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

By Carol H. Shiue and Wolfgang Keller*

Why did Western Europe industrialize first? An influential view holds that its exceptionally well-functioning markets supported with a certain set of institutions provided the 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 that were relatively advanced in the preindustrial period, but would start to industrialize about 150 years apart. We find that the performance of markets in China and Western Europe overall was comparable in the late eighteenth century. Market performance in England was higher than in the Yangzi Delta, and markets in England also performed better than those in continental Western Europe. This suggests strong market performance may be necessary, but it is not sufficient for industrialization. Rather than being a key condition for subsequent growth, improvements in market performance and growth occurred simultaneously. (*JEL* N13, N15, O47)

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-nineteenth 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 Douglass C. North and others, by 1700 Britain and the Netherlands had developed exceptionally well-functioning markets supported with a set of institutions—nondistortionary 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 Barry R. Weingast 1989; North 1981; North and Robert Paul Thomas 1973).[2] This facilitated the movement

* Shiue: Department of Economics, University of Colorado, Boulder, CO 80309 (e-mail: shiue@colorado.edu); Keller: Department of Economics, University of Colorado, Boulder, CO 80309 (e-mail: kellerw@colorado.edu). 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 the 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] 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 Angus 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 (Barry R. Chiswick and Timothy Hatton 2003; Kevin H. O'Rourke and Jeffrey G. 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 (Abhijit V. Banerjee and Lakshmi Iyer 2005;

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 eighteenth century, possibly because it lacked, for example, institutions that support technical progress (Joel Mokyr 1990; David S. Landes 1969), which are different from the allocative institutions supporting market integration.

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 preindustrial 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 eighteenth century (e.g., Mark Elvin 1973; Dixin Xu and Chengming 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 seventeenth to the nineteenth 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 preindustrial era. This is particularly useful for investigating the fundamental determinants of growth, as these two regions were relatively advanced as of the mid-eighteenth 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 (N. F. R. Crafts 1995; Kenneth Pomeranz 2000; Jack A. 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 to markets both 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

Daron Acemoglu, Simon Johnson, and James A. Robinson 2001).

[3] For living standard comparisons, see Robert C. Allen et al. (2005), Allen (2002, 2001), and Paul Bairoch (1975, 3–17).

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 about differences in the transportation systems? Notwithstanding a number of important contributions (Pomeranz 2000; Philip C. C. Huang 2002; R. Bin Wong 2002), little is known 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 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 (Jonathan Isham and Daniel Kaufman 1999), as well as the importance of institutions that provide the framework in which markets operate (Robert E. Hall and Charles I. Jones 1999; Dani Rodrik, Arvind Subramanian, and Francesco 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.

I. 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 preindustrial era. Geographically, China's rice-growing area is located in the south and central parts 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 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 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) (Fang Xing et al. 2000, 170).[4] Assuming this would have been enough to feed 14 million people (Pomeranz 2000, 34), some 8 percent 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 eighteenth century, the Yangzi Delta may have imported, in a typical year, about 25 percent of its rice consumption; Southern Zhejiang imported in one year, 1748, more than 50 percent of its rice consumption (Han-sheng Chuan and Richard A. Kraus 1975, 62). Grain was exchanged for commodities such as cotton

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

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 percent of the total long-distance grain trade was the Baltic trade through the Danish Sound (Fernand 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 eighteenth century (Milja 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 round-trip from Southern Fujian to Zhapu in Zhejiang took about 8 days in the 1720s, 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 per hour), while the trip from Danzig to London could take as little as 9 days (about 5.4 miles per hour) (van Tielhof 2002, 158–59).

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 per hour for river transport and up to 1.5 miles per hour when it was (mostly) canal traffic (based on W. T. Jackman 1962, 450, 725), not too different from the 1.0 mile per hour round-trip speed for travel on the Yellow River in the vicinity of Luoyang, in Henan province (Laurence Evans 1984, 289). The most common Yangzi junk in Hubei had a round-trip speed of up to 2.4 miles per hour (G. R. G. 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 eighteenth century, the freight charge may have been around 40 percent 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 percent of the grain shipped, and as much as 50 percent for more involved transports, such as that from the Yangzi Delta to Beijing through the Grand Canal (Evans 1984, 298–99).

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 late eighteenth century England was normally two to four 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 eighteenth century England was between 2 to 2.75 (Evans 1984, 294, Petersen 1995, 150, respectively).

[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 the inland navigation system of England and Wales in 1780 was less than 3,500 kilometers long (Christian Petersen 1995, 153). If one abstracts from the large areas in China's west where few people lived, the density of the waterway network was likely higher in China than that of England.

[7] For the well-navigable Yangzi River, overland transport was between 3 and 5.5 times as expensive as waterway transport. Peking road transport was 5.5 times the cost on the Yangzi (Evans 1984, 293); and land transport in Hubei and Shanxi is 3 to 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).

Using the mid-point estimates and 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 eighteenth century.

Both public and private institutions 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 percent of China's long-distance trade in the mid-Qing may have been official government shipments—primarily in the 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 percent of its total revenues were devoted to public projects, which included flood control and passageability of major routes. (Susan Naquin and Evelyn S. Rawski 1987, 23; Ramon H. Myers and Yen-Chien 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, and 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 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. With the notable exception of England, however, the amount of revenue from these taxes in China was typically below that of countries in Western Europe, even as late as the eighteenth 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 (Susan 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, nonofficial 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 (William T. 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, and established the dates at which markets would be open, as well as regulations for sales, deliveries, and market conduct (Xing et al. 2000, 180–83; Rowe 1984, 295–96). Over time, the state may have relied more and more on the guilds for market oversight. In some cases, guilds were eventually delegated the

[8] Additional details and comparisons with Europe can be found in the Web Appendix (http://www.e-aer.org/data/sept07/20040419_app.pdf), as well as in Shiue and Keller (2006).

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 their 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 (Ping-Ti 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.

II. Data, Econometric Methods, and Results

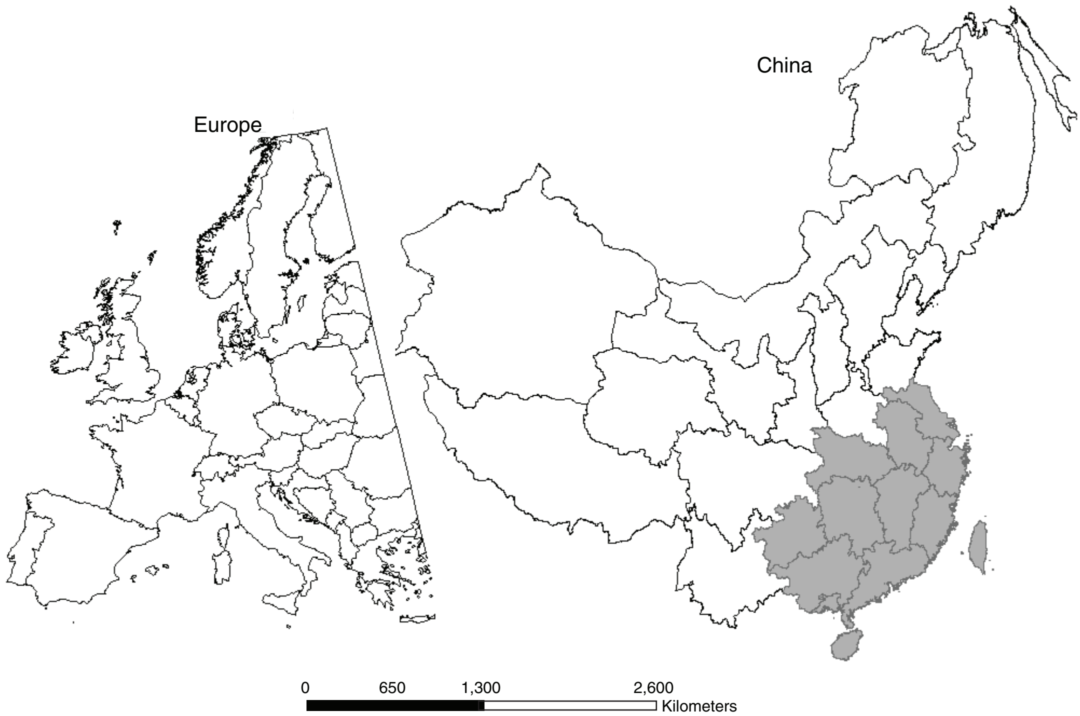
A. *Data*

We have assembled a large dataset of about 250 price series, roughly equally divided between China and Western Europe, and ranging in time period from the fifteenth to the twentieth century. Within Europe, the markets are predominantly located in today's Belgium, England, France, Germany, Luxemburg, and the Netherlands, that is, in Northwest 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 eighteenth century (about 60 percent of China), while the population of Europe excluding the former USSR might have been 120 to 150 million (John Durand 1960; Colin McEvedy and Richard 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 are available for both the pre– and the post–Industrial Revolution era. While most of the data on China are 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 eighteenth century tend 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



MAP 1

on our results, because even though the overall sample period is from the seventeenth to nineteenth century, our comparisons between China and Europe are typically based on periods of only about 25 years.[9]

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 nearby 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, we first show 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

[9] Grain prices were broadly trending upward 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 experimented with adding a trend to the cointegrating relationship (see equation (5) below); however, tests generally reject this specification.

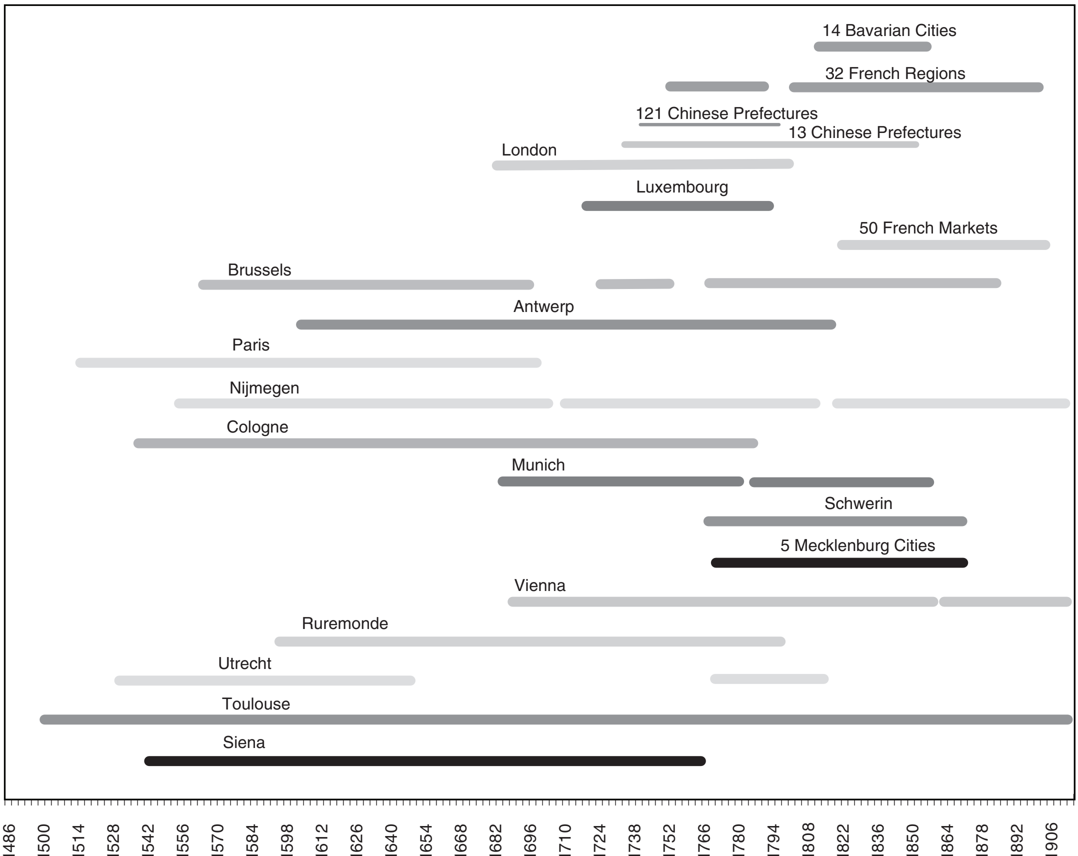


Figure 1. Data Availability, Selected Locations

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 a sample of nine 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 North as the time by which a number of countries in Northwest Europe had developed a set of exceptionally advantageous institutions (North and Thomas 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 eighteenth 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 nineteenth century (years 1825–1849). This is the sample on which the post–Industrial Revolution analysis will be based.[10] We also

[10] We cannot analyze the same set of cities before, during, and after the eighteenth century due to lack of data availability, but the overlap in the three samples is high (see

TABLE 1—SUMMARY STATISTICS*

			(I)#	(II)#	(III)#	Frequency distribution of bilateral distance (km) (in percent)			
China	Years	n	Standard deviation	Residual first difference volatility^	Skewness	$x < 300$	$300 < x < 600$	$600 < x < 900$	$x > 900$
All prefectural markets**	1742–1795	121	0.130	0.088	0.340	13.8	28.1	26.9	31.1
Yangzi Delta (expanded)**	1742–1795	26	0.146	0.103	0.422	68.9	30.5	0.9	0.0
Provincial capitals**	1742–1795	10	0.136	0.094	0.264	13.3	31.1	31.1	24.4
Yangzi River prefectures**	1742–1795	34	0.146	0.101	0.605	34.2	47.4	16.2	2.1
Western Europe									
West European cities (1)	1692–1716	9	0.246	0.182	0.336	16.7	25.0	22.2	36.1
West European cities (2)	1770–1794	15	0.192	0.140	0.581	30.5	31.4	23.8	14.3
West European cities (3)	1825–1849	15	0.266	0.179	0.212	16.2	29.5	35.2	19.0
England (4)	1770–1794	41	0.149	0.130	−0.438	81.8	18.2	0.0	0.0

* Based on monthly (log) prices, two observations per year (March and September for Europe, second and eighth 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, Luxembourge, 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*.

include a within-country sample: 41 county-level markets in England for the years 1770–1794. 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 eighteenth 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 percent of all bilateral pairs in the "all prefectural markets" sample in China are more than 900 kilometers apart from each other, whereas for the West European city sample for 1770–1794, 14.3 percent of bilateral pairs fall into 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.

The left side of Table 1 shows various measures of price variability. 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) and 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., D. N. McCloskey and John 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 negative (e.g., Angus Deaton and Guy Laroque 1992). Here, the skewness measures range from −0.438 for English markets 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).

the notes at the bottom of Table 1). Small changes to the sample composition do not affect our main results.

B. *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, $t = 1, \ldots, T$, there is an inelastically supplied harvest z_t which follows a stochastic process characterized by a cumulative distribution function $\Phi(z, Z)$,

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

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 IV—the harvest z is consumed in each period. With log-linear demand the price is given by

$$p_t = a + bz_t, \tag{2}$$

where a and $b < 0$ are parameters, and $p_t = 1\text{n}(P_t)$. 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

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

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 nonstationary, and prices follow a random walk,

$$p_{t+1} = p_t + u_{t+1}, \tag{4}$$

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, multiyear 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 nonstationary variables is stationary, the prices are said to be cointegrated (Clive W. J. Granger 1981; Robert F. 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 and mountains) as well as route maintenance and the sensitivity to weather-related problems (such as mud on streets, or the 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 have an 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

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

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,

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

where the lagged dependent variable is added as a regressor to reduce problems of serial correlation. Under the null hypothesis that e_t is nonstationary, 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]

C. 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 eighteenth 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 nonstationarity 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):

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

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

[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 (Alan M. Taylor 2001; Nathan S. Balke and Thomas B. 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.

[12] Typically, the null hypothesis of a unit root cannot be rejected using standard unit root tests. For example, during the years 1770–1794, the average p-value for the null of a unit root was 0.27 for the 15 European cities, whereas it was 0.12 for the expanded Yangzi Delta prefectures.

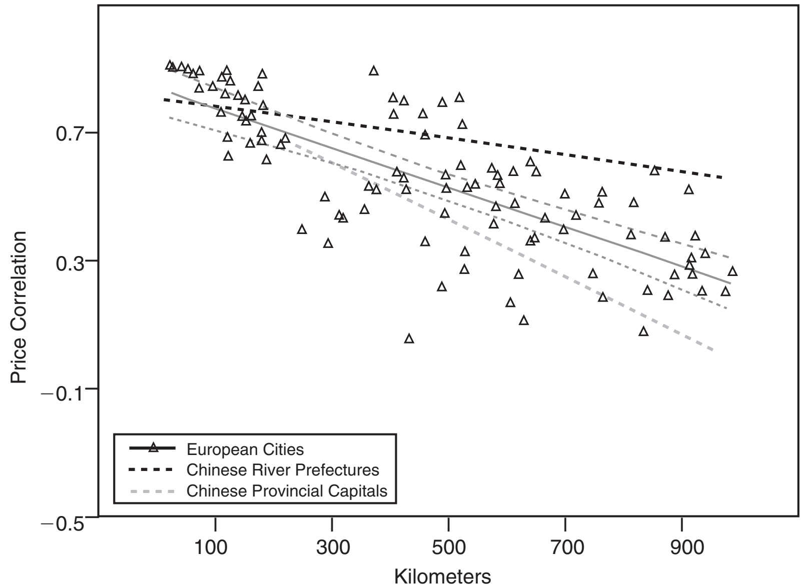


Figure 2. China and Europe, Selected Markets, 1770–1794

estimate on $\hat{e}_{t-1}$, the stronger is the evidence for cointegration between prices p_1 and p_2.[13]

Figure 3 presents the average ADF t-statistics for the sample of 15 European countries in the late eighteenth 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 of 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

[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 in James G. 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 II), 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).

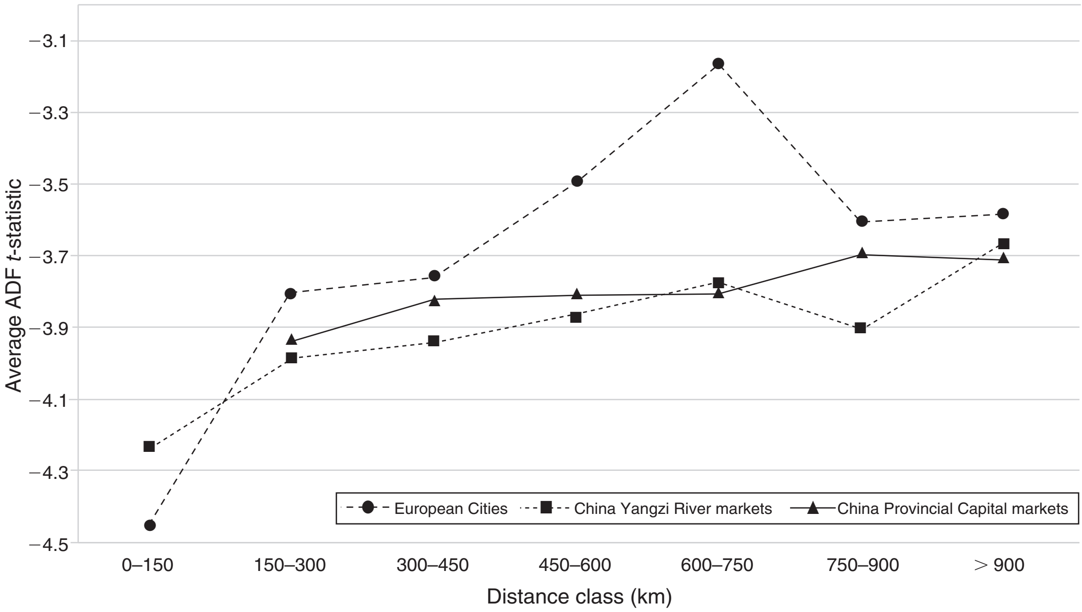


Figure 3. Cointegration in China and Europe, 1742–1795

development in the Yangzi Delta. Relative to Western Europe, there is less evidence of 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 eighteenth century. But what about England? Figure 5 compares the cointegration statistics for eighteenth 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 eighteenth 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 over the next several decades. Figure 5 shows the cointegration statistics for European markets for the years 1825–1849, in the aftermath of the Napoleonic Wars (1799–1815). Market integration was substantially higher in Western Europe in the early nineteenth century than in the late eighteenth 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]

III. Qualifications and Sensitivity Tests

In this section, we briefly discuss a number of additional issues and robustness checks that are

[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.

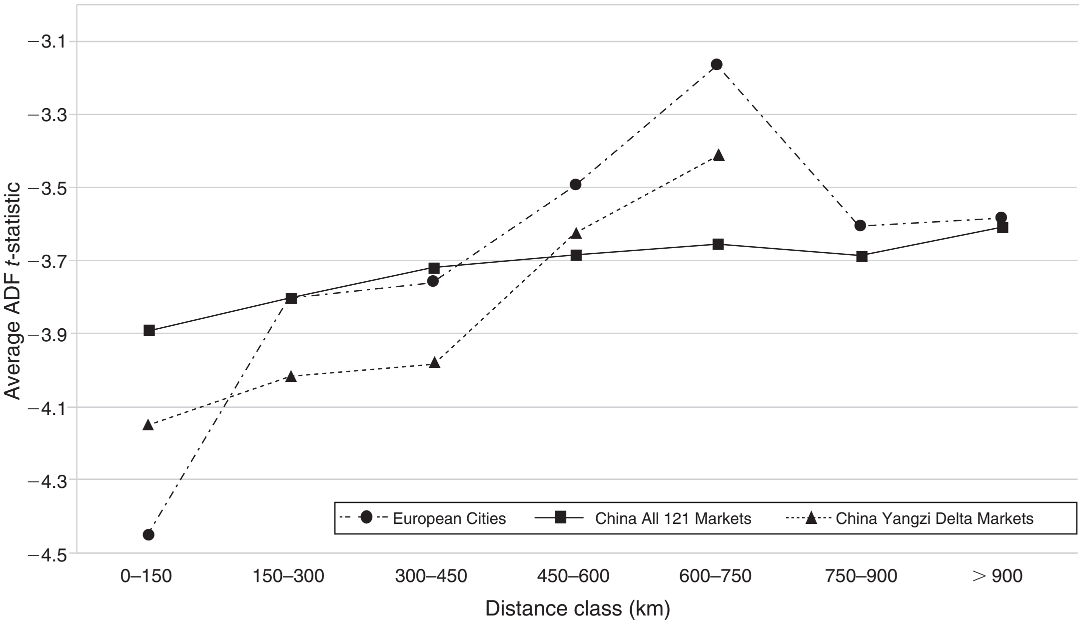


FIGURE 4. COINTEGRATION IN CHINA, ITS YANGZI DELTA, AND EUROPE, 1742–1795

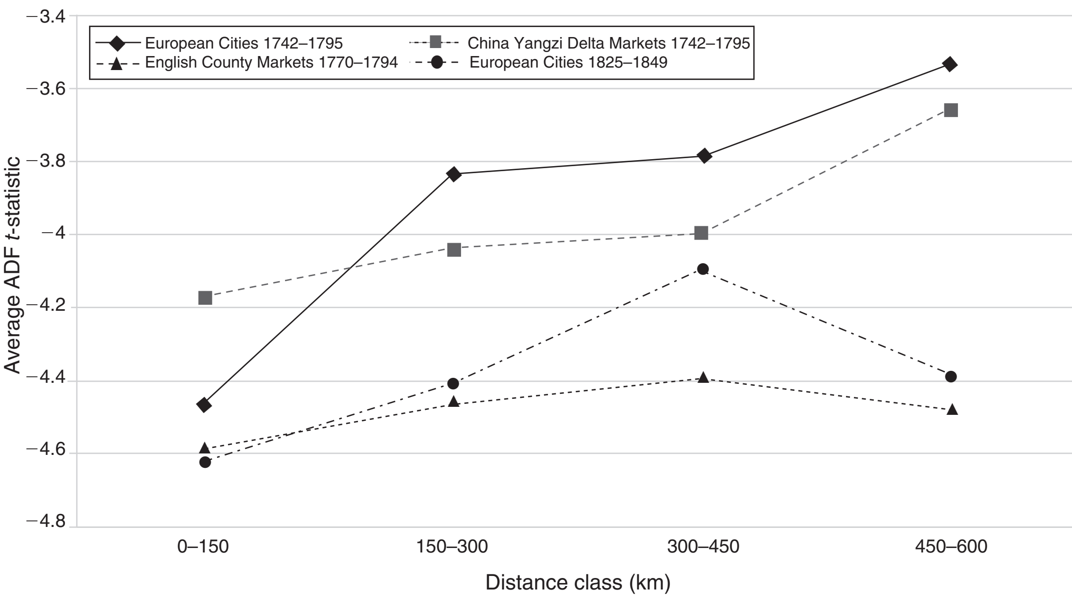


FIGURE 5. COINTEGRATION IN YANGZI DELTA, ENGLAND, AND WESTERN EUROPE IN THE EIGHTEENTH CENTURY, VERSUS WESTERN EUROPE IN THE NINETEENTH CENTURY

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).

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 (rain-fed) conditions while rice is grown under irrigated conditions. The irrigated environment lends itself to a much more labor-intensive systems of cultivation than rain-fed production. In addition, an irrigated system may exhibit lower inter-year and spatial price variability than rain-fed 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; Jeffrey C. Williams and Brian D. 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.

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 eighteenth century (a) wheat prices in China and Western Europe, (b) rice and wheat prices in China, and (c) 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.

With regards to storage in Europe, there is generally little direct evidence of storage in either private or public facilities (Randall Nielsen 1997, 12). In contrast, the Qing state operated large-scale granaries (Pierre-Etienne 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

[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, chap. 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 eighteenth century China is presented in Shiue (2002).

[19] This is consistent with estimates that in China, the amount of grain held in private storage exceeded that held in public granaries (Francesca Bray 1984, 416).

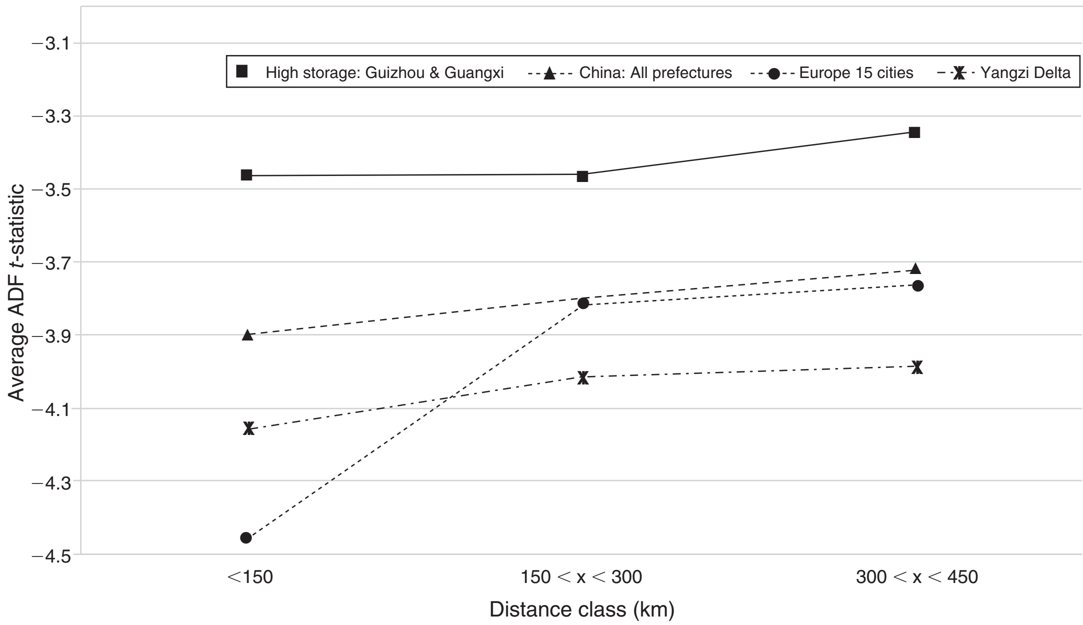


Figure 6. Storage and Cointegration

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 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 was comparable tends toward 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 prevailing in England.

To sum up the results of this section, it is unlikely that our analysis is biased toward 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 eighteenth 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.

IV. 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 of why Western Europe

[20] The two provinces with the highest level of per capita storage in our sample are Guizhou and Guangxi; see Shiue (2005a, fig. 1).

industrialized in the late eighteenth century. In this paper we examine the similarities and differences in markets in preindustrial China and Western Europe from the fifteenth to nineteenth 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 did not perform uniformly better in Western Europe than in China. Over relatively short distances of 150 kilometers 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 nineteenth 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 nineteenth 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 nineteenth century. They are also more integrated than markets found in poor countries today. But it would in part 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, also needs 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 eighteenth century. That Britain was 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-eighteenth 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-nineteenth century is similar to Britain's in the late eighteenth 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 II (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 came 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 also affected 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.

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 come from market price reports at the prefectural level (an administrative level above the county level 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 prices are available, we form the average price as (min + max)/2.

There is spatial aggregation to a varying extent. We explored the effects of spatial aggregation and did not find major effects. Jesus 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 ten provinces for which rice was the major grain, which suggests that sample selection plays essentially no role for China. For Europe, our data tend to be for markets of relatively big cities that were often also centers of trade and of relatively rich cities. For instance, the 50 French markets in Sylvie Drame et al. (1991) are selected from some 900 markets where the greatest quantities were sold.

Missing data: There are substantial gaps in the sources; approximately 23 percent (15 percent) 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 were not too many missing data (Victor Gomez and Agustin 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 Céréales à Luxembourg aux XVII*[e] *et XVIII*[e] *siècles*, Université 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 ten 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: second and eighth 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.

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 asked one by one 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. 514–35 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 Franc.
Original source: Archives Nationales (Paris), F11* 1779–2678 and F11* 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*. Part of 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 four to five weekly prices. The source also lists weekly prices and quantities, which allows verifying that the difference between quantity-weighted and quantity-unweighted monthly price is typically less than 1 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 this.

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 eighteenth and nineteenth 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.

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