, the state levied domestic customs as well as transit taxes. However, with the notable exception of England, the amount of revenue from these taxes in China was typically below that of the countries in Western Europe, even as late as the 18th century. The Chinese state also responded to perceived monopolization and collusive behavior in the marketplace by instituting a brokerage system wherein government-licensed brokers earned commission for supervising payments between buyers and sellers, overseeing delivery, inspecting for quality and quantity, and serving as a guarantor on the exchange (Mann 1987, 63-65). While it was illegal to conduct any wholesale transaction without a licensed broker, the requirement was not fully enforced and the number of unlicensed brokers proliferated, weakening the brokerage system.

Second, non-official institutions in China were developed and enforced by guilds, self-governing organizations that were permitted a broad range of discretionary powers by the government. Unlike European guilds, Chinese guilds were dominated by interregional merchant networks and typically did not keep outside arriving merchants from guild membership (Rowe 1984, 297). Did the Chinese guilds help or hinder trade? The guilds' role in providing information as well as an institutional framework for contract enforcement likely supported trade in China. Guilds provided lodging and services for merchants, helped them to calculate profits and losses, and taught members bargaining techniques. Often, they also chose and enforced the local weights and measurements for transactions, established the dates at which markets would be open as well as regulations for sales, deliveries, and market conduct (Xing et al. 2000, 180-183; Rowe 1984, 295-296). Over time, the state may have relied more and more on the guilds for market oversight. In some cases, guilds were eventually delegated the unusual privilege of assessing and collecting trade taxes for the state (Mann 1987, 23-24).

Third, merchant networks, typically identified by kinship or common place of origin, were another major feature of trade in China. These networks were known for its trade in a particular commodity (such as salt or paper, with grain and other commodities often shipped on the return trip), and were an important means by which geographically dispersed groups shared information about conditions in distant markets. Contract enforcement among network members may have been facilitated by reducing commitment problems. Merchant networks also established an interlocked chain of banks along their trade routes, complementing the official banking developments in Qing China. Private and official distinctions were at times heavily blurred. For example, merchants purchased official titles or became officials of the state, and officials not only accepted but regularly solicited financial contributions from merchants for government projects (Ho, 1964, 82).

Although some of the largest fortunes in Qing times were built on domestic and international trade, this trade clearly functioned in an institutional setting that was different from those prevailing in Western Europe. *A priori*, there does not appear to be strong reasons to expect a particular institutional framework to be more conducive to trade than another.

We now proceed to our quantitative analysis.

3. Data, Econometric Methods, and Results

3.1 Data

We have assembled a large data set of about 250 price series, roughly equally divided between China and Western Europe, and ranging in time period from the 15th to the 20th century. Within Europe, the markets are predominantly located in today's Belgium, England, France, Germany, Luxemburg, and the Netherlands, that is, in Northwestern Europe. This area is generally considered to have been the most advanced part of Europe. The Chinese markets are located in the following ten central/south-central provinces: Anhwei, Fujian, Guangdong, Guangxi, Guizhou, Hubei, Hunan, Jiangsu, Jiangxi, and Zhejiang.

The Chinese and European areas are comparable in terms of population size. About 120 million people lived in these ten provinces of China at the end of the late 18th century (about 60% of China), while the population of Europe excluding the former USSR might have been 120 to 150 million (Durand

1960, McEvedy and Jones 1978). To put this in another perspective, a typical Chinese province has roughly the same population as the average European country. The two sample areas are also comparable in terms of geographic size. Map 1 depicts the areas on the same scale; the ten Chinese sample provinces are shaded. Trade between the fertile agricultural areas in the upper reaches of the Yangzi River and the urban regions of Shanghai at the Yangzi Delta involved covering distances of at least 1,200 kilometers, approximately the distance of the trade route between Antwerp and Vienna. The maximum distance between any two markets in our sample is about 1,400 kilometers for Europe and about 1,850 kilometers for China.

The data coverage for China and Europe differs in some respects. As Figure 1 indicates, Europe is relatively well represented in the temporal dimension, and data is available for both the pre- and the post-Industrial Revolution era. While most of the data on China is for a shorter period—the 54 years from 1742 to 1795—the geographical coverage of the Chinese data is relatively broad; it consists of all 121 prefectural markets of the ten provinces shown in Map 1, including both the most commercialized as well as the relatively less developed regions. In contrast, the European price data up to the 18th century tends to be for relatively large and important markets. To the extent that there is selection bias coming from large market size, it is likely to favor Europe over China.

Some major characteristics of our price data are as follows. Except for one of the London series, the sources give the market price for grain; the less informative data, such as prices paid by hospitals, charities and other entities were not used. Prices have been converted to common units of currency per volume (or weight) within a series. In general, we have not tried to account for changes in the value of the currencies over time because missing information on the (typically) silver content of coins would necessarily lead to low-quality estimates. We do not expect that inflation has a major influence on our results, because even though the overall sample period is from the 17th to 19th century, our comparisons between China and Europe are typically based on periods of only about 25 years.[9]

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[9] Grain prices were broadly trending upwards in both China and Western Europe, and it is not generally the case that inflation in one or the other continent was higher (see Wang 1992 on inflation in China). We have also

Most of the price observations are at a monthly frequency; however, in some series the price given is for the first market day of the month, while for other series it is the average for all market days of the month, where this average may or may not be quantity weighted. In addition, in some cases, prices pertain to spatially aggregated regions, not to a market (or several markets) in a given city. Generally, the fact that prices were collected in only a few different ways and that we can typically find several markets sharing commonalities in their method of recording prices permits us to analyze the impact of differences in data characteristics. In addition, some sources contain specific information that allows us to gauge the influence of quantity-weighing (by using weekly prices together with quantities sold), nominal versus constant prices (by using the latter instead of the former), and spatial aggregation (by size-weighted aggregation of several near-by markets). Experimentation with these alternative price series showed that our main results below are not driven by such differences in data characteristics. The Appendix provides additional details, as well as the sources and construction for each of the price series.

Table 1 shows summary statistics for certain key samples. For China, shown first is the full sample with 121 prefectural markets. As noted earlier, these prefectures differ substantially in terms of commercialization and geography. To take advantage of the breadth of this data, a number of subsamples were formed. The first subsample listed is the set of prefectures that belong to the expanded Yangzi Delta. This area is an important one for our comparison because the Yangzi Delta was very likely the most advanced area of China. The second Chinese subsample consists of the prefectures that are the ten provincial capitals in our sample. These markets, which are shown in Map 2 in the Web Appendix, were important from a political point of view, but were not necessarily on well-linked trade routes. We also distinguish 34 prefectures that are located on the Yangzi River, directly or linked through a major tributary. All available evidence suggests that these regions traded more than the average region in China.

For Western Europe, Table 1 shows first a sample of 9 cities around the year 1700 (1692 to 1716). This sample is useful for at least two reasons: for one, the year 1700 is specifically mentioned by

experimented with adding a trend to the cointegrating relationship (see equation 5 below); however, tests generally reject this specification.

North as the time by which a number of countries in Northwest Europe had developed a set of exceptionally advantageous institutions (North 1973). Moreover, this sample will also be analyzed to study market integration in the pre-Industrial Revolution era. The second sample covers 15 cities in the later part of the 18th century. This sample is contemporaneous to our Chinese data, and it is therefore of key interest; the markets are shown in Map 3 in the Web Appendix. A third sample covers 15 European cities in the second quarter of the 19th century (years 1825-49). This is the sample on which the post-Industrial Revolution analysis will be based.[10] We also include a within-country sample: 41 county-level markets in England for the years 1770-94. This allows us to study whether market integration in England, the host country of the first industrial revolution, appears to have been different from that in other regions of Western Europe in the late 18th century.

Because the extent of market integration and spatial price variability depends on geographic distance, the frequency distributions of bilateral distance between all pairs in a given sample are shown on the right in Table 1. For example, 31.1% of all bilateral pairs in the 'All prefectural markets' sample in China are more than 900 km apart from each other, whereas for the West European cities sample for 1770-94, 14.3% of bilateral pairs fall in that category. This breakdown gives additional information on the relative sizes of areas compared; specifically, the sample for England is closest to that of the Yangzi Delta according to these frequency distributions.

Table 1 shows various measures of price variability on the left. The summary statistics show that price variability in China tends to be lower than in Europe. This is true both in terms of price levels (column I) as well as in terms of price changes (column II). Previous studies have often used such price volatility measures as an indication of how segmented one market is from other markets, on the rationale that volatility is lower if markets are more connected through trade (e.g., McCloskey and Nash 1984). Low price variability may also be caused by other factors, such as by relatively low storage costs. One indicator of that is an asymmetric price distribution, which is driven by the fact that storage cannot be

[10] We cannot analyze the same set of cities before, during, and after the 18th century due to data availability, but the overlap in the three samples is high (see the notes at the bottom of Table 1). Small changes to the sample composition do not affect our main results.

negative (e.g., Deaton and Laroque 1992). Here, the skewness measures range from -0.438 for English to 0.605 for the Yangzi River markets; overall, there is no clear difference between markets in China and in Western Europe in this respect (column III).

3.2 Econometric Methods

This paper studies the performance of markets in China and Western Europe by comparing the spatial integration of grain markets in the two regions. In this section, we present a model of an agricultural commodity, and show how testing for cointegration in prices can be used in this context.

Consider the following simplified model. In each period t, t = 1,…, T, there is an inelastically supplied harvest z_t which follows a stochastic process characterized by a cumulative distribution function $\Phi(z, Z)$,

(1) $\Phi(z, Z) = \Pr(z_{t+1} \leq Z | z_t = z)$.

The harvest shocks are exogenous, determined by the conditions of agricultural production, and are what ultimately determines the behavior of the price, P_t. The economy is populated with final consumers who have identical inverse demand functions. Under the assumption that the commodity cannot be stored—storage is discussed later, in section 4—the harvest z is consumed in each period. With log-linear demand the price is given by

(2) $p_t = a + bz_t$,

where a and $b < 0$ are parameters, and $p_t = \ln(P_t)$. Because consumers are the only buyers in the market, given equation (2), the behavior of prices follows directly from the behavior of the harvests. We assume that the harvest process follows

(3) $z_{t+1} = \rho z_t + \varepsilon_{t+1}$,

where $-1 < \rho \leq 1$, and the ε's are i.i.d. with mean μ. From equation (3), harvests and prices are i.i.d. for the case of ρ equal to zero. The case of positive autocorrelation may emerge if weather shocks damage crops for several periods. In the extreme case of $\rho = 1$, such damages (or improvements) have a permanent effect. This is what we assume here. The process of harvests is non-stationary, and prices follow a random walk

(4) $p_{t+1} = p_t + u_{t+1}$,

with $u_{t+1} = b\varepsilon_{t+1}$. While (4) typically cannot be rejected using standard time series tests—as is the case below—the random walk hypothesis is not fully satisfactory. For instance, multi-year damage due to weather shocks is more plausible for tree crops than for annuals such as rice and wheat (Deaton 1999). We adopt it here as the point of departure for our analysis of cointegration, noting that there is no consensus yet on a model of agricultural price behavior that is clearly preferred to it in terms of accounting for both short-term and long-term dynamics (see Deaton 1999, Deaton and Laroque 1992, 1996).

Suppose that there are two markets, with prices p_{1t} and p_{2t}, satisfying equation (4). If a linear combination of these non-stationary variables is stationary, the prices are said to be cointegrated (Granger 1981, Engle and Granger 1987). Cointegration means that there exists a long-run relationship between prices in the two markets, and prices cannot move arbitrarily far away from each other. This is consistent with arbitrage through trade establishing a link between markets. We thus use tests for cointegration to provide evidence on the degree of market integration.

Cointegration generally supports the notion that trade and the forces of arbitrage are at work. The strength of these forces is determined by a number of factors. First, trade is reduced by high transport costs, and in general, transport costs are increasing in geographic distance. Second, because transporting grain over water is cheaper than over land, transport costs also reflect an area's topography (including waterways, mountains) as well as route maintenance and the sensitivity to weather-related problems (such as mud on streets, drying out of rivers and canals). Third, the degree of market integration is also affected by the quality of institutions. It matters, for example, whether the political system is unified (as in China), or more fragmented (as in Western Europe), because often governments impose tariffs, quotas and other trade barriers at borders. Even in the absence of trade barriers, a unified system may reduce transactions costs if currencies, weights and measures, or languages are more standardized than in a politically fragmented region. Further, there are differences in government support for institutions that impact on trade, in particular property rights, contract enforcement, the rule of law, and the provision of security for trade. Governments can also be more or less prone to yielding influence to lobbies and interest groups, which, in line with private incentives, often favor restrictions on trade and competition.

To summarize, our comparative study of spatial market integration in China and Western Europe provides information on the overall performance of grain markets in the two areas. One advantage of the cointegration approach is that it captures the outcome of many factors, ranging from transport technology over the quality of grain market-supporting institutions to factors that affect transactions costs, such as contract enforcement.

We follow Engle and Granger (1987) and estimate by OLS the equation

(5) $p_{1t} = \beta_0 + \beta_1 p_{2t} + e_t$.

If p_{1t} and p_{2t} are cointegrated, there will be some long-run parameters β_0 and β_1 such that $p_{1t} - \beta_0 - \beta_1 p_{2t} = 0$ is satisfied. To test for this, we examine the time series properties of e_t, because p_{1t} and p_{2t} are cointegrated if and only if e_t is stationary. An augmented Dickey-Fuller (1979) test on $\hat{e}_t$, the residual of (5), is employed

(6) $\Delta \hat{e}_t = \delta_1 \hat{e}_{t-1} + \delta_2 \Delta \hat{e}_{t-1} + u_t$,

where the lagged dependent variable is added as a regressor to reduce problems of serial correlation. Under the null hypothesis that e_t is non-stationary, the parameter δ_1 is equal to zero, and the stronger is the evidence that $\delta_1 < 0$, the more evidence there is that p_{1t} and p_{2t} are cointegrated. Below we will compute the t-statistics of δ_1 for various samples in China and Western Europe to compare the evidence for market integration in the two regions.[11]

[11] Extensions of this approach have been considered as well. In Shiue and Keller (2004), we use Johansen's (1988) maximum likelihood estimation (MLE) to estimate the long-run parameters together with the speed-of-adjustment parameters, and we also use MLE methods to test specific hypotheses, in particular, the law of one price, $\beta_0 = 0$ and $\beta_1 = 1$. Overall this yields results consistent with what is described below. In addition, we have considered threshold estimation techniques (Taylor 2001, Balke and Fomby 1997) as well as cross-sectional spatial correlation techniques (Keller and Shiue, forthcoming) to compare market integration; we think that these methods would yield the same qualitative conclusions as our cointegration approach.

3.3 Empirical results

This section begins by showing relatively descriptive evidence from bilateral price correlations, which require making fewer assumptions but are similar in spirit to the cointegration analysis to which we turn next. Figure 2 shows a scatter plot of bilateral price correlations versus distance for a number of samples during the years 1770 to 1794. Transport costs are, at least in part, increasing in the time traveled on a journey, and as a first approximation costs are captured here by geographic distance. The figure shows the price correlations with confidence bands for the 15 European markets together with regression lines of price correlations for the Yangzi River and Provincial Capitals samples. At a given distance, the price correlations for Europe tend to be higher than for the Chinese Provincial Capitals but lower than for the Yangzi River markets. Also, note that price correlations along the Yangzi River fall less as distance increases than in the other two samples. This is indicative of lower marginal transport costs on the Yangzi than overland (or a less direct waterway route). The fact that we can bound price correlations in 18th century Europe with those of samples from contemporaneous China is consistent with the idea that the degree of market integration was comparable in the two areas at this time.

We now turn to examining market integration using tests for cointegration among prices in market pairs. After testing for non-stationarity in the individual price series p_{1t} and p_{2t},[12] we estimate the cointegrating relationship given in equation (5), augmented with monthly fixed effects (β_m)

(5') $p_{1t} = \beta_0 + \beta_m + \beta_1 p_{2t} + e_t$,

and then test $\hat{e}_t$ for stationarity with an Augmented Dickey-Fuller (ADF) regression. The lower is the t-statistic of $\hat{\delta}_1$, the parameter estimate on $\hat{e}_{t-1}$, the stronger is the evidence for cointegration between prices p_1 and p_2.[13]

[12] Typically, the null hypothesis of a unit root cannot be rejected using standard unit root tests. For example, during the years 1770-94, the average p-value for the null of a unit root is 0.27 for the 15 European cities, whereas it is 0.12 for the expanded Yangzi Delta prefectures.

[13] We also reduce the effect from outliers in equation (5') by adding indicator variables to the deterministic component for periods with exceptionally strong price changes. We treat a price change that is larger than one standard deviation as an outlier; some experimentation with other definitions indicates that the main results are not sensitive to that choice. Note that although we have computed approximate critical values using techniques laid out

Figure 3 presents the average ADF t-statistics for the sample of 15 European countries in the late 18th century as a function of distance class, and the implication of these results qualifies several conclusions from the price correlations versus distance plot in Figure 2. Generally, the lowest average t-statistics are found for the smallest distances—less than 150 kilometers—which is what one would expect: the evidence in support of cointegration is strongest among relatively nearby markets. Figure 3 also presents the average ADF t-statistics for the Chinese Yangzi River and Provincial Capital samples; it suggests that market integration among European cities was greater than in China for short distances (less than 150 kilometers). Above that, it appears that the level of market integration, not only among the Yangzi River markets, but also among the Chinese Prefectural Capitals, was at least comparable to levels of market integration that prevailed in the Western European sample.[14]

Figure 4 compares the cointegration measures for the 15 European cities with the Yangzi Delta region as well as with the entire sample of 121 Chinese markets. Generally, there is more evidence for market integration for the extended Yangzi Delta region than for China as a whole, consistent with qualitative evidence on the relative degree of commercialization and development in the Yangzi Delta. Relative to Western Europe, there is less evidence for market integration in the expanded Yangzi Delta for distances up to 150 kilometers, while for larger distances markets appear to be more integrated than markets in Western Europe. As the results for all 121 prefectures show, even the average Chinese market seems to have been as spatially integrated as markets in Western Europe for all but the shortest distances. This indicates that the earlier analyses are not driven by selection bias.

Overall, the results suggest that there were no large difference in terms of market integration between China and Western Europe in the late 18th century. But what about England? Figure 5 compares

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in MacKinnon (1991), the outlier treatment and the inclusion of seasonal effects imply that these critical values do not strictly apply anymore. For this reason, we prefer to look for general patterns in the ADF t-statistic as opposed to testing sharp hypothesis.

[14] The city of Danzig is not located in Western Europe, but given its importance for the European long-distance grain trade (see section 2), we have experimented with including Danzig in the sample of European cities and recalculated the cointegration statistics. Although Danzig has a positive influence on the average market integration levels in Europe, its inclusion does not qualitatively change our results; the average ADF t-statistics without (with) Danzig are: 0-150 km -4.45 (-4.45), 150-300 km -3.81 (-3.81), 300-450 km -3.76 (-3.78), 450-600 km -3.49 (-3.60), 600-750 km -3.16 (-3.17), 750-900 km -3.60 (-3.74), and above 900 km -3.58 (-3.76).

the cointegration statistics for 18th century markets in England with those in contemporaneous Western Europe overall, as well as in China's Yangzi Delta.[15] The evidence for cointegration in England is stronger than for Western Europe overall, and moreover, the evidence for cointegration in England is also stronger than for the Yangzi Delta markets.

Thus, while in the late 18th century the Yangzi Delta region had similarly or possibly more integrated markets than Western Europe as a whole, England's markets at the time were more integrated still. The gap between England and continental Western Europe started to close within the next several decades. Figure 5 shows the cointegration statistics for European markets for the years 1825-49, in the aftermath of the Napoleonic Wars (1799-1815). Market integration was substantially higher in Western Europe in the early 19th century than in the late 18th century, and this improvement led to a level of market integration that was not so different from that in Britain during the years 1770 to 1794.[16]

4. Qualifications and Sensitivity Tests

In this section, we briefly discuss a number of additional issues and robustness checks that are important for our analysis. They have to do with the spatial patterns of weather shocks in China and Europe and differences between rice and wheat, specifically related to storage.

Weather shocks. Differences in weather shocks in China and Western Europe may affect the market integration results. Specifically, if weather shocks would change quite differently across geographic space in China compared to Europe, this could lead to substantial differences in spatial price correlations without any implications for market integration and trade. To address this issue, we compare historical weather data for China and Western Europe, and find that climatic differences are not a likely explanation for our results; see the Web Appendix available on the journal's web site.

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[15] The critical values of the ADF t-statistics are a function of T, the time series length: it becomes easier to find evidence in favor of cointegration the larger is T, so that the critical values need to be adjusted to hold the significance level constant if T is not the same. We have ensured the comparability of the t-statistics using the response surface results of MacKinnon (1991).

[16] These cointegration results are also broadly in line with our findings using bilateral price correlations, as discussed in the Web Appendix available on the journal's web site.

Rice versus wheat. Rice markets in China and wheat markets in Europe are selected for comparison because rice and wheat were the dominant grain in each continent, respectively. Rice and wheat production differ in terms of cultivation and harvesting, and possibly in other respects such as transport cost or value-to-weight ratio.

The most important agronomic distinction between the technology of wheat production in Western Europe and rice production in China is probably that wheat is grown under upland (rainfed) conditions while the rice is grown under irrigated conditions. The irrigated environment lends itself to much more labor intensive systems of cultivation than rainfed production. In addition, an irrigated system may exhibit lower inter-year and spatial price variability than rainfed production, and this would favor estimating lower levels of market integration in China than in Western Europe, all else equal. We now turn to other important differences between rice and wheat that may affect our results.

Storage. The model above does not include storage. The availability of storage possibilities, however, is important because storage leads to serially autocorrelated prices even if the harvest shocks are i.i.d. (Deaton and Laroque 1996, 1992; Williams and Wright 1991). Moreover, if storage costs for rice and wheat differ, then even if storage behavior is efficient and harvest shocks are i.i.d. in both markets, storage will induce differences in the time series properties of the two prices.[17] Storage cost differences matter also because trade and storage are substitutes for achieving consumption smoothing. All else equal, there is less need for trade if cost-effective storage is available, and *vice versa*.[18]

Seasonality. In this paper we study cointegration using monthly, and not quarterly or annual prices. While this tends to reduce problems resulting from temporal aggregation (see Taylor 2001), we are likely to pick up seasonal effects for these agricultural goods. To the extent that seasonal effects differ for rice cultivation in China and wheat cultivation in Europe, this may confound our results.

[17] Deaton and Laroque (1992, 6-7) show that the critical price level p^* at which storage turns positive is a function of the storage costs.

[18] Williams and Wright (1991, Chapter 9) show that allowing for storage in a model of trade leads to fewer periods in which trade takes place in equilibrium, to lower trade volumes, and to a lower correlation of prices than there was in the absence of storage. Evidence consistent with this for 18th century China is presented in Shiue (2002).

Comprehensive information on possible differences along these lines is not available for our markets. As a first step to deal with differences in seasonal effects between rice cultivation in China and wheat cultivation in Europe, monthly fixed effects (β_m) are added in the deterministic component of the cointegrating equation (5). The question of possible differences between rice in China and wheat in Western Europe has also been addressed by a number of auxiliary analyses: comparisons of 18th century (i) wheat prices in China and Western Europe, of (ii) rice and wheat prices in China, and of (iii) rice and wheat prices in the United States. These analyses suggest that large biases in our market integration comparison due to differences between wheat in Europe and rice in China are unlikely, and to the extent that biases exist, they tend to favor finding relatively high levels of market integration in Europe. A more detailed discussion can be found in the Web Appendix on the journal's web site.

With regards to storage in Europe, there is generally little direct evidence of storage in either private or public facilities (Nielsen 1997, 12). In contrast, the Qing state operated large-scale granaries (Will and Wong 1991). The Qing public granaries, however, were rarely a reliable source of food for the general population, even over the rather limited period of time that the granaries were operational.[19] Nevertheless, the institution is one that countries of Europe did not support, and it is worth employing data on public grain storage to obtain an estimate of the role that this storage might play for our comparison of market integration. In addition, a second reason makes the quantitative comparison valuable. Since the state was responsive to overall market trends (Shiue 2005a, 2004), public storage, even if it alone did not exert a decisive effect on the level or variability of grain prices, could well provide a proxy for total (public and private) grain storage in China.

In Figure 6, we compare the evidence for cointegration in Chinese provinces that had relatively high levels of public storage with other Chinese provinces, as well as with European markets.[20] As expected, there is less evidence for cointegration in markets located in provinces with high levels of storage

[19] This is consistent with estimates that in China, the amount of grain held in private storage exceeded that held in public granaries (Bray 1984, 416).
[20] The two provinces with the highest level of per-capita storage in our sample are Guizhou and Guangxi; see Shiue (2005a, Figure 1).

compared to the average Chinese market, or the Yangzi Delta markets. If storage costs for rice in China were indeed low relative to those for wheat in Europe, as suggested by Bray (1984, 385), our analysis would be biased in favor of finding relatively high levels of market integration in Europe. Therefore, our result that market integration in China and Europe were comparable tends towards the conservative. Controlling for storage cost differences, China's level of market integration may have been even higher than in continental Western Europe, although judging from the magnitudes in Figure 6, it seems unlikely that is was as high as that which was prevailing in England.

To sum up the results of this section, it is unlikely that our analysis is biased towards finding relatively high levels of market integration in China, and if anything, there may be a small bias in the opposite direction. This confirms our main finding that while in the late 18th century England's markets were more integrated than those of the Yangzi Delta, China's markets had similarly or possibly more integrated markets than Western Europe as a whole.

5. Summary and concluding discussion

The concept of allocative market efficiency holds a prominent place in our understanding of economic growth, and it has also been offered as a leading explanation for why Western Europe industrialized in the late 18th century. In this paper we examine the similarities and differences in markets in pre-industrial China and Western Europe from the 15th to 19th centuries. We use a range of descriptive and more formal methods to assess market integration in China and Western Europe around 1770, to see whether one continent—specifically Western Europe—was clearly ahead. According to the evidence presented in this paper, as of the period right before the Industrial Revolution took place in Western Europe, grain markets performed not uniformly better in Western Europe than in China. Over relatively short distances of 150 km or less there are indications that European markets were more integrated. This edge, however, is relatively small when we consider what occurs right after the onset of industrialization. In the early 19th century, soon after the dates associated with industrialization, markets in Continental Europe became, rather quickly, significantly more integrated than in centuries prior. That the bulk of the market's improvement took place only once modern growth had started indicates that most of the improvements in the degree of market integration in the 19th century in Western Europe may be largely a consequence of industrialization rather than a cause.

Markets today in the United States and Western Europe are yet more integrated than they were in the 19th century. They are also more integrated than markets found in poor countries of today. But it would be in part to confound cause and effect to conclude from this that integrated markets must first be secured before modern growth can proceed. This, at least, does not appear to be what happened in Western Europe before the onset of the Industrial Revolution.

That the overall level of market integration was not exceptional stems in part from the political fragmentation of Europe. A unified Europe would likely have seen higher integration across countries. The lack of free markets, however, even within most European countries needs also to be considered. England was an exception in this regard as internal markets were relatively free, and consistent with that, we find market integration levels in England to be higher than anywhere else in the late 18th century. That we find Britain clearly ahead is an important finding. But was the relatively high level of market integration the reason why Britain industrialized? In China, internal commercial taxes until the mid-18th century were probably not higher than in Britain, and in addition, Chinese merchant networks did much to facilitate trade, especially over long distances. The British government appears to have had more public provisions for road maintenance and transport, but Chinese merchants and gentry also made sometimes substantial financial contributions for a variety of public goods. We take the fact that the level of market integration seen in Continental Europe by the mid-19th century is similar to Britain's in the late 18th century as evidence that important economy-wide change had indeed occurred in Britain by around 1770.

What about the role of the Qing state and the emergence of good institutions in China? As mentioned earlier in our discussion of the institutional foundations of the Chinese grain trade in section 2 (with more details given in the Web Appendix), contracting institutions (such as laws and courts) were in part provided by the Chinese state, and in part by guilds, merchant networks, and customary laws. While there were no organizations or institutions that could effectively challenge the power of the Qing state, we do not have much evidence that the state had a strongly expropriative or redistributive character, by European standards. That is, the 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. The dichotomy proposed by North (1981) and examined by Acemoglu and Johnson (2005) thus appears to be too narrow to fit the Chinese case. Based on our research, we hypothesize that if the failure of China to industrialize had at all to do with shortcomings of the state, it was not so much that the state suppressed private economic activity, but that the state did too little to support it through the provision of public goods and formal legal institutions. Clearly more research needs to be done on this topic.

Our discussion also highlights that it would be difficult to argue that the overall comparability of market integration in China and Western Europe comes about because China had excellent natural endowments in its rivers while Western Europe achieved the same through generally stronger allocative institutions and organization in all other respects. In both China and Western Europe, the institutions governing grain trade were often not specific to grain, but affected also trade in other commodities and possibly other endeavors, including the incentives for technical change. The influence of merchant guilds, for example, in the area of standardization, property rights, judiciary, and security were wide-ranging. Because of the complexity of these institutions, it appears that the effects of institutions on growth cannot be unidimensionally ranked with any ease. The findings in this paper provide new evidence on whether trade causes growth. Future research is necessary to improve our understanding of what factors facilitate market integration, what factors can trigger industrialization, and how the two sets of factors are related.

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Appendix: General characteristics of the price series

Quality. Prices in China are for mid-quality rice; for Europe we do not have much specific information on quality. The sources indicate that the quality of grains sold varied, and the quoted price in Europe should be close to that for commonly available average quality of wheat.
Source. In Europe, the prices come typically from *mercuriales*, which are official records of transactions at public markets. In China, the data comes from market price reports at the prefectural level (an administrative level above the county- and below the province-level).
Temporal and spatial aggregation: The price series vary in terms of temporal as well as spatial aggregation. Most prices are at a monthly frequency. The calculation of the monthly price varies, but the three most important methods are (1) average price of first market day of month, (2) average price of all transactions in a month, and (3) minimum and maximum during a month. The price averages are typically not quantity-weighted; however, we have used prices and quantities available at a weekly frequency for some markets to compute the correct average prices, and found that the difference is negligible. If the minimum and maximum price is available, we form the average price as (min+max)/2.

There is spatial aggregation to a varying extent. We have explored the effects of spatial aggregation, and did not find major effects. Gonzalo (1993) discusses the extent to which time series properties—order of integration, cointegration—are preserved under temporal and cross-sectional (spatial) aggregation.
Selection of markets: The sample for China includes virtually all markets in the 10 provinces for which rice was the major grain, which suggests that sample selection plays essentially no role for China. For Europe, our data tends to be for markets of relatively big cities that were often also centers of trade and relatively rich cities. For instance, the 50 French markets in Drame et al. (1991), see below, are selected from some 900 markets as those where the greatest quantities were sold.
Missing data: There are substantial gaps in the sources; approximately 23 % (15%) is missing in an average Chinese (European) series. We have used the TRAMO (Time Series Regression with ARIMA Noise, Missing Observations and Outliers) program to interpolate series for which there was not too much missing data (Gomez and Maravall 1997). This estimation of data does not critically affect our results.

Specific information and sources of the price series

Austria--Vienna
Source: Pribram, Alfred Francis. *Materialien zur Geschichte der Preise und Löhne in Österreich,* Volume I. Vienna: Carl Überreuters Verlag, 1938.
Overall years: 1692 to 1914; frequency: monthly; method: quantity-weighted average of all market days.
Quantity units: In "Wiener Metzen" (1692-1752), in "Niederösterreichen Landmetzen" (1752-1875), and in "100 Kilogram" (1875-1914). Conversion rates: 1 Wiener Metzen = 0.76 Niederösterreiche Landmetzen; 1 Niederösterreicher Landmetzen = 46.32 Kilogram.
Monetary Units: "Kreuzer" (1692-1752); "Kreuzer Konventionsmünze" (1752-1812); "Kreuzer Wiener Währung" (1812-1858); "Kreuzer Österreichischer Währung" (1858-1897); "Heller Kronenwährung" (1898-1914). Conversion rates: 1 Gulden = 60 Kreuzer = 60 Kreuzer Konventionsmünze = 150 Kreuzer Wiener Währung = 105 Kreuzer Wiener Währung = 210 Heller Kronenwährung.
Original source: "Marktprotokolle der Stadt Wien".

Belgium--Brussels
Source: For years 1568-1696, 1728-1795: Craeybeckx, J., "De Prijzen van Graan en van Brood te Brussel", in C. Verlinden (ed.) *Dokumenten voor de Geschiedenis van Prijzen en Lonen in Vlaanderen en Brabant,* Vol. I. Bruges: De Tempel, 1959.
Source: For years 1800-1889: Vandenbroeke, C., "Brusselse Merkuriale van Granen, Aardappelen, Hooi, Stro, Boter, Vlees, Koolzaad, Boskool en Steenkol", in C. Verlinden (ed.) *Dokumenten voor de Geschiedenis van Prijzen en Lonen in Vlaanderen en Brabant,* Vol. III. Bruges: De Tempel, 1972.
Overall years: 1568-1889, with gaps; frequency: monthly; method: average from the month's first market day.
Quantity units: In "Bruxelles setier" (1568-1696, 1728-1795); in "100 liters" (1800-1871), and in "100 Kilograms" (1872-1889). Conversion rates: 1 Bruxelles setier = 48.76 liters, and 79 kilograms = 100 liters.
Monetary units: In "Brabantse stuivers" (1568-1696, 1728-1795); in "French Francs" (1800-1817, 1833-1889), and in "Dutch Guilders" (1817-1832). Conversion rates: 20 Brabantse stuivers = 1 Dutch Guilder; and in 1816, 1 Dutch Guilder = 2.085 French Francs, and in 1832, 1 Dutch Guilder = 2.117 French Francs.
Original source: "Algemeen Rijksarchief te Brussel, Terminatieboeken".

Belgium--Brugge
Source: Vanderpijpen, W., "Brugse Merkuriale van Granen, Brood, Aardappelen, Boter en Vlees (1796-1914)", in C. Verlinden (ed.), *Dokumenten voor de Geschiedenis van Prijzen en Lonen in Vlaanderen en Brabant,* Vol. IV. Bruges: De Tempel, 1973.
Overall years: 1796 to 1914, with few gaps; frequency: monthly; method: average from the month's first market day.
Quantity units: In "10 Kilograms" (1796-1802), in "100 liters" (1802-1890), and in "100 kilograms" (1892-1914).
Conversion: 100 liter = 79 kilograms.
Monetary units: In "French Francs" (1796-1817, 1833-1914), and in "Dutch Guilders" (1817-1832); see notes on Belgium-Brussels.
Original sources: "Rijksarchief Brugge (R.A.B.), Leiedepartement, 1076-1080 en 2831-2846" (for 1796-1812), and "Stadsarchief Brugge (S.A.B.), Gazette van Brugge" (for 1813-1914).

Belgium—Aalst
Source: Wyffels, A., "Prix du havot de froment à Alost", in C. Verlinden (ed.), *Dokumenten voor de Geschiedenis van Prijzen en Lonen in Vlaanderen en Brabant, XV-XVIII* Centuries, Bruges: De Tempel, 1959.
Overall years: 1729-1802, with major gaps before 1750; frequency: monthly; method: average, with variations.
Quantity units: In "havot" (i.e., per barrel).
Monetary units: In "Gros de Flandre".
Original source: "Alost, Archives communales, n° 261".

Belgium--Antwerp
Source: Craeybeckx, J., "De Prijzen van granen en van brood te Antwerpen van 1608 tot 1817", in C. Verlinden (ed.) *Dokumenten voor de Geschiedenis van Prijzen en Lonen in Vlaanderen en Brabant,* Vol. I. Bruges: De Tempel, 1959.
Overall years: 1608 to 1817; frequency: monthly; method: average price on first market day of each month.
Quantity units: In Antwerp "Viertel".
Monetary units: In "Brabantse stuivers".
Original sources: "Vierschaar, Antwerps Stadsarchief", nr.1817^1; nr.1824*bis*; nr.1817^2; nr.1817^3; nr.1814; nr.1815; nr.1816.

Luxemburg
Source: Helin, E., *Prix des Cereales a Luxembourg aux XVII^e et XVIII^e siecles*, Universite de Louvain, 1966; part of Joseph Ruwet et al. (1966), *Marché des céréales à Ruremonde, Luxembourg, Namur et Diest aux XVIIe et XVIIIe siècles,* Leuven: Presse de l'Universite de Louvain, 1966.
Overall years: 1721 to 1794, with gaps; frequency: monthly; method: average of highest and lowest price on first market day of month, with some variation.
Quantity units: In "bichet", where 1 bichet (or setier) = 20.463 liters.
Monetary units: In "Sous", where 1 Luxemburg Gulden is equal to 20 sous.
Original source: "Les Hallages de Luxembourg".

China--121 Prefectural capitals
Source: Data collection by Carol H. Shiue. These are rice prices; the sample covers virtually all prefectures of 10 provinces in China's Central/South-Central area; see Shiue (2002) as well as Roehner and Shiue (2000) for additional details.
Overall years: 1742 to 1795, with gaps; frequency: monthly (collected and used: 2nd and 8th lunar month); method: highest and lowest price from all markets in a given prefecture. We take (highest price+lowest price)/2 as the average price in the prefectural capital.
Quantity units: In "shi", where 1 shi = about 103 liters.
Monetary units: In "liang", which is a Chinese silver currency; it is also called "tael".
Original source: *Gongzhong liangjiadan* [Grain price lists in the palace archives]. Number One Historical Archives, Beijing.

China—Chengdu, Chongqing, Nanchang, and Xichang
Source: Data provided by Madeleine Zelin, Columbia University; these are prices for rice and for wheat.
Overall years: 1736-1782, with gaps.
Quantity units: In "shi", where 1 *shi* = about 103 liters.
Monetary units: In "liang", which is a Chinese silver currency; it is also called "tael"; 1 tael silver is about 37 grams.

Original source: Provincial collection of prices in Sichuan that were then reported to the imperial government and published in *Gongzhong liangjiadan* [Grain price lists in the palace archives], at Number One Historical Archives, Beijing.

China—Tianjin
Source: Data provided by Loren Brandt, University of Toronto.
Overall years: 1739-1794, with gaps.
Quantity units: In "shi", where 1 *shi* = about 103 liters.
Monetary units: In "liang".
Original source: Provincial collection of prices in Zhili that were then reported to the imperial government and published in *Gongzhong liangjiadan* [Grain price lists in the palace archives], at Number One Historical Archives, Beijing.

England--London
Source: Beveridge, William H. B. *Prices and Wages in England from the Twelfth to the Nineteenth Century,* Volume 1, (Price Tables: Mercantile Era; first edition 1939). London: Frank Cass & Co. Ltd., 1965.
Overall years: 1683 to 1801, with gaps; frequency: monthly; method: average from prices for spot or future (usually up to one month) delivery.
These are not market, but British Navy procurement prices for grain. The Navy Victualling Board met daily to contract with dealers for the supply of provisions. There was a public announcement, after which the interested dealers were one-by-one asked to place their bid. The Navy tried to achieve the competitive market price outcome (for instance, indications of collusion among bidders resulted in the postponement of procurement activity). See pp.514-535 for details.
Quantity units: In "Quarters".
Monetary units: In "Shillings".

England--London and 40 Counties
Source: *The London Gazette*.
Overall years: 1770 to 1794, with gaps; frequency: we employ data for the months January, March, July, and September (the source reports prices every week); method: average price of first week of month.
Quantity units: In "Standard Winchester Bushel of 8 gallons" (1770-93), and in "Standard Winchester Quarter of 8 bushels" (1793-94).
Monetary units: In "Shillings" and "pence".

France--Paris
Source: Baulant, Micheline and Jean Meuvret. *Prix des céréales extraits de la mercuriale de Paris.* Paris: Ecole des Hautes Etudes, 1960.
Overall years: 1520 to 1698; frequency: monthly; method: average of maximum and minimum price on the first market day of month.
Quantity units: In "setier de Paris", where 1 setier = 156 liter.
Monetary Units: In "Livres turnois".
Original source: "Mercuriale de Paris".

France--Toulouse
Source: Bertrand Roehner's preparation of figures in Frêche, Georges and Geneviève Frêche. *Les prix des grains, des vins et des legumes à Toulouse.* Paris: Presses Universitaires de France, 1967.
Overall years: 1486 to 1913; frequency: monthly; method: average of first market day of the month.
Quantity units: In "Hectoliter" (one hectoliter = 100 liter).
Monetary units: In "French Francs and Centimes".
Conversions: The Frêche-Frêche data is in different quantity and monetary units for different periods; we have followed the conversion rates applied in Drame et al. (1991).
Original source: "Mercuriale de Toulouse".

France--Alençon, Amiens, Bourges, Bourgogne, Bretagne, Caen, Lyon, Riom, Rouen, Tours
Source: Labrousse, C.E. *Esquisse du mouvement des prix et des revenus en France au 18e siècle.* Paris: Paris C. 1932. See Roehner and Shiue (2000) for additional details.

Overall years: 1756 to 1790, 1806 to 1900; frequency: annually; method: average. If the price is given for a region (e.g. Bretagne), we use the location of the central city of the region. Note that administrative boundaries were partly redefined during the French Revolution.
Quantity units: In "setier de Paris" (1756-1790), and in "Hectoliter" (1806-1900); conversion: one setier de Paris = 156 liters.
Monetary units: In "100 livres" (1756-1790), and in "French Centimes"; conversion: 100 Centimes = 1 Francs = 1 livre.

France--50 cities in French departements
Source: Drame, Sylvie, Christian Gonfalone, Judith A. Miller, and Bertrand Roehner. *Un Siècle de Commerce du Blé en France, 1825-1913.* Paris: Economica, 1991.
Overall years: 1825 to 1913; frequency: every 15 days (1825-1903), and every month (1903-1913); method: quantity-weighted average from all market days in a given period (15 days, or a month).
Quantity units: In "Hectoliters".
Monetary units: In "French Centimes", where 100 Centimes = 1 French Francs.
Original source: Archives Nationales (Paris), F^{11*} 1779-2678 and F^{11*} 2877-2984.

Germany--Cologne
Source: Ebeling, Dietrich and Franz Irsigler, "Getreideumsatz, Getreide- und Brotpreise in Köln 1368-1797, Erster Teil: Getreideumsatz und Getreidepreise: Wochen-, Monats- und Jahrestabelle", in H. Stehkämper (ed.), *Mitteilungen aus dem Stadtarchiv von Köln*, Vol. 65-66. Köln-Wien: Böhlau-Verlag, 1976.
Overall years: 1368 to 1797, with gaps; frequency: monthly; method: average from 4 to 5 weekly prices. The source also lists weekly prices and quantities, which allows verifying that the difference between quantity-weighted and –unweighted monthly price is typically less than one percent.
Quantity units: In "Kölner Malter", which is approximately 150 liters or about 117 kilograms.
Monetary units: In "Albus"; conversions: 1 Albus = 12 Heller, where the value of Albus to Gulden and Mark is 1 Gulden = 4 Mark = 24 Albus.
Original sources: "Die Fruchtpreisbücher von 1531-1674", "Die Bäckerbescheidbücher von 1658-1773", and "Das Preise- und Umsatzverzeichnis von 1773-1797".

Germany--Rostock, Schwerin, Wismar, Boizenburg, Parchim, and Grabow
Source: *Die Getreidepreise im Grossherzogthum Mecklenburg-Schwerin während des Zeitraums von 1771 bis 1870, Beiträge zur Statistik Mecklenburgs.* Schwerin: Mecklenburg-Schwerin Statistisches Landesamt, 1873.
Overall years: 1771 to 1870, with gaps; frequency: monthly; method: average of mid-price of all market days in a month.
Quantity units: For Rostock and Schwerin in "Rostocker Scheffel" (RS); for Wismar in "Wismarer Scheffel" (WS); for Grabow and Parchim in "Maass" (M); and quantity units in Boizenburg are " ¼ Sack" (¼ S). Conversions: 1 WS = 1.023331 RS, 1 M = 1.436 RS, and ¼ S = 1.077 RS, where 1 RS = 0.385371 Hectoliter.
Monetary units: In "Ganzen und Zehntel-Schillingen Courant" (i.e., in Courant, with decimals).
Original source: "Mecklenburgische Anzeigen" (a newspaper).

Germany--Munich
Source: Elsas, Moritz John. *Umriss einer Geschichte der Preise und Löhne in Deutschland vom ausgehenden Mittelalter bis zum Beginn des neunzehnten Jahrhunderts.* Leiden: A.W. Sijthoff, 1936.
Overall years: 1690 to 1820, with gaps after 1779; frequency: monthly; method: average price of first market day of the month.
Quantity units: In "Scheffel", where 1 Scheffel = about 223 liters.
Monetary units: In "Alten (schwarzen) Rechnungspfennigen".
Original source: "Schrannenzettel" of the city of Munich.

Germany—Augsburg, Bamberg, Bayreuth, Erding, Kempten, Landshut, Lindau, Memmingen, Munich, Nördlingen, Nürnberg, Regensburg, Straubing, Würzburg, Zweibrücken
Source: Seuffert, Georg Karl Leopold. *Statistik des Getreide- und Viktualien-Handels im Königreiche Bayern mit Berücksichtigung des Auslandes.* München: J.G. Weiss, 1857.
Overall years: 1815 to 1855 (Munich: 1790 to 1855); frequency: monthly; method: average price of all market days in a month. For Munich, the Seuffert (1857) source also contains weekly prices (for each Saturday). In principle, those are the prices listed in Elsas (1936); a comparison of the two sources essentially confirms that.
Quantity units: In "Bavarian Scheffel".

Monetary units: In “Gulden and Kreuzer”; 1 Gulden = 60 Kreuzer; conversion to prices for Munich from Elsas (1936): 1 Kreuzer = 3.5 “Alte Rechnungspfennige”.

Italy--Siena
Source: Parente, Giuseppe. *Prezzi e Mercato del Grano Siena 1546-1765.* Florence: Carlo Cya, 1942.
Overall years: 1546 to 1765, with gaps; frequency: monthly; method: average from all prices of the month.
Quantity units: In “Staio Senese”; 1 Staio Senese = 22.84 liters.
Monetary units: In “Soldi”; this source gives conversion factors to compute constant prices. They are for the years 1542-1557: 0.23240; for the years 1558-1676: 0.22288; for the years 1677-1738: 0.21419; and for 1739-1766, the conversion factor is 0.18912. We have experimented with both current and constant prices, with similar results.
Original source: “Archivio degli Esecutori della Gabella”, Archives of the State of Siena, documents # 1283 to 1290.

The Netherlands--Utrecht
Source: Sillem, Jérome Alexandre. *Tabellen van Marktprijzen van Granen te Utrecht in de Jaren 1393 tot 1644,Verhandelingen der Koninklijke Akademie van Wetenschappen te Amsterdam,* Johannes Müller: Amsterdam, 1901; a supplement with the 18th and 19th century figures is published in Posthumus, N.W., *Inquiry into the history of prices in Holland*, E.J. Brill: Leiden, 1964.
Overall years: 1534-1644, 1760-1814; frequency: monthly; average of all prices for a given month.
Quantity units: In “Modius"; 1 Modius = 88.93 kilograms.
Monetary units: In Dutch Guilders.
Original source: “Rekeningen en weeklijsten der Domprossdij”.

The Netherlands--Nijmegen
Source: Tijms, W. *Historia Agriculturae*. Groningen: Nederlands Agronomisch-Historisch Instituut, 1977.
Overall years: 1558-1916, with gaps; frequency: monthly; method: average price of the first market day of each month.
Quantity units: In “Malder” (1558-1822), and in “Hectoliter” (1824-1916); conversion: 1 Malder = 166.88 liter = 1.6688 Hectoliter.
Monetary Units: In “Guldens” (Dutch Guilders).

The Netherlands--Røermond (Ruremonde)

Source: Ruwet, J., F. Ladrier, E. Helin, and L. van Buyten (1966), *Marché des céréales à Ruremonde, Luxembourg, Namur et Diest aux XVIIe et XVIIIe siècles,* Leuven: Presse de l’Universite de Louvain, 1966.
Overall years: 1599 to 1796; frequency: monthly; method: average of minimum and maximum of the first market day of each month.
Quantity units: In “Malder”, where 1 Malder is about 170 liters (a range from 164.7 to 174.5 is given, p.17).
Monetary units: In “Stuivers”, which in French are “patards”.

Poland--Danzig (Gdansk)
Source: Furtak, Tadeusz (1935), *Ceny w Gdańsku w latach 1701-1815*, Lwow, 1935.
Overall years: 1703-1806; frequency: monthly, with gaps; the source gives minimum and maximum price in a given month; we use the average of that.
Quantity units: In “łaszt” (or last), where 1 last is about 3,010 liter.
Monetary units: In “złoty”.
Original source: Reports no. 559 and 560 of the Danzig city library, and the newspapers “Danziger Erfahrungen” (1739-40) and “Danziger Nachrichten” (1740-1815).

The United States---Boston, Charleston, New York, Philadelphia
Source: Cole, Arthur H. (1938), *Wholesale commodity prices in the United States, 1700-1861: statistical supplement: actual wholesale prices of various commodities.* Cambridge, MA: Harvard University Press. This is the price for rice in Philadelphia and Charleston, and the price for wheat in Boston, New York, and Philadelphia.
Overall years: 1700-1861, varies by series; with gaps.
Quantity units: Various.
Monetary units: in US dollars.

Table 1: Summary statistics*

China	Years	n	(I)# Standard Deviation	(II)# Residual First-difference Volatility^	(III)# Skewness	Frequency distribution of bilateral distance (km) (in %) x < 150	150 < x < 300	300 < x < 450	450 < x < 600	600 < x < 750	750 < x < 900	x > 900
All prefectural markets**	1742-95	121	0.130	0.088	0.340	3.7	10.1	13.5	14.6	14.3	12.6	31.1
Yangzi Delta (expanded)**	1742-95	26	0.146	0.103	0.422	26.2	42.5	23.4	7.1	0.9	0.0	0.0
Provincial Capitals**	1742-95	10	0.136	0.094	0.264	0.0	13.3	17.8	13.3	20.0	11.1	24.4
Yangzi River prefectures**	1742-95	34	0.146	0.101	0.605	12.1	22.1	26.0	21.4	10.2	6.1	2.1
Western Europe												
West European Cities (1)	1692-1716	9	0.246	0.182	0.336	11.1	5.6	11.1	13.9	8.3	13.9	36.1
West European Cities (2)	1770-94	15	0.192	0.140	0.581	16.2	14.3	12.4	19.0	13.3	10.5	14.3
West European Cities (3)	1825-49	15	0.266	0.179	0.212	7.6	8.6	8.6	21.0	23.8	11.4	19.0
England (4)	1770-94	41	0.149	0.130	-0.438	40.0	41.8	16.2	2.0	0.0	0.0	0.0

* Based on monthly (log) prices, two observations per year (March and September for Europe, 2nd and 8th lunar month in China)
^ Residual first-difference volatility defined as standard deviation of residual from a regression of first-differences on month dummies
# Averages across n markets

** Details on the names and locations of the Chinese markets are available from the authors upon request
(1) Brussels, Cologne, London, Munich, Nijmegen, Ruremonde, Siena, Toulouse, Vienna
(2) Aalst, Antwerp, Boizenburg, Brussels, Cologne, London, Luxemburg, Munich, Nijmegen, Rostock, Ruremonde, Schwerin, Toulouse, Utrecht, Vienna
(3) Augsburg, Boizenburg, Brugge, Brussels, Evreux, Lindau, Munich, Nantes, Nijmegen, Nurnberg, Rostock, Rouen, Schwerin, Toulouse, Vienna
(4) All 41 English markets covered in the London Gazette

Figure 1. Data Availability, selected locations.

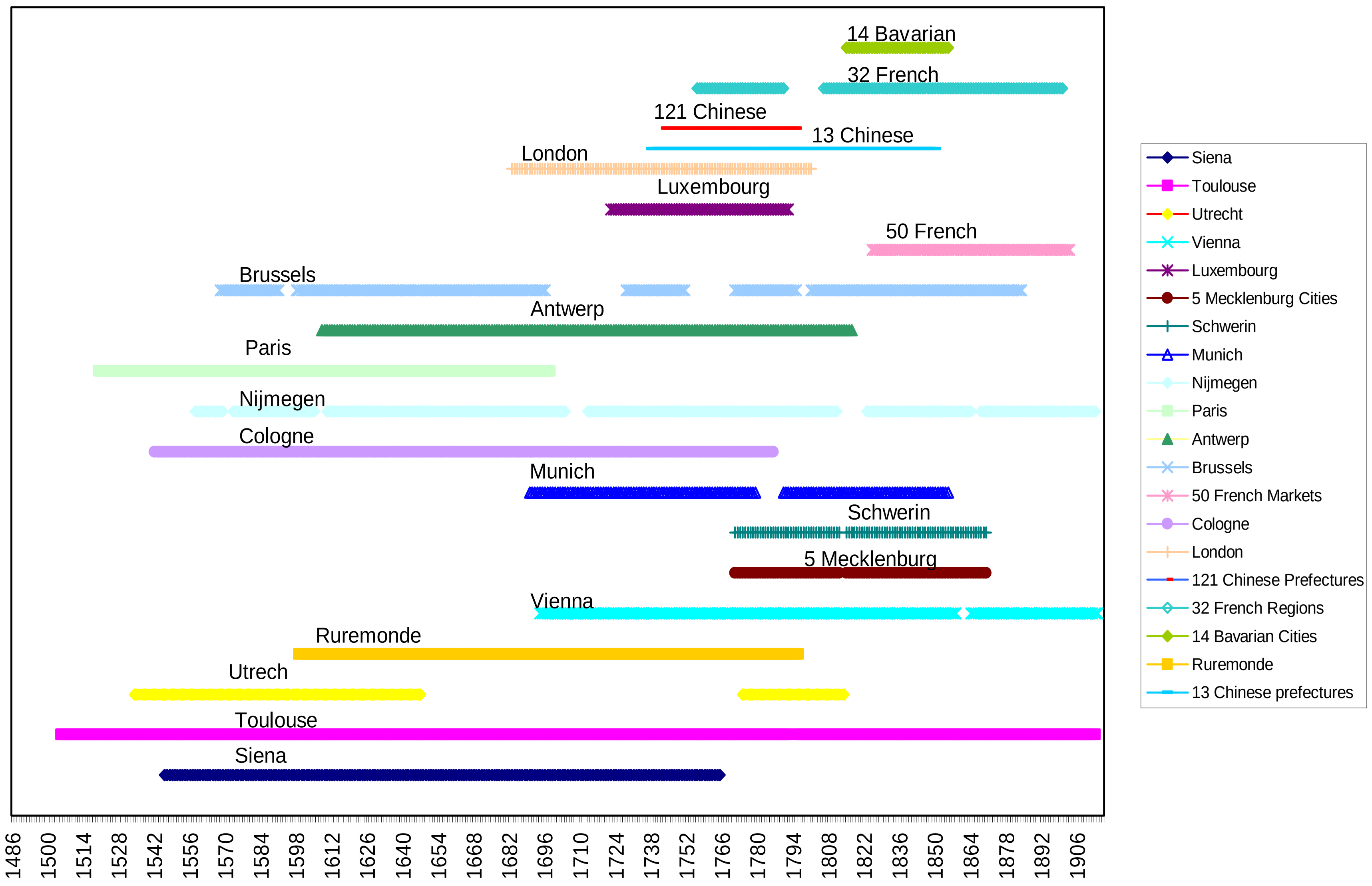


Figure 2. China and Europe, selected markets, 1770-1794

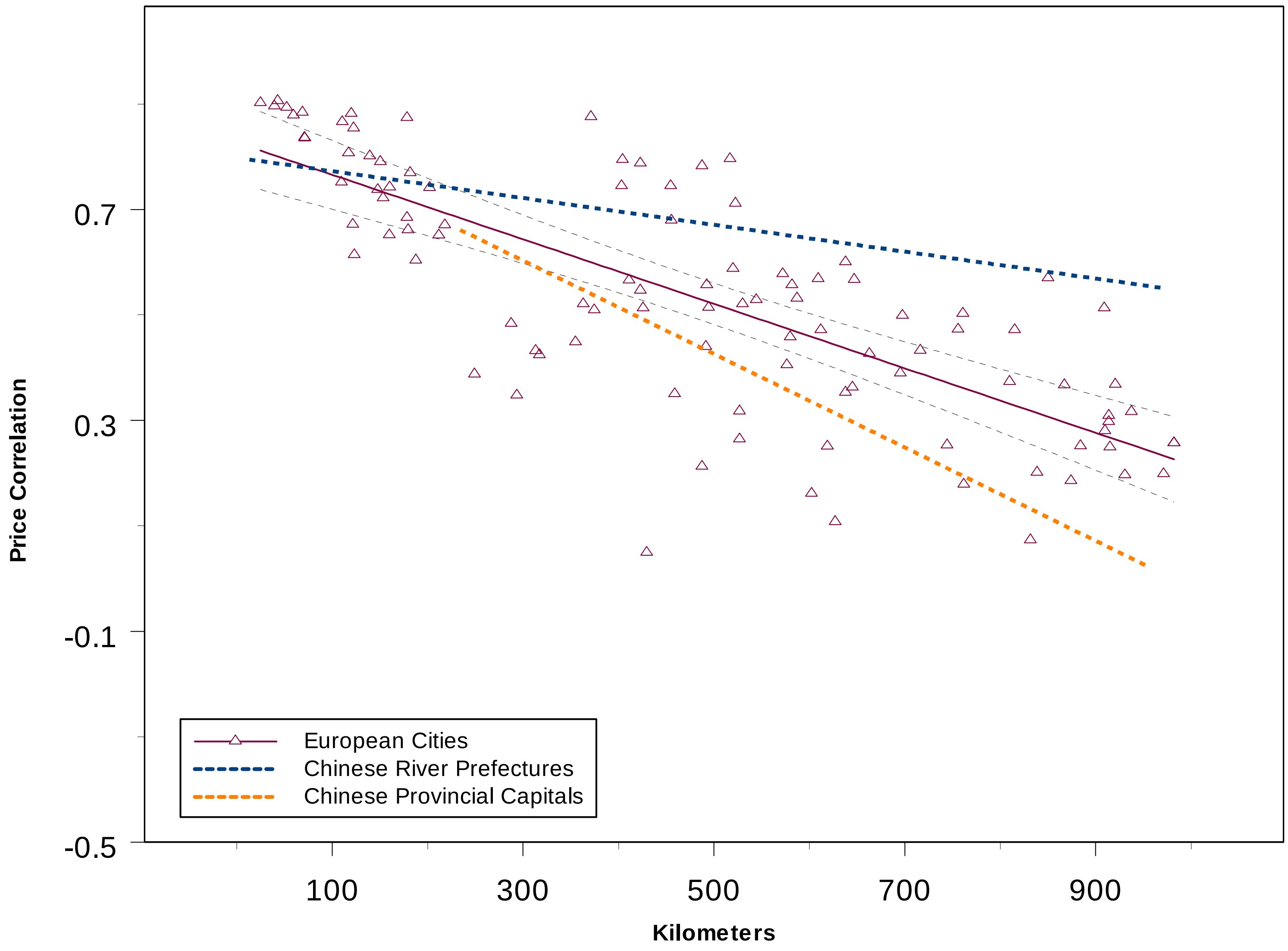


Figure 3: Cointegration in China and Europe, 1742-95

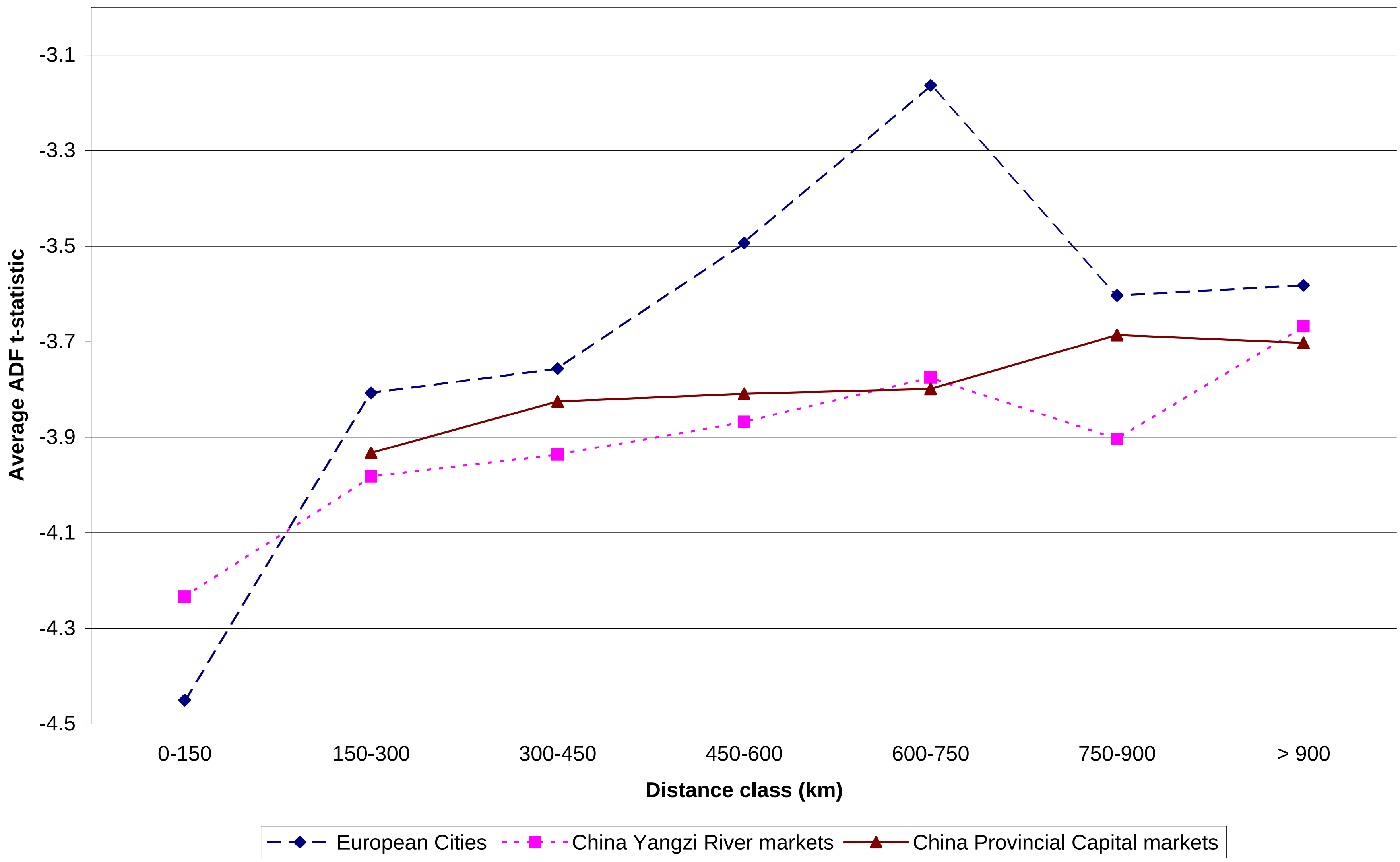


Figure 4: Cointegration in China, its Yangzi Delta, and Europe, 1742-95

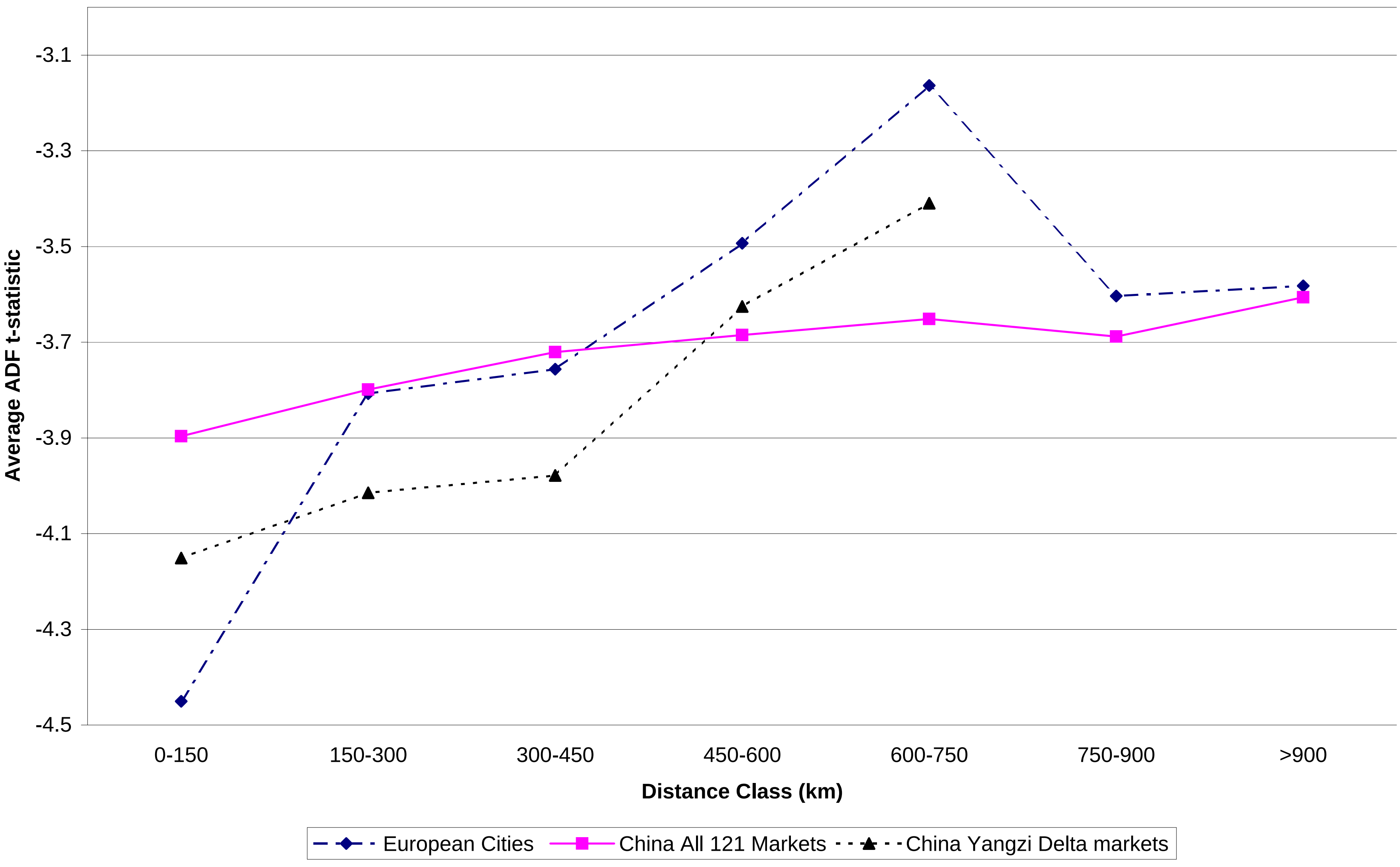


Figure 5: Cointegration in Yangzi Delta, England, and Western Europe in the 18th century, versus Western Europe in the 19th century

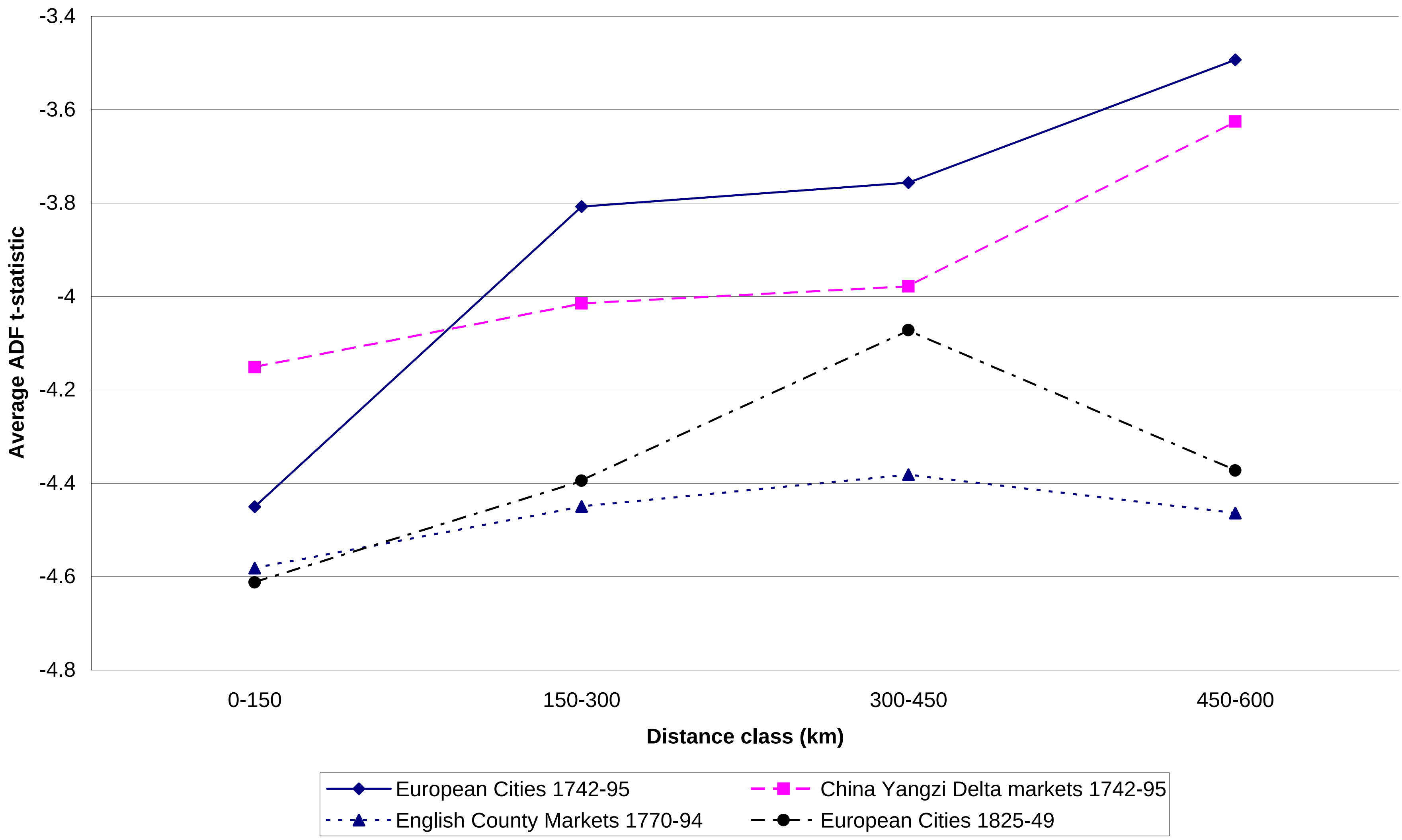
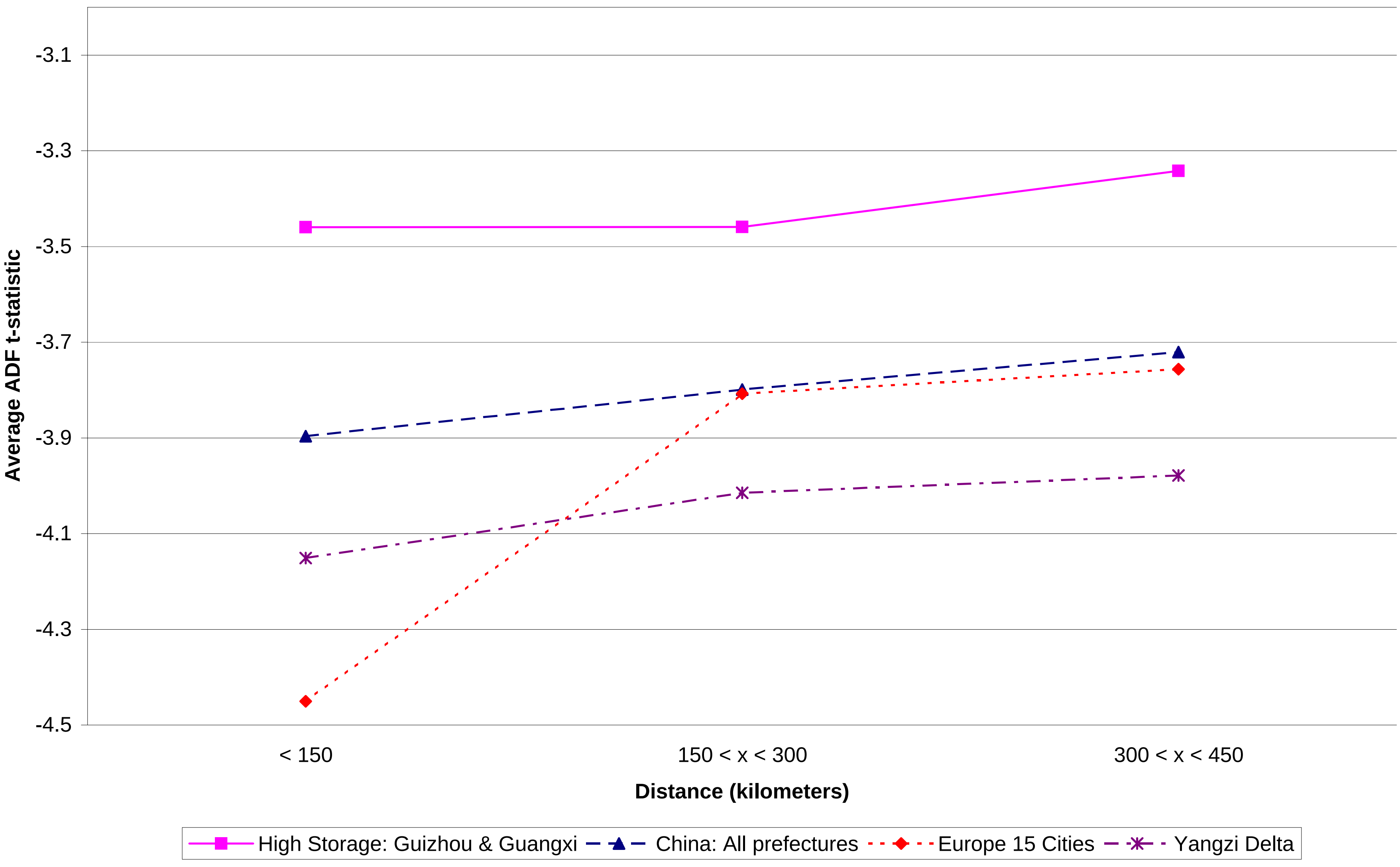
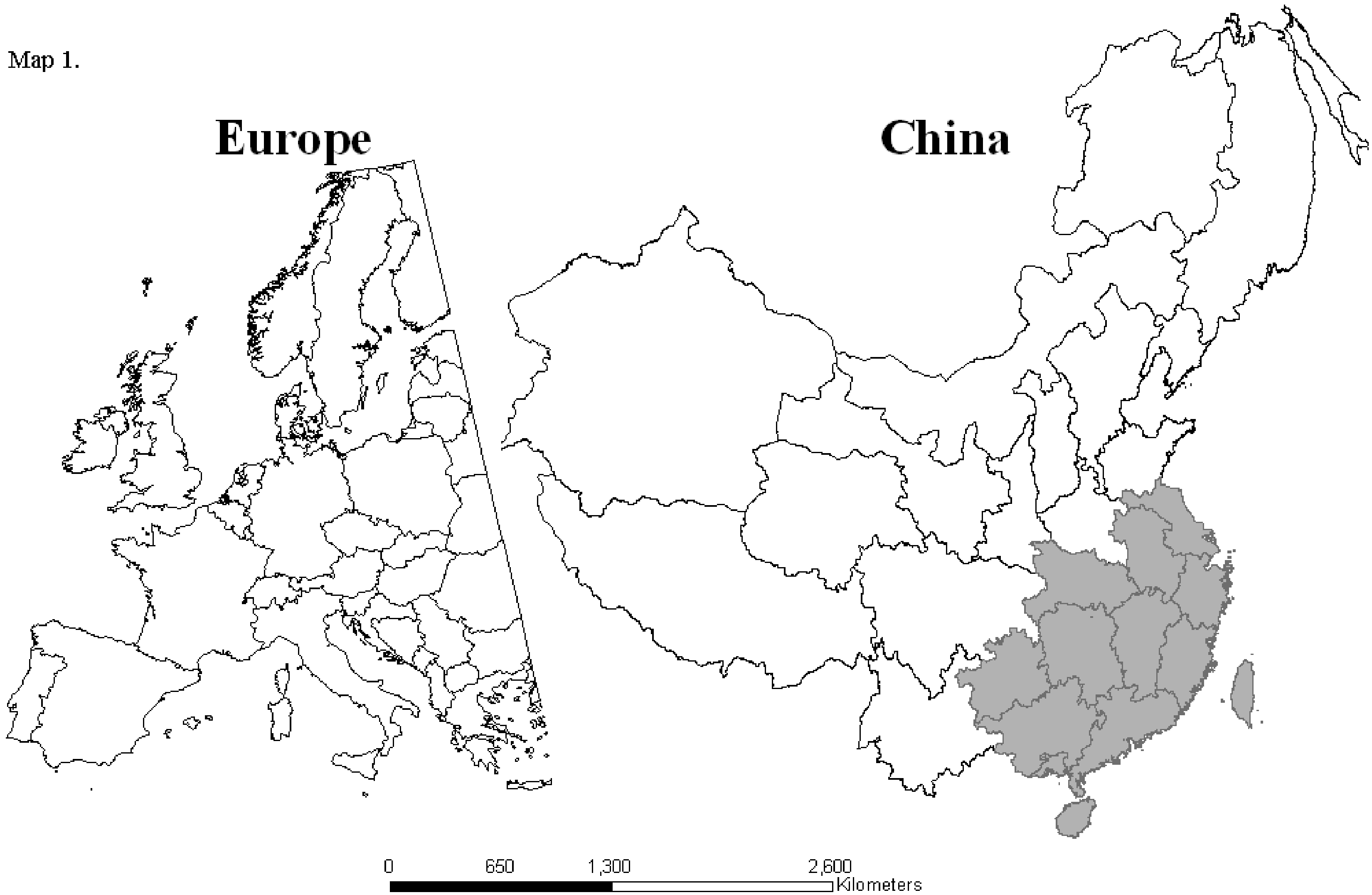


Figure 6: Storage and Cointegration



Map 1.



Web Appendix

1. A micro view of the organization of grain trade

The following section discusses major elements that had an influence on grain trade, with an emphasis on China where generally less is known. The references are to work cited in the main text.

(1) Actors: Most of the direct accounts of trade in 18th century China deal with government officials transporting rice. Far fewer records exist on the role of private merchant trade. In reality, the official shipments were only a minor component of total trade (Chuan and Kraus 1975, 56-58). In the mid-Qing, the official shipments—primarily tribute grain to Beijing and food for soldiers—were about 16.7% of China's total long distance trade (Xing et al. 2000, 170). Even on the Grand Canal, which was constructed, first and foremost, for the transport of tribute grain and other goods to the capital, the volume of private shipping probably outnumbered the official tonnage (Feuerwerker 1995, 31).

Who were the actors in this trade? In China, trade was a relatively specialized activity involving local (petty) traders, brokers, wholesale dealers, and itinerant (traveling) merchants. Petty traders worked on a small scale, usually with little capital, and were engaged in retail sales as well as carrying goods between urban centers and rural markets. Brokers (*yahang*) were middlemen engaged in a variety of roles, including supervising payment between buyers and sellers, overseeing delivery, providing information, inspecting for quality and quantity, and serving as guarantor on the exchange (Rowe 1984, 188-189; Mann 1987, 63-65). The broker was also responsible to the merchant for the safety of his goods during shipment, so that if the merchant was swindled, or incurred losses, the broker or shipping agent was obligated to pay compensation (Jing 1994, 59). In return, the brokers earned commission and rental fees for warehousing. Wholesale dealers typically specialized in a single item or a line of items and in some cases partially processed the merchandise.

Merchants varied greatly in the scale of operation. Some merchants formed networks that were typically identified by their common place of origin, such as the merchant networks from Huizhou or

Shaanxi. A particular merchant network was typically known for its trade in one commodity, such as the Fujian merchants' paper trade (Xing et al. 2000, 180) or the Yangzhou merchants' trade in salt (Ho 1954). Nevertheless, even these merchants frequently carried grain on the return trip, so that the development of long-distance grain trade was directly linked to the development of long-distance trade overall. For instance, a large percentage of the rice shipped downriver on the Yangzi River traveled on the ships of the salt merchants of Hankou, who would bring back salt from Yangzhou in Jiangsu (Rowe 1984, 55).

The largest fortunes in Ming-Qing times were as a rule built on domestic and international trade. Although formal Qing laws took a relatively hands-off approach to the daily affairs of trade, this did not mean that there was little interaction between merchants and the state. The distinction between merchants, gentry, and officials seems heavily blurred by the early 18th century. Many merchants purchased official titles or became officials of the state, and officials not only accepted but regularly solicited financial contributions from merchants for government projects. At the same time, the value of rich merchants to the government was enhanced by their large monetary contributions to the central treasury. The Liang-huai salt merchants contributed more than 36 million *taels* of silver to the government between 1738 and 1804, not counting the 4.6 million *taels* spent on the Qianlong emperor's southern tours and the numerous smaller contributions of salt officials (one *tael* of silver is about 37 gram). Although the merchant guilds authorized to trade out of Canton contributed only 3.95 million *taels* between 1773 and 1832, the Wu family alone contributed at least 10 million *taels* in 3 generations. For their contributions merchants were awarded with official titles and ranks, some as high as that of financial commissioner (Ho 1964, 82).

(2) Information: Information about prices, market conditions, and travel routes were transmitted in several key ways. First, teahouses and lodges formed meeting points at which merchants, gentry, and other members of the marketing community exchanged information, built up relationships, extended credit, coordinated actions, and negotiated over deals (Skinner 1964, 37). Second, merchant networks were an important means by which geographically dispersed groups cooperated and shared information about conditions in distant markets. Such groups were well-coordinated internally, and their spread over China amounted to networks of "commercial intelligence" about possibilities to produce and market various commodities. Merchant route books were practical manuals that laid out roads between market towns, giving distances that can be covered in a day, suggestions on where to stay overnight, as well as advice pertaining to commercial transactions (Brook 2002, 3). Third, the Qing state gathered information about agricultural practices, harvest outcomes, and market prices. In the case of agricultural technology, written treatises distributed among officials helped to spread information about agricultural techniques that could increase land productivity among farmers (Myers and Wang 2002, 599). Although information on harvests and prices were not widely distributed, local agents nevertheless knew official Qing harvest ratings; tenants, for instance, used the rating to reduce the amount of rent they expected to pay landlords (Marks 1998, 208). It is likely that merchants were aware of this information as well, and that it spread through market towns and networks quickly. The information flow between merchants and officials occurred in both directions—Qing government officials both imitated merchant trade practices and followed trade routes long established by merchants. As Chuan and Kraus note, if government officials thought about going to Shandong, for example, to buy grain, it was because they knew merchants frequently did it (1975, 66).

(3) Regulation, trade taxes, measurements and standards: At the local market town or community, itinerant merchants relied both on government-licensed brokers and on guilds (*huiguan*) to assess market prices (Mann 1987, 63-65; Xing et al. 2000, 180, respectively). The brokerage system allowed the state to have an official presence in certain wholesale transactions. The list of commodities subject to brokerage involvement varied from place to place, but in most central market towns it included grain. In Hankou in the mid-Qing, for instance, there were licensed brokers for 14 agricultural commodities, as well as cotton and silk cloth (Rowe 1984, 186). Although it was illegal to conduct any wholesale transaction without a licensed broker, the requirement was not fully enforced, resulting in a proliferation of unlicensed brokers and eventual protests calling for the removal of brokerage system altogether in the name of free trade.

Local guilds in China were corporate, self-governing organizations that were permitted a broad range of discretionary powers by the government (Mann 1987, 23). They provided lodging and services for merchants, helped calculating profit and loss, and they taught merchants bargaining techniques. Other functions included the establishment of dates that the market was open as well as regulations for sales, deliveries, and business conduct more generally (Xing et al. 2000, 180-183; Rowe 1984, 295-296). Unlike the guilds of Europe, where membership was based on residence, Chinese guild organizations were dominated by interregional merchant networks. Thus, while European guilds often would pitch residents (potential importers) against non-residents (potential exporters) and created a barrier to entry for new members, Chinese guilds typically did not keep out arriving merchants from membership (Rowe 1984, 297). One reason for this was that guilds operated on membership dues. Membership in the Hankou rice guild cost 15 *taels* up front and 0.8 percent of a member's annual gross receipts, for instance (Rowe 1984, 301-302).

Neither the government brokers nor the guilds ever came to dominate the marketplace. Whereas the Qing state saw monopolization and collusive behavior as a key reason for intervention in the marketplace, the guilds worked to oppose the state brokers and their high commissions (Xing et al. 2000, 180-182). If anything, the state relinquished the task of market regulation to the guilds, as the latter were delegated the unusual privilege of assessing and collecting trade taxes for the state (Mann 1987, 23-24).

The Chinese state also regulated the market directly. In addition to the brokerage tax, the state levied domestic customs, the Imperial maritime customs, and later, in the 19th century, the *likin* transit tax (Rowe 1984, 181). However, not only was the degree to which guilds restricted competition relatively low in China, but the amount of revenue the Chinese state received from trade taxes appears to have been lower than in Western Europe as well. With the notable exception of England, in Europe there were significant trade taxes within many countries at least through the 18th century, in addition to the tariffs between countries. For example, the trade of grain was highly regulated and restricted in 18th century

France, and there were also many tolls in the German areas.[1] Revenues from trade taxes were a higher fraction of total revenues in Europe even though over time, the Qing state came to rely relatively more on trade taxes.[2]

Relative to a situation where measures and monies are standardized, the different currencies and units of measurement used across Europe likely led to higher transactions costs and greater trade barriers. Even within countries, there were persistent variations in measurements. In England, for example, the final demise of local weights and measures did not occur until after 1850 (Mingay 1989, 226-227). Conversion rates into other units and currencies of (local) importance are occasionally available, but they tend to be subject to considerable uncertainties.

In the case of China, there was a consistent effort to ensure that the official units of accounting for rice prices in terms of *taels* of silver per *shi* was comparable across regions (Chuan and Kraus 1975, 12-14). Nevertheless, there were numerous local weights and measures under use. In addition, local exchange rates between copper cash and silver also varied across regions; see Vogel (1987, 30-31) who reports some local copper exchange rates for Jiangsu and Zhejiang provinces. Variation in local exchange rates may not have been as large as the variation in totally different currencies in Europe, but they may nevertheless have been an important trade barrier.

Overall, is difficult to say for certain whether the variations in the level of standardization presented a greater problem in China or in Europe since the issues were different. Merchants and other market participants were likely to be aware of and sensitive to variations in measurements and the value of the currency, so that the lack of standardization *per se* would not necessarily make trade impossible, but still, the variations had to be sorted out by local buyers and sellers. In this regard, guilds may have

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[1] For example, see Kaplan (1984) on France, and Henderson (1939) on the pre-*Zollverein* situation in Germany. An analysis of the economic effects of the *Zollverein* can be found Shiue (2005b).

[2] One reason for this was that the state-licensed brokerage system was increasingly abolished in the 19th century (see above). At the same time, the Qing state's relatively stronger reliance on trade taxes during the 19th century may just have brought China to where the European countries already were. Consistent with this, the relative importance of land taxation in 18th century China was much higher than in England: by the year 1753, about three-quarters of the total state revenue came from the land tax, declining to 35% by 1908 (Wang Yeh-chien's estimate, reported in Rowe 1984, 181), whereas by 1750 in England, land, income, and property taxation accounted for only 29% (Mitchell 1988, 825).

reduced the transaction costs since common local units of measurement were chosen and partly enforced by the guilds. As an example for that, the 1678 Rice Market Guild of Hankou stated that “when any [guild member] acts as a wholesale rice broker for an itinerant merchant in the transactions of his business, the weights and measures employed in the transaction much first be submitted to the guild for approval, rather than adoption on an individual basis” (Rowe 1984, 295).

(4) Maintenance: The maintenance of transport routes was critical for the transport of grain. The Qing state devoted some 10 % of its total revenues to public projects, and also effectively supplied the necessary technology, especially for large scale projects such as flood control and maintenance of the passageability of the Yellow River and the Grand Canal. The state was also active in organizing local communities in the upkeep of transport routes, dykes, bridges, and roads (Naquin and Rawski 1987, 23; Myers and Wang 2002, 597). When provincial officials received an order to undertake a project, they called on local leaders to help finance the work. The costs of the repairs would usually come mainly from cash contributions of local landowners, gentry, and merchants, and labor contributions of tenant households. These efforts probably benefited the economies nearby to some extent, although it remains unclear whether public goods were still undersupplied.

Also in Europe, local authorities were initially responsible for maintaining transport infrastructure. In France, the central government finally assumed control over new investments along the major roads leading into Paris, but it did not improve secondary roads, leaving instead local governments responsible for them. After 1700 in England, however, the transport infrastructure was improved because maintenance was entrusted to private organizations created by Acts of Parliament (turnpike trusts, river navigation companies). More details on this in the case of England can be found in Jackman (1962) and in the more recent work of Bogart (2005).

(5) Security and property rights: Predation and extortion by bandits, pirates and governments alike threatened the trade of merchants both in China and in Europe. Some Chinese merchant route books note the locations of not only police stations en-route but also bandit hideouts (Tong 1991, 146). In England, farmers, millers and corn dealers at times of bad harvests in the late 18th century were often stopped and had their loads seized, in spite of significant penalties (Mingay 1989, 234-5), and arbitrary tolls imposed by local rulers in continental Europe were effectively another form of extortion. It is difficult, however, to assess how the overall security risks for traders in China compared with those in Europe. Qing laws sanctioned bandit activity with capital punishment, while predation and extortion of merchants by Qing officials or by local gentry was illegal and also subject to severe punishment. Nevertheless, capturing the bandits could be difficult, especially in harsh terrain. Complementing the Qing state, a variety of private activities emerged to provide security. For example, civilians joined forces with local military commanders, and local communities raised bounties to reward soldiers (Tong 1991, 85). Large merchants were also known to commission a merchant-militia for protection while traveling.

The Qing Code, the formal legal framework of Qing China, contains many articles related to property, such as on theft, sale of property belonging to others, or trespassing (Jing 1994, 43-44). Legal protection from acts of government officials as well as private agents was afforded to all privately owned property, regardless of whether it was held by individuals or lineages. The laws applied also to disputes among family members, so that intra-familial property disputes were not off-limits to the laws of the empire. Other laws forbid monopolization and price collusion, especially by government brokers, and prohibited counterfeiting and the use of fraudulent weights and measures in trade. It appears that the court system was widely used; for instance, civil cases accounted for about a third of the total case load of local courts in a study by Huang (1996, 11). Moreover, official arbitration of property disputes was apparently available for poor people as well (see Buxbaum 1971, 268, and Bernhardt and Huang 1994, 5).

Fundamentally, however, the Qing Code was not designed for the reconciliation of conflicting private economic interests. Rather, the emphasis was on maintaining public order by providing incentives for lawful behavior through the threat of punishment (also Huang 1996, 107). A good example of that is the law on bridge maintenance, which simply states:

"…If there is injury to the bridges and roads, and there is neglect in repairing them, hindering traffic along the routes, then the supervisory official and clerk will receive 30 strokes of the light bamboo." Board of Works Article 436 Repairing Bridges and Roads; in Qing Code (1994, 412).

Thus, there is little in Qing laws on what evidence is needed before judgment on guilt is parsed, and how the punishment is to be enforced, which in contrast with the written laws of the British Commonwealth,

With respect to the legal framework for trade, merchant guilds probably played a greater role than the Qing Code. They established rules for business conduct and means of contractual documentation (Rowe 1984, 295). Merchant guilds were also involved in adjudicating disputes (Mann 1987, 23). In short, the guilds supplied a wide range of legal functions—sometimes called "customary" or informal—both independently of the state and in parallel to official notions of justice.[3] Private (white) contracts were legally valid and eventually outnumbered official (red) contracts, which were stamped official versions registered for a fee with the local government headquarters. There does not appear to have been much of a contradiction or competition between the official and the customary laws since customary practice was judged within the official code, and conversely, private written contracts were enforced in the ruling of the Qing official's court when disputes arose. The system allowed legally recognized and enforced written commercial agreements to be routinely circulated, from shipping orders to bills of loading to promissory notes to contracts of sale (Rowe 1984, 75 and Chapter 5). In this sense, the legal framework for trade did not appear to be missing in China.

(6) Financial instruments: The involvement of the Qing state in financial institutions was relatively limited, but the state was not inactive: state controlled customs banks issued certain notes and stored customs revenue collected by the government. There were also government-owned pawnshops. Another important area controlled by the state was the bimetallic monetary system of the Qing, based on silver and copper cash, which produced some seigniorage revenue. There was, however, no formal regulatory agency responsible for overseeing financial administration and banking.

Many innovations in the area of credit and banking in the Qing can be traced to private merchant

[3] See Naquin and Rawski (1987, 102), and Jing (1994, 42) on the following.

activity. From the early Qing period, merchants purchased peasants' agricultural products and handiworks by paying money in advance, and it became an important method for purchasing commodities in rural areas. Financial institutions of various types often took deposits and made loans. Among the most important were the so-called *yinhao* ('native banks') and *piaohao* ('currency stores') (Zurndorfer 2004). During the Qianlong era (1736-95), native banks conducted local money exchange, accepted deposits, issued private banknotes, and lent money to partnerships in the local market (Zhou Yumin 2000, Rowe 1984, 161). There exist some similarities with early deposit banks in Europe (Mann Jones 1972, 47). In contrast to the local focus of the native banks, the currency stores dealt with interregional transactions, having often several branches all over the empire, and were related to the merchant networks. The *piaohao* were closer than the *yinhao* to being a state institution in banking since the government used these banks for deposit and required that companies desiring to found similar institutions be endorsed by the members of the established banks. (Mann Jones 1972, 50). These financial institutions issued promissory notes payable in the future, and facilitated the movement of goods and money over long-distances through innovations in credit.

It appears that some merchants entered the banking business as a means of capitalizing their commercial projects (Rowe 1984, 162). The private paper money issued by these banks may have constituted as much as 1/3 of total money in circulation in the mid-Qing. Thus, even though the Qing state did not issue paper notes, it permitted merchants to transform the monetary economy into one where paper notes circulated widely (Naquin and Rawski 1987, 101, 104-105).

That these banks developed relatively free from government involvement meant both little obstructionism and little constructive support. The establishment of ties and contract enforcement between creditors and debtors was mostly informal, and often based on kinship, common origin, or otherwise established through the merchant networks. This was especially true of the Shanxi merchants, for example, who relied on network connections to facilitate transactions between their operations in North China and the Yangzi Delta (Wong 2002). There were also Hunanese merchants that operated through an interlocked chain of banks at various points of their trade route (Rowe 1984, 162), and merchants from neighboring provinces to the north who dominated Sichuan's financial institutions for most of the Qing (Zelin 1993, 88). While we know that the interregional transactions were served by the *piaohao*, there is still the question of the extent of access to credit for non-members of the interregional networks. There is suggestive evidence that China's financial institutions were multi-faceted and extensive, but to date there is little quantitative evidence on the size and the performance of China's banking and credit sector during the 18th and 19th century in comparison to those in Europe.

2. Comparing market integration in China and Europe using bilateral price correlations

In Figure 2, we have shown that the degree of market integration for 15 West European cities in the late 18th century is comparable to that for certain markets in China during the same period. This section extends this analysis, thereby complementing the cointegration results shown in the main text. First of all, it appears that the degree of market integration attained in Europe as of the late 18th century had been roughly constant for some time. Figure A.1 compares the late 17th century (1692-1716) and the late 18th century (1770-1794), showing the regression lines for both samples together with the confidence bands of the earlier period. The estimated level and slope of the relationship between price correlation and distance for the 18th century lies fully within the confidence bands of the 17th century period. The lack of any dramatic shift in market integration between the late 17th and the late 18th century is in contrast to the changes that would be seen in Europe in the 50 years after 1770. Figure A.2 shows the price correlations for European cities for the years 1825-1849, together with the other samples shown in Figure 2. As the confidence bands indicate, the 19th century price correlations are above those in either 18th century Europe or China. It is apparent that the level of market integration in Europe has made dramatic improvements over a relatively short period of time.

If across-country market integration was not higher in Western Europe than in China on the eve of the Industrial Revolution, might within-country market integration have been? Figure A.3 compares the markets of the extended Yangzi Delta with those in England. The regression line for the English sample is located above that for the Yangzi Delta at virtually all distances. For distances below 400 kilometers, the confidence band of the Yangzi Delta sample is below the regression line for the English markets, indicating that the two sets of price correlations are also statistically different. This confirms the cointegration results from Figure 5. However, within-country market integration was not generally higher in Western Europe, as the comparison of the Yangzi Delta and regions in Central France in Figure A.4 shows: here, there is no statistical difference between price correlations in France and in China. Overall, our bilateral price correlation results confirm the cointegration results shown above.

3. Historical weather patterns in China and Europe

If weather patterns changed quite differently across geographic space in China compared to Europe, this could lead to substantial differences in the spatial price correlations, which could potentially cloud our inferences on market integration. We have thus collected and analyzed historical weather information for China and Europe to see whether such effects might be important.

For China, the weather data available to us is an indicator of rainfall and wetness in a given harvest year. Systematic rainfall recording began as early as the Tang Dynasty (618-907 A.D.), and from at least the 17th century the collection of rainfall and weather reports at the county level had become standard government practice (Wilkinson 1969). Our source for historical weather data are the weather maps in the State Meteorological Administration (1981). The maps give weather data throughout China for each year for 120 "stations", where one station corresponds to one or two of our prefectures. It is a discrete indicator of the degree of rainfall relative to what is considered normal for that region. The indicator, R_{nt}, ranges from 1 (severe droughts) to 5 (heavy rains and floods), and normal conditions are given by $R_{nt}=3$. The information is hand-coded from the weather maps to compute the weather correlations between any two prefectures.

For Western and Central Europe before 1300 A.D., there are reports of natural disasters, and by 1800 A.D. there are almost complete descriptions of monthly weather, although cross-border (international network) weather observations before 1860 were still rare (Pfister 2002). The exact relationship between climate and agricultural output is complicated, but it is clear that both extreme temperatures as well as extreme humidity tend to lead to bad harvests. Moreover, humidity and temperatures in different years or in different cities are correlated (Baten 2000 provides additional discussion). This means that we can employ the temperature data for 8 European cities available to us to compare the spatial weather patterns in Europe with those in China.[4] The cities are Paris, Vienna,

[4] The temperature data was provided by Rüdiger Glaser (see Glaser 2001); thanks to Jörg Baten for sharing the data with us.

Munich, De Bilt (the Netherlands), Nottingham (as Central England), Berlin, Basle (as Switzerland), and Stockholm (as Sweden). For each of the eight European cities, we have re-classified the weather data from temperature in degrees Celsius into five discrete classes, 1 to 5, and computed for each city pair the correlation of weather.[5]

The regressions presented in Table A.1 compare weather correlations in China and Europe as a function of distance. We see that throughout weather correlations in Europe were higher than they were in China, indicated by the higher intercepts for the former sample (China: 0.39 to 0.62, versus 0.83 to 1.17 for Europe). This in itself suggests that our evidence on price correlation might be affected by spatial patterns of weather (and not of arbitrage and trade) to a relatively greater extent in Europe, or put differently, without controlling for weather we have stacked the odds against finding China ahead in terms of market integration. However, it may be that the spatial correlation of humidity (used for China) and of temperature (used for Europe) are just different, and this may explain in part why we estimate a higher level of weather correlations for Europe.

Another question, thus, is how weather correlations changed with distance in the two continents. It turns out that there is no clear difference between China and Europe. In the preferred specification for the European sample (in terms of $\overline{R}^2$), we estimate a value of -0.243 on log distance for Europe, while for China it is smaller in absolute value (at -0.195). However, the 95% confidence interval of the estimate for Europe is (-0.310, -0.177), which covers the point estimate for China. Moreover, one may want to drop Stockholm from the sample because its location is substantially to the North of our core sample. That alone brings the distance coefficient to -0.186, less in absolute value than the estimate for China while at the same time increasing the $\overline{R}^2$ (see specifications III and VI, respectively). In addition, the preferred specification for the Chinese sample has both log distance and its square, and for this specification distance has the expected effects for China (linear: negative, squared: positive), while for Europe distance has no significant effect.

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[5] We replicate the frequencies that are present in the data for China (1770-1794): R_{nt}=1, 2, 3, 4, and 5 with probabilities of 5.7%, 28.1%, 46.5%, 15.3%, and 4.5%, respectively.

On the bottom of the table, the predicted *level* of weather correlations in China and Europe is reported based on the OLS regressions. It is clear from these figures that the predicted weather correlation in Europe was higher than in China, while if one focuses on *changes* in weather correlation (moving from 300 km to 600 km e.g.), the magnitudes are roughly comparable. Finally, the remaining two specifications indicate that our results do not seem to be driven by the particulars of China's weather distribution during 1770-94 (specification V) or the fact that the minimum bilateral distance in our China is smaller than in our European sample (12 kilometers versus 265 kilometers; specification VI).

Overall, this analysis suggests that the influence of weather is unlikely to favor China over Europe in our comparison. First, the changes in weather accompanied by changes in distance were comparable in China and Europe. Second, we estimate that the level of weather correlations was substantially stronger in Europe than in China, and to the extent that this is not entirely due to differences in temperature versus humidity patterns, the analysis tends to favor Europe over China for finding relatively high price correlations.

4. A quantitative comparison of price behavior for rice and wheat

Our first approach is to employ additional price data on wheat in China. Wheat was an important crop in China primarily in the North. We have obtained a price series for Tianjin prefecture, near Beijing in Zhili province, for the 18th century, and this series can be compared to the 18th century European wheat price series. We also have obtained additional rice and wheat data for four major cities in Sichuan. Both crops are important in this province, which borders with the Guizhou, Hunan, and Hubei provinces in our sample.[6] Both the Tianjin wheat data as well as the rice and wheat data for the Sichuan cities originate from the empire-wide price reports that provide the data on the 121 prefectures used in the main text.

In Table A.2, we show summary statistics for 15 European wheat series and for Tianjin. The volatility of the Tianjin series is relatively low, with only Brussels having a lower standard deviation. The fact that storage cannot be negative creates an asymmetry that is typically reflected in the skewness of the price distribution (e.g. Deaton and Laroque 1992); here, both Tianjin and the average European series exhibit positive skewness, and this effect is stronger in Europe. If we focus on the years 1770-1781—a period with greater series overlap and before the turmoil of the French revolution—, the price volatility is still comparatively low in Tianjin, but its price distribution exhibits greater skewness than that of the average European market (on the right of Table A.2).

We have also examined the seasonal cycles in the two areas (Table A.2, bottom). In Europe, in two thirds of the cities the wheat price obtains its maximum in June to August and its minimum in January to April. In contrast, in Tianjin the maximum price is in March and the minimum in July; these results confirm the more extensive analysis by Li (1992). The price range within the harvest year is on average 7.2% in Europe, while it is 8.4% in Tianjin. This can be taken as an indicator of interest and other storage costs (McCloskey and Nash 1984, Shiue 2002). Thus, even though storage costs may have been higher in China, the lower volatility and possibly higher skewness in China may indicate somewhat

[6] We also have examined the price of wheat for a number of Hunan prefectures. However, the quality of the data is lower than for the Sichuan wheat price series. We suspect that it is related to the fact that wheat yields in Hunan were relative low compared to those in Sichuan (Bray 1984, 17-18).

more storage activity in China than in Europe. Note that the price volatility for Tianjin remains somewhat lower than for the average European city also if, alternatively, we (1) use seasonal controls and (2) employ first-differences instead of price levels. Overall, except for the timing of the seasonal cycle, the differences between wheat production in Europe and China as reflected in these statistics appear to be quite small.

A comparison of rice and wheat prices in four major cities of 18th century Sichuan—Chengdu, Chongqing, Nanchang, and Xichang—gives the following results (see Table A.3). In all cities, rice is more expensive than wheat, reflecting in part the fact that consumers preferred rice to wheat. The volatility for wheat is lower than for rice in three out of four cities. Wheat prices are also on average somewhat more skewed to the right than rice prices. Both of these findings are consistent with more wheat than rice storage. Given that storage and trade are substitutes, all else equal, this could mean less wheat trade than rice trade.

Other evidence we can bring to bear on this, however, does not support this hypothesis. First of all, the range of within-harvest year price fluctuations over the harvest cycle is on average higher for wheat than for rice in these markets (13.4% versus 10.8%, respectively). Moreover, wheat and rice tend to be both cheapest in the same month (the 8th lunar month). In addition, a computation of all six bilateral price correlations among these Sichuan cities shows that the rice price correlation is higher for three city pairs, while it is lower for the other three pairs, with the average price correlation for wheat actually exceeding that for rice (0.69 versus 0.66; see Table A.3, bottom). All in all, in this analysis for China, the similarities between rice and wheat outweigh the differences between the two crops.

Finally, we have examined grain prices in the United States to assess the likely impact that the difference in crops. While rice production in the United States likely differed from that in China, and the United States' wheat production differed from that in Europe, this comparison at least eliminates any bias coming from examining a few Chinese wheat price series so as to match European data when it is clear that rice was the more important crop in China.

For the period of 1749-74, we have examined monthly rice prices for Charleston and Philadelphia, and wheat prices for Boston, New York, and Philadelphia (source: Cole 1938). On average, rice prices are more volatile than wheat prices (standard deviation of log price 0.204 versus 0.176; see Table A.4), and the range of within-year fluctuations is larger for rice than for wheat as well (8.5% versus 6.8%). The difference between the two crops, while not large, may in fact be even smaller than what is implied by these figures, because Charleston appears to be an outlier; the within-year price range for rice in Philadelphia, for instance, is lower than for wheat in Philadelphia.

To shed additional light on the ease of rice versus wheat trade, we have also looked at how prices move with each other across markets. Computing all bilateral price correlations for these cities, we have found that conditional on geographic distance, rice price correlations are comparable to wheat price correlations in the United States. We note the small sample in this analysis of the US, and therefore have also extended the analysis of United States grain prices into the early 19th century, when price series for more cities become available; these results are similar to the results for the 18th century.

Overall, on the basis of this analysis, large biases in the comparison of market integration due to differences between rice and wheat appear to be unlikely.

Table A.1: The spatial correlation of weather in Europe and China, 1770 to 1794

Dependent variable: Bilateral weather correlation

	(I)		(II)		(III)		(IV)		(V)	(VI)
									Europe	Europe
	China	Europe	China	Europe	China	Europe	China	Europe	Alt. Dist'n***	w/o Stockholm
Intercept	0.390**	0.832**	0.588**	0.956**	0.535**	1.116**	0.618**	0.890*	1.166**	1.024**
	(0.007)	(0.034)	(0.013)	(0.095)	(0.008)	(0.065)	(0.010)	(0.387)	(0.071)	(0.068)
Distance	-0.029**	-0.025**	-0.096**	-0.048*						
	(0.001)	(0.004)	(0.003)	(0.020)						
Distance sq.			0.004**	0.001						
			(0.0001)	(0.001)						
Log Distance					-0.195**	-0.243**	-0.352**	-0.026	-0.260**	-0.186**
					(0.036)	(0.032)	(0.022)	(0.372)	(0.004)	(0.033)
Log Distance sq.							0.054**	-0.050		
							(0.007)	(0.085)		
Rbar-squared	0.158	0.616	0.218	0.637	0.234	0.626	0.251	0.630	0.586	0.648
# of obs.	7260	28	7260	28	7260	28	7260	28	28	21
Implied weather correlation at										
300 km	0.303	0.757	0.487	0.812	0.321	0.899	0.296	0.890	0.880	0.820
600 km	0.216	0.682	0.429	0.668	0.186	0.731	0.161	0.890	0.700	0.691
900 km	0.129	0.607	0.396	0.524	0.107	0.632	0.105	0.890	0.595	0.615

OLS regressions with heteroskedasticity-consistent standard errors in parentheses
Europe is the cities Paris, Vienna, Munich, De Bilt, Nottingham, Berlin, Basle, and Stockholm
China is 121 prefectures
**(*) indicates that a coefficient is significantly different from 0 at a 1% (5%) level
*** The European data is re-coded to match the distribution of weather in China during 1496-1916 (not 1770-94)

Table A.2: Comparison of wheat prices in Europe and Tianjin
(Monthly data, in logs)

	Years 1739 - 1794				Years 1770 - 1781			
	Std. Dev.	**Skewness**	**Kurtosis**	**n***	**Std. Dev.**	**Skewness**	**Kurtosis**	**n***
Aalst	0.184	-0.074	3.289	541	0.075	0.351	2.275	144
Antwerp	0.165	1.021	4.169	272	0.096	0.341	2.206	116
Boizenburg	0.183	0.453	3.180	293	0.198	0.214	1.832	137
Brussels	0.153	0.928	3.597	276	0.103	0.654	2.461	120
Cologne	0.233	0.242	3.129	672	0.207	0.207	2.397	144
London	0.271	-0.313	2.475	672	0.157	-0.580	2.538	144
Luxemburg	0.277	1.275	5.368	672	0.165	1.220	4.588	144
Munich	0.246	1.086	5.139	672	0.361	0.845	2.336	144
Nijmegen	0.220	0.347	3.060	672	0.184	0.330	1.909	144
Rostock	0.210	-0.034	2.473	293	0.227	0.139	1.617	137
Ruremonde	0.245	0.153	3.534	672	0.178	-0.029	1.887	144
Schwerin	0.185	0.120	3.153	293	0.196	-0.020	2.253	137
Toulouse	0.304	-0.240	2.499	648	0.150	0.295	2.653	144
Utrecht	0.191	0.330	2.925	420	0.174	0.463	1.986	144
Vienna	0.261	0.725	3.204	672	0.253	0.537	2.230	144
Average	0.222	0.401	3.413	516	0.182	0.331	2.345	139
Tianjin	0.162	0.058	2.876	509	0.156	0.581	2.321	137

* Number of observations varies by series

Seasonal Price Changes
(Log price, 1739-94)

	Minimum	**Maximum**	**Range**
Aalst	March	Oct	0.066
Antwerp	March	Aug	0.114
Boizenburg	Jun	Nov	0.065
Brussels	March	Aug	0.104
Cologne	Jan	July	0.068
London	Oct	July	0.051
Luxemburg	Sept	July	0.068
Munich	Feb	July	0.059
Nijmegen	March	Nov	0.069
Rostock	Jan	July	0.068
Ruremonde	Feb	July	0.066
Schwerin	Jan	July	0.086
Toulouse	Aug	March	0.052
Utrecht	Apr	Nov	0.107
Vienna	Oct	June	0.033
Average			0.072
Tianjin	July+	March+	0.084

+ These are the seventh and third lunar months; they differ from solar months by a relatively small but varying amount; see Perdue (1992)

Table A.3: Comparison of wheat and rice prices in Sichuan
(Monthly data)

Market		Years 1736 - 1782				
		Mean	Std. Dev.	Skewness	Kurtosis	n*
Chengdu	Rice	0.072	0.393	0.668	3.293	236
	Wheat	-0.094	0.360	0.578	2.794	210
Chongqing	Rice	0.063	0.311	0.563	3.106	222
	Wheat	-0.322	0.301	0.841	2.488	187
Nanchang	Rice	0.103	0.306	0.703	2.970	214
	Wheat	-0.278	0.309	0.845	2.455	182
Xichang	Rice	0.263	0.316	0.029	2.147	215
	Wheat	-0.074	0.281	0.022	2.921	174
Average	Rice	0.125	0.332	0.491	2.879	222
	Wheat	-0.192	0.313	0.572	2.665	188

Units: Price in silver taels per shi (about 103 liters); in logs

Bilateral price correlations between Sichuan markets
Common sample (T=104)

Bilateral pair	Rice	Wheat
Nanchang-Chengdu	0.862	0.846
Nanchang-Chongqing	0.877	0.930
Nanchang-Xichang	0.521	0.510
Chengdu-Chongqing	0.888	0.845
Chengdu-Xichang	0.498	0.572
Chungqing-Xichang	0.317	0.446
Average	0.661	0.691

Table A.4: Price data on rice and wheat in the 18th century United States
Common sample, years 1749-1774 (T=312); log price

	Standard deviation		Within-year price variability (Maximum-Minimum price)	
	Wheat	**Rice**	**Wheat**	**Rice**
Philadelphia	0.212	0.144	0.066	0.048
Boston	0.132		0.068	
New York	0.184		0.069	
Charleston		0.263		0.122
Average	0.176	0.204	0.068	0.085

Figure A.1 European locations, 17th and 18th century samples compared

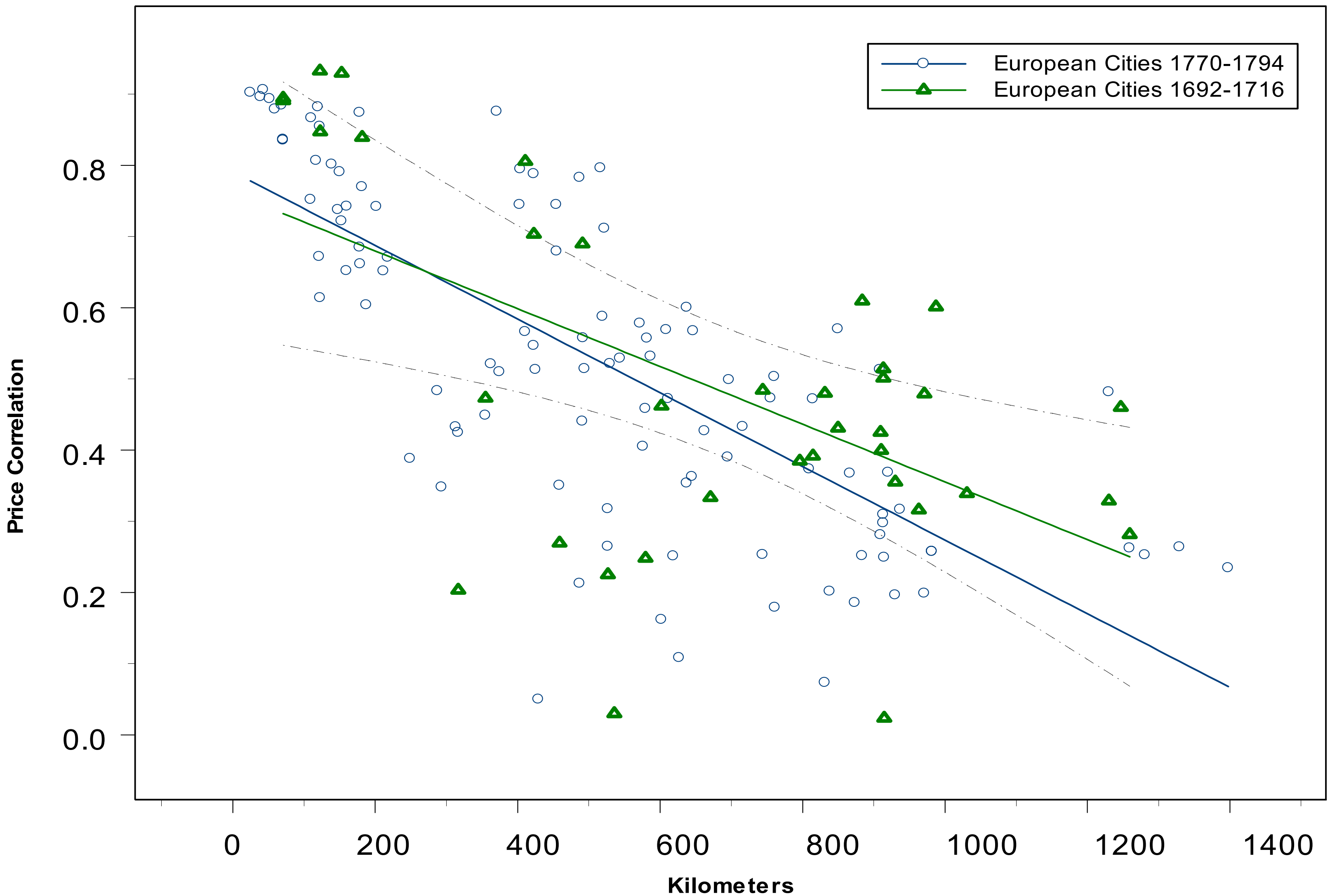


Figure A.2 China and Europe, selected markets over 18th and 19th centuries

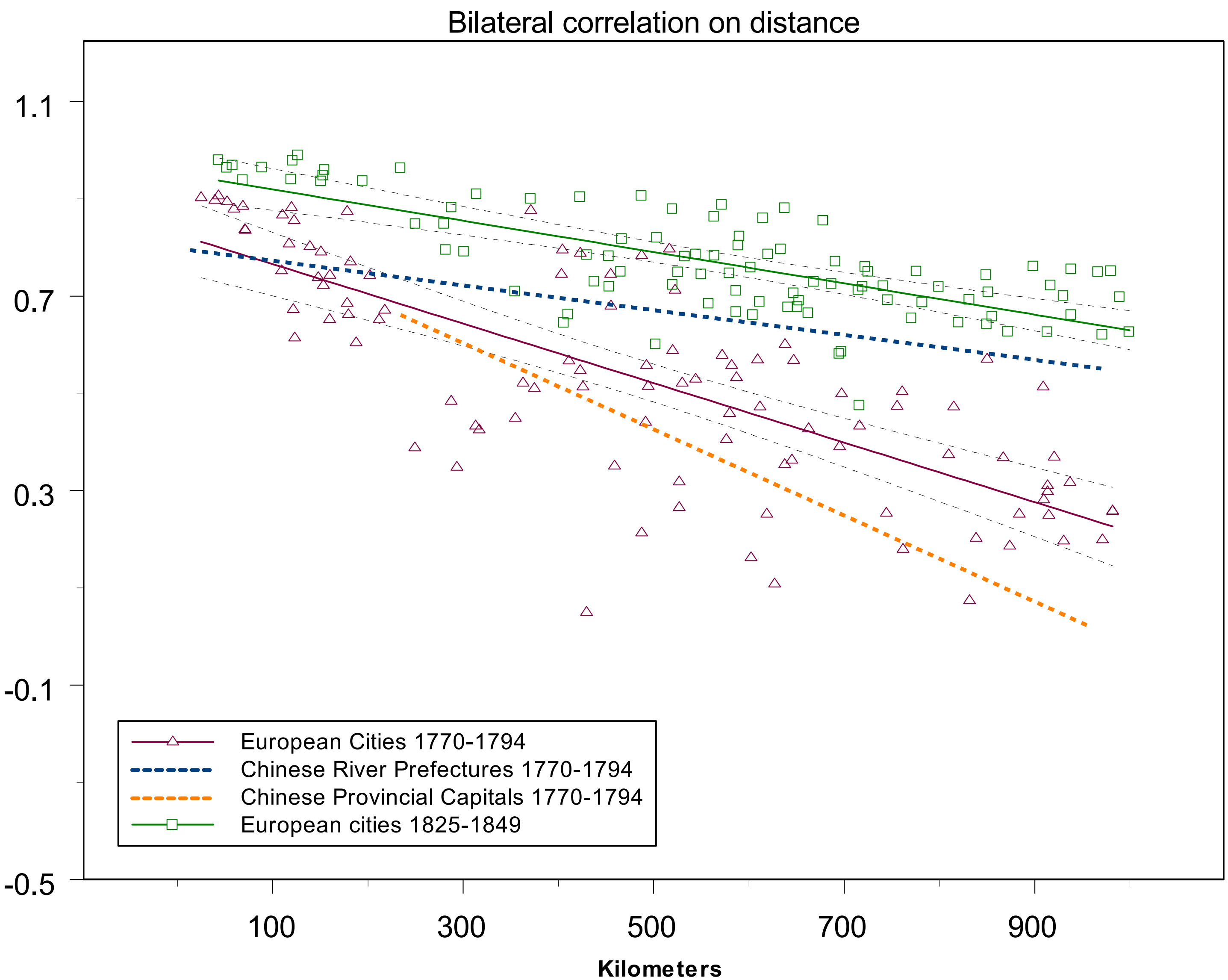


Figure A.3 England and the Yangzi Delta, 1770-1794

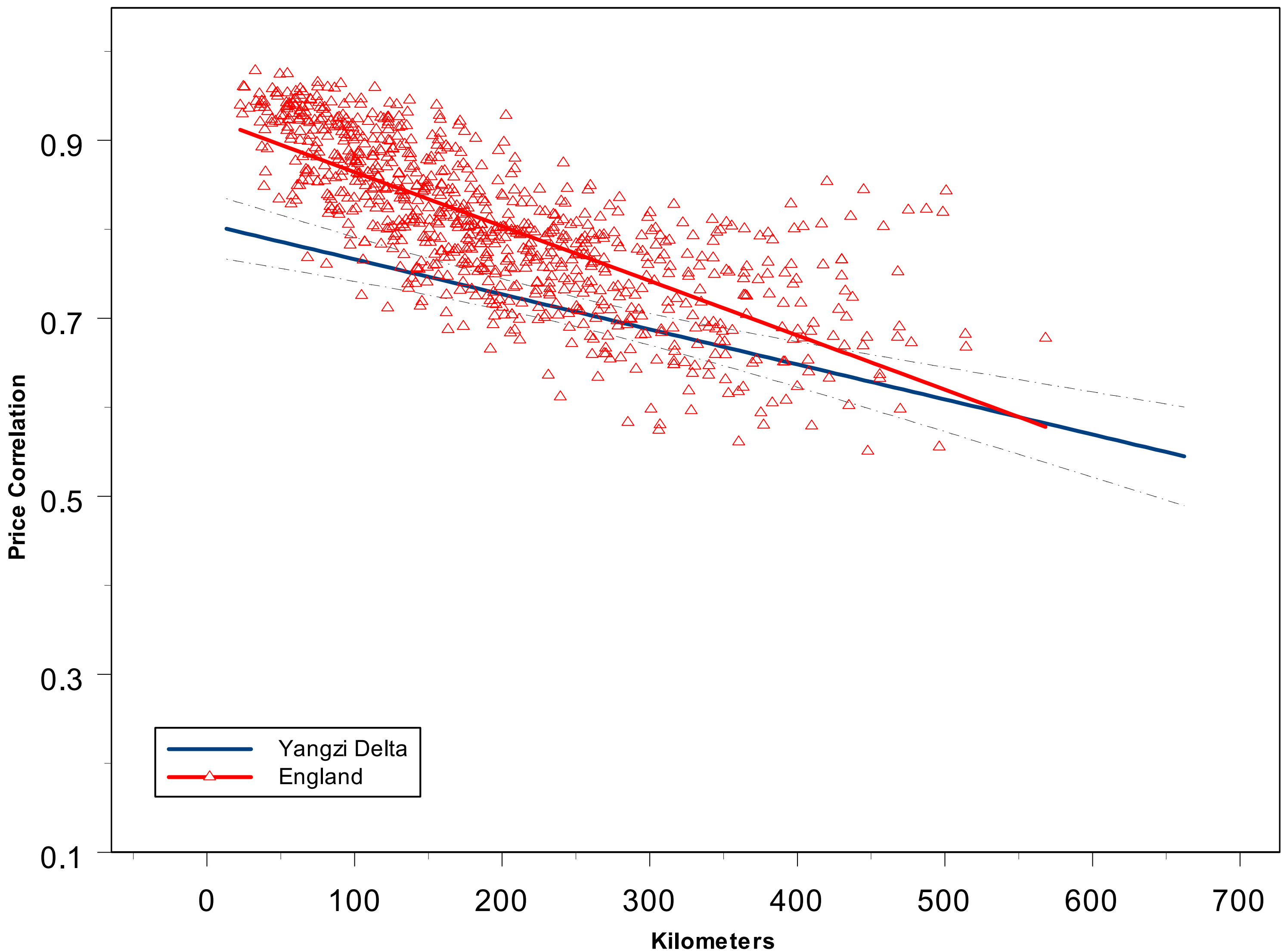
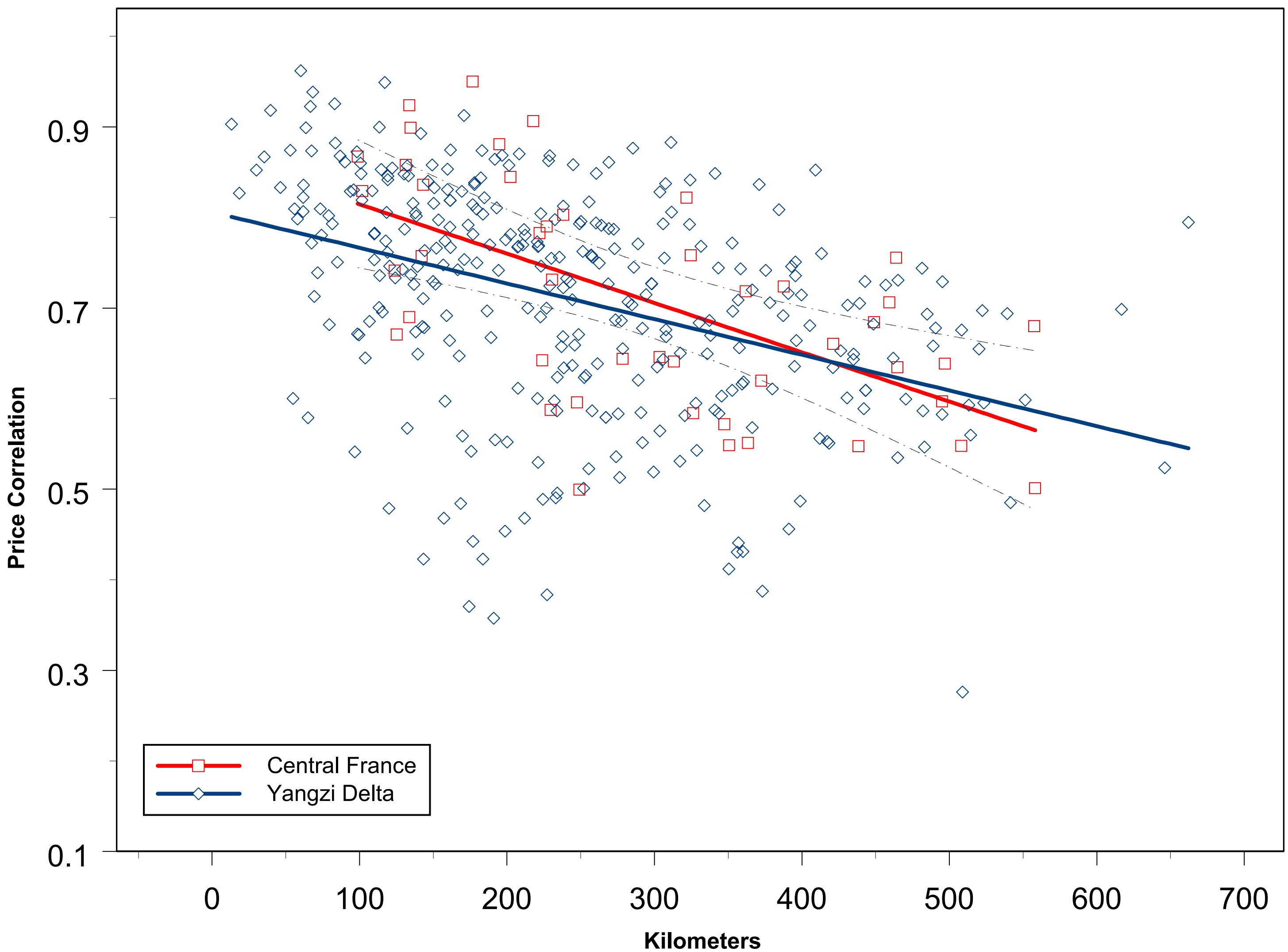
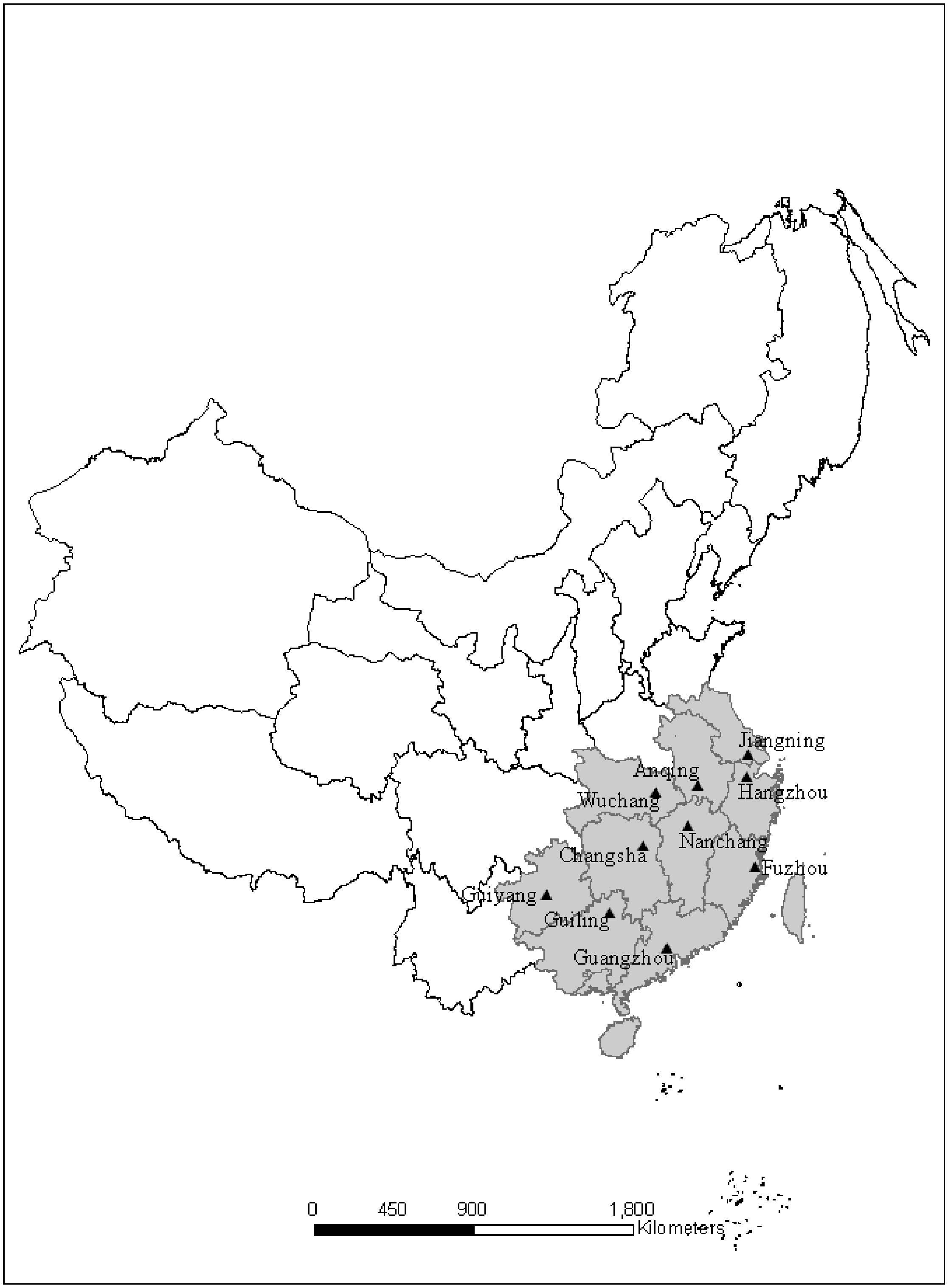


Figure A.4 Yangzi Delta and France, 1770-1794



Map 2


Jiangning
Anqing
Hangzhou
Wuchang
Nanchang
Changsha
Fuzhou
Guiyang
Guilin
Guangzhou
0
450
900
1,800
Kilometers

Map 3


1. Aalst
2. Antwerp
3. Boizenburg
4. Brussels
5. Cologne
6. London
7. Luxemburg
8. Munich
9. Nijmegen
10. Rostock
11. Ruremonde
12. Schwerin
13. Toulouse
14. Utrecht
15. Vienna
0
337.5
675
1,350
Kilometers