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Abstract

This paper challenges established claims of comparable degrees of market integration in Europe and China on the eve of industrialization. Our empirical strategy focuses on the dynamics of price convergence and accounts for general equilibrium effects arising from common shocks and network effects. Using monthly grain prices for 1740-1820, our analysis uncovers a secular process of market disintegration in 221 prefectures of Qing China. Comparing our results with those for grain price panels from Western Europe we conclude that in terms of market integration the Great Divergence was well under way decades before the start of the 19th century.

JEL Classification: F15, N75, L11, C23, O10

Keywords: market integration, price convergence, China, Europe, the Great Divergence, common factor model, cross-section dependence

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I. Introduction

One of the seminal questions in economic history is why the world's then largest economy, China, failed to industrialize during the 18th and 19th centuries, whereas Western Europe embarked on modern economic growth. This difference between China and Europe's path to industrialisation is central to the question about the causes for the 'Great Divergence.'[1] Social and economic historians have sought the answer to this question by identifying the necessary conditions for industrialization. One plausible condition is the degree of market integration of an agricultural economy. The argument here is that integrated markets generate static and dynamic gains from specialization and trade, leading to investment in non-farm activities, which facilitate the transition from an agricultural to an industrial economy.

A long-held view is that markets in Western Europe were more integrated because of state-supported property rights institutions, while in China markets were correspondingly underdeveloped because of poor legal enforcement of property rights, despite the unified political system that reduced war and civil strife so common in early modern Europe.[2] This view has been challenged by a revisionist body of scholarship – Wong (1997), Frank (1998), and Pomeranz (2000), among others – who have claimed that early modern China was not only on par with Western Europe, but that "eighteenth-century China… came closer to resembling the neoclassical ideal of a market economy than did Western Europe" (Pomeranz, 2000: 70).

A major weakness of the revisionist argument is poor and fragmentary data to underpin it. Recent econometric work by Shiue and Keller (2007) supports the revisionist view that market integration in Southern China was comparable to Western Europe at the dawn of the Industrial Revolution. Shiue and Keller's (2007) findings have transformed the revisionist view into a now

[1] The literature on the Great Divergence is large. A work seminal to the current debate is Pomeranz (2000), along with critiques by Brenner and Isett (2002) and Huang (2002). For an extensive recent survey, see Vries (2015).

[2] See Li (2000, p.656f) for discussion and references.

conventional view that differences in market integration can be ruled out as an explanation for the Great Divergence.

This paper reassesses the degree of market integration in early modern China and Europe. It challenges the conclusions of Shiue and Keller (2007) and earlier studies (Wang, 1989, 1992; Wang and Chen, 2002) and finds to the contrary a secular decline in the degree of integration in 18th century China. We provide an alternative approach to Shiue and Keller's (2007) empirical analysis, which is based on cross-continental comparisons of averaged cointegration test statistics for market pairs in China and Europe.[3] Instead we assess the dynamic evolution of market integration, taking account of the general equilibrium effects arising from common shocks and network effects. We apply novel econometric techniques to rich panel data on grain prices from China and Europe for the 18th and early 19th centuries. Our dynamic analysis of market integration confirms historical narratives that market integration in the South of China was more advanced than in the North, primarily because of the advantage of water transport in the South over land modes in the North (Eastman, 1988; Evans, 1984; Kim, 2008). Our estimates uncover a prolonged process of market disintegration for China leading to lower degrees of market integration relative to Western Europe on the eve of Western Industrialization. We demonstrate that the combination of addressing general equilibrium effects and examining the dynamics of integration explains the difference between our results and those of Shiue and Keller (2007).

The revealed weakening in integration over time lends support to earlier narratives that market integration was relatively weak and already in decline during the 18th century (e.g. Pomeranz, 2000: 22). Explanations include the segmentation of China's regional economies (Skinner, 1977a), the presence of vibrant local markets without there being integration between regions (Rawski, 1972), and environmental-technological constraints arising

[3] In a companion paper (Bernhofen, Eberhardt, Li and Morgan, 2016) we use Shiue and Keller's (2007) cointegration methodology, albeit with monthly data and a rolling window of analysis, to find secular decline in Southern Chinese market integration.

from the fundamental character of water control and transport systems in the absence of technological break-through and against a background of weakening (fiscal) capacity of the state (Elvin, 1973, 2004; Perkins, 1969; Rawski, 1972; Skinner, 1977b; Sng, 2014).

Our comparison of China with Western Europe draws on an analysis of monthly grain prices for Belgian markets (1765-1794), French *départements* (1800-1872) and English counties (1770-1820), as well as annual data for German cities (1700-1800) and a cross-European sample of markets (1700-1820), respectively. Adopting an identical methodology to that used in our Qing price analysis, and (for the most part) identical data frequency, we show that China's divergence from European levels of market integration was already well under way several decades before the end of the 18th century.

We subject our findings of Chinese market disintegration to several robustness checks related to alternative crops, the sample of prefectures analysed, and the reference price adopted in the convergence regressions. We also investigate whether nonlinear adjustment dynamics may have distorted our linear convergence analysis (Taylor, 2001) and consider alternative specifications to capture common shocks and network effects.

Our empirical methodology is rooted in a general equilibrium perspective, which postulates that local grain prices are jointly determined by factors such as local and global weather shocks and by the market's relative position in the existing trading network. Accordingly, the investigation of price convergence between any two markets can be misleading unless we take account of the 'outside options' available to consumers and traders as well as the relative attractiveness of these opportunities. Furthermore, bilateral price movements in reaction to common shocks may make price pairs appear to co-move, although the cause for this co-movement is entirely unconnected to spatial arbitrage (e.g. widespread flooding or locust plague).

Our conceptual framework incorporates a mechanism akin to multilateral resistance in the gravity model of bilateral trade flows (Head and

Mayer, 2014, for a recent survey), the third country effect in the analysis of exchange rate movements (Berg and Mark, 2015), and the distinction of global and local shocks in recent work on (micro) price dynamics (Beck, Hubrich and Marcellino, 2015; Andrade and Zachariadis, 2016). The network aspect of price movements manifests itself in our observed price series in what econometricians refer to as 'cross-section dependence' (Andrews, 2005; Coakley, Fuertes and Smith, 2006; Chudik and Pesaran, 2013). Failure to address this dependence in the empirical strategy can result in misleading inference and inconsistent estimators (Phillips and Sul, 2007; Sarafidis and Wansbeek, 2012).[4]

We introduce a simple theoretical model of grain price behaviour that incorporates the network dependence aspect of trade (and thus grain prices) and of exogenous shocks to production by means of a multifactor error structure. This framework accounts for the fact that location-specific prices are determined within a general equilibrium system. Our empirical investigation builds on the Pesaran (2006) common correlated effects (CCE) estimator to investigate heterogeneous price convergence to the regional or Skinner (1977a) macro-regional average – Section II.1 provides more details on these geographical groupings. In contrast to the cointegration approach (Shuie and Keller, 2007), our estimator is robust to nonstationary price series but does not crucially rely on this data property to establish or reject long-run price convergence across prefectures.

The remainder of this paper is organised as follows: Section II introduces the data and methodology. Section III discusses the empirical findings and provides robustness checks. Section IV concludes.

[4] The literature distinguishes between *strong* cross-section dependence, which is pervasive, and *weak* cross-section dependence, which represents a spatial process with distance decay (Bai and Ng, 2002; Bailey, Kapetanios and Pesaran, 2015). Ignoring the former can lead to bias whereas ignoring the latter will merely lead to misleading inference (Chudik and Pesaran, 2013).

II. Data and Methodology

II.1 Data

We briefly introduce the Chinese and European data used in our analysis. More details are contained in an Online Appendix.

Qing China

We use the averages of the monthly reported minimum and maximum prices for rice from 131 prefectural markets in eleven provinces of South China, and for wheat from 80 prefectures in six provinces of North China over the 1740-1820 period. Our data capture all of the 18 provinces of Qing China Proper with the exception of Yunnan province. The Qing state collected these data as part of an elaborate commodity price reporting system, which was progressively implemented during the reign of Emperor Kangxi (1662-1723) and which became a nation-wide system at the start of the reign of the Emperor Qianlong (1736-1795). We use the subset of rice and wheat prices, recorded in taels (*liang*, ounces of silver) per granary bushel (*cang shi*, around 104 litres), compiled by the late Professor Wang Yejian [Yeh-Chien] and collaborators. There is a general consensus that these price data have a high degree of veracity and are comparable across locations (Chuan and Kraus, 1975; Marks, 1991, 1998; Shiue, 2002, 2004, 2015; Shiue and Keller, 2007).

Our analysis is split in two on the basis that South China produced rice while North China produced wheat as the main staple grain crop (Buck, 1937: Map 3). On average there are over 730 time series observations for each of the 131 Southern prefectures and 785 observations for each of the 80 Northern prefectures.[5] The sample period covers January 1740 to December 1820,

[5] Our panel is unbalanced with about 19% of observations missing in each regional sample – plots for average as well as maximum and minimum number of observations in a 20-year rolling window convergence regression are presented in the Online Appendix. Our heterogeneous panel econometric approach avoids the undesirable weighting implicit in pooled regressions of unbalanced panel data and thus is robust to this data feature. We carried out robustness checks to demonstrate that the differential data availability across prefectures and time does not drive our empirical results (see Online Appendix).

during which changes in market integration were mostly related to internal factors rather than external-related political, technology and trade shocks that increasingly affected China in the 19^{th} century.

We use geospatial data to match prefectural grain prices to information on politico-bureaucratic, geomorphological and agro-climatic borders. We employ Harvard's China Historical Geographic Information System (CHGIS) maps for the boundaries of the administrative hierarchy (prefectural and provincial borders) at our sample end point in 1820 (Figure 1).

Geomorphological features can act as natural barriers to trade. We employ information on boundaries for eight 'physiographic macro-regions', a concept introduced by William Skinner (1977a), which correspond to major river basins with watersheds and crests of mountain ranges as boundaries (Figure 2). At its core each macro-region has a concentration of arable land, population, capital and other resources, which thin out toward the periphery. Skinner (1977a) argued that the macro-regions developed separately and that the most trade took place *within* rather than between macro-regions.[6]

Austrian Low Countries (Belgium)

The Belgian dataset comprises 20 markets with observations between January 1765 and November 1794 (3.5% missing observations), reporting wheat prices for the first market day of the month, from Vandenbroeke (1973). Data collection was standardized and carried out by central government customs officials who converted measurements to a common unit – Brabantine *stuivers* per *razier* from Brussels (49 litres). Buyst, Dercon and Van Campenhout (2006: 188) argue these markets "compose a representative sample of all large and medium-sized grain markets in the Austrian Low Countries".

[6] In robustness checks we employ the agricultural areas developed by Buck (1937: Map 4 – see Online Appendix).

England

We use the *English Corn Returns*, a weekly price series for selected grains published in the London Gazette, the official government newspaper, between 1700 and 1914. Our analysis uses the weekly wheat prices from November 1770 to September 1820 collected and digitized by Brunt and Cannon (2013, 2014), covering 40 counties (all of England excluding London). The data (0.3% missing observations) are prices per Winchester bushel of wheat (about 35.2 litres) in shillings and pence, representing county average prices for the previous week. From these records we extract monthly prices, the same data frequency as that of the Qing grain prices. [7]

France

From Labrousse, Romano and Dreyfus (1970) we obtain monthly average wheat prices in 85 *départements* for the period September 1800 to December 1872 (below we limit our presentation to analysis up to 1825), collected by French ministerial officials and first published in the 1870s. Our sample covers the entire French mainland (0.6% missing observations). We convert dates from the French Republican Calendar used for 1800-1805 into the Georgian calendar. All prices are in francs per hectoliter.

Germany

We adopt average annual rye prices in grams of silver per hectoliter for 12 cities from Rahlf (1996). The geographic distribution of these markets is skewed towards the Rhineland and surrounding areas (Aachen, Düren, Köln, and Xanten) as well as Southern Germany (Augsburg, Frankfurt, München, Speyer, Strassburg, and Würzburg), with only two markets, Leipzig and the Prussian city of Danzig, in the North or East of the country. The time series of these data cover 1500 to 1800 (17% missing observations), though below we

[7] Temporal aggregation of prices biases estimates of convergence and half-lives (Taylor, 2001; Brunt and Cannon, 2014) and we therefore pick prices for the first week of every month instead. Using any other week yields qualitatively identical results (available on request). We also use the full weekly data as a robustness check (see Online Appendix).

limit our presentation to results for the 18th century (9% missing). We have also adjusted for differences among the city-level data between harvest year and calendar year reporting.

European markets (cross-national sample)

Average annual wheat prices in grams of silver per litre for 55 markets across Europe are taken from the *Global Commodity Prices Database* collated by Bob Allen and Richard Unger. Our sample selection is based on data for 1700-1820, and we only include cities for which observations cover at least 50% of this period. As in the German data we adjusted for differences in harvest and calendar year reporting across countries.

II.2 Empirical Framework

Building on Deaton and Laroque (1996), we begin with a price model for an agricultural commodity in multiple markets *i* at time *t*. Local harvest output h_{it} is supplied inelastically and follows a stochastic process characterized by the cumulative distribution function $\Phi(h, H) = \Pr\left(h_{i,t+1} \leq H_{it} \middle| h_{it} = h_i\right)$. We specify that the price P_{it} in location *i* at time *t* is *not exclusively* determined by local harvest output h_{it} but also other factors such as harvest conditions in other markets, joint weather shocks to multiple locations, relative trading costs between location *i* and other locations and government intervention in the management of grain storage in *i* relative to other locations.[8] We model this general equilibrium dependence in a flexible way by employing a vector of 'unobserved common factors' $\boldsymbol{f}_t$ with market-specific 'factor loadings' $\boldsymbol{\lambda_i}$.[9] A

[8] The Qing intervened in grain markets in various ways, including direct control of supply and marketing, provisions for troops, reduced price sales, disaster relief, grain tribute for the capital, and civilian granaries (Li and Dray-Novey, 1999; Will and Wong, 1991; Shiue, 2004; Li, 2007). Local officials managed granaries but the central state set the storage targets. Their purpose was to provide food relief in times of shortages and to smooth price fluctuations over the growing and harvest cycle (Li, 2007).

[9] The literature commonly assumes the common factors are AR(1) processes. This allows for the potential of a unit root in the price series if the AR coefficient is equal to unity, which is the assumption made in Shiue and Keller (2007). Deaton and Laroque (1992: 3) argue that for

non-zero factor loading in locations i and j would suffice to induce cross-sectional price dependence.[10] For example, if the component k of $\boldsymbol{f}_t$ pertains to a series of common weather shocks affecting multiple locations, the corresponding factor loading λ_i^k captures the location-specific impact of these shocks: excessive rainfall will affect markets in low-lying locations close to flood-prone rivers differently from markets on a plain or at an elevation. Thinking of the network structure of trade and thus prices, the combination of $\boldsymbol{\lambda}_i$ and $\boldsymbol{f}_t$ can capture the relative trading costs for each market i with its neighbors or markets further afield (above we referred to this as the relative attractiveness of 'outside options'): a remote prefecture on the periphery of Sichuan will have a higher λ than a prefecture along the Pearl River delta of Guangdong. The relative magnitudes of factor loading λ_i^k across locations could be defined by a whole plethora of causes (e.g. remoteness, river access, terrain, local climate, security of roads, availability of porters) – our common factor framework allows us to be agnostic about which of these determinants are present in the data. [11]

In a pre-modern agrarian economy such as Qing China with limited technological progress we assume that shocks to harvest output (such as weather shocks) are exogenous. However, our setup recognizes that widespread flooding, locust plagues, civil strife or other shocks to market i are likely to extend beyond prefectural boundaries to affect the harvest in close-by market j as well: harvest outcomes *themselves* are correlated across markets.[12] Since local Qing officials intervened in grain markets through the management

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commodity prices such a random walk process "seems very implausible, at least for commodities where the weather plays a major role in price fluctuations", since this implies that all shocks to harvests have a permanent impact. Our own investigation of the price series (see Online Appendix) provides strong evidence against unit root behaviour.

[10] We make no assumptions about the reach of such shocks. Our empirical implementation is robust to localised shocks as well as shocks that affect all prefectures in the entire region.

[11] Further details on this model and its implementation can be found in Eberhardt, Helmers and Strauss (2013) and Eberhardt and Presbitero (2015).

[12] We assume that Cov(h,**f**)>0 in each market i, which creates a direct link between harvest output and the unobserved common factors.

of granaries our setup also captures the effect of correlated public granary management across prefectures in response to common harvest shocks.

The local price can then be written in form of a (deterministic) log-linear inverse demand function (Deaton and Laroque, 1996)

$$ln\, P_{it} = a_i + b_i h_{it} + \boldsymbol{\lambda}_i' \boldsymbol{f}_t, \tag{1}$$

where $a(> 0)$, $b(< 0)$ and $\boldsymbol{\lambda}$ are location-specific parameters. An alternative motivation for our common factor setup in (1) could be developed by appealing to transaction cost dynamics.[13] We assume that there is no speculation[14] and that price behavior is driven by production decisions and stochastic harvest outcomes.

Following a long literature (Parsley and Wei, 1996; Cecchetti, Mark and Sonora, 2002; Goldberg and Verboven, 2005; Fan and Wei, 2006),[15] we conceptualize the *degree* of market integration as a convergence process in which markets are more integrated the quicker prices return to their equilibrium level after a shock. The 'return to equilibrium' relates to the change in the nominal price P_{it} in location *i relative to* an 'equilibrium proxy' $\bar{P}_t$, defined as $\tilde{p}_{it} = \left(\ln P_{it} - \overline{\ln P_t}\right)$. We provide more details on how we specify the equilibrium proxy $\bar{P}_t$ below. Price convergence is modeled as:

$$\Delta\tilde{p}_{it} = \beta_i \tilde{p}_{i,t-1} + \boldsymbol{\gamma}_i' \boldsymbol{f}_t + \varepsilon_{it}, \tag{2}$$

where the dependent variable is the change in the relative price between $t - 1$ and t, $\Delta\tilde{p}_{it} = \tilde{p}_{i,t} - \tilde{p}_{i,t-1}$. The first term on the right-hand side contains our parameter of interest, β_i, which is the location-specific speed of convergence. If there is no convergence, a shock will have a permanent effect on price

[13] In standard price models transaction costs are captured by a_i. Thus a further interpretation of $\boldsymbol{\lambda}_i' \boldsymbol{f}_t$ would be that transaction costs may follow a more complex dynamic evolution.
[14] The imperial ban on speculation and hoarding of grain by private merchants during the Qing Dynasty can be taken as a motivation for this assumption commonly made in the literature.
[15] See also related work on purchasing power parity by Imbs, Mumtaz, Ravn and Rey (2005) and Bergin, Glick and Wu (2013, 2014).

movements and β_i will be zero. Convergence implies that β_i will be negative and the magnitude of β_i measures the convergence speed: the larger the value of β_i (in absolute terms), the faster prices will converge back to their equilibrium after a shock. Presuming that economic agents seeking profits from arbitrage dissipate price differentials, more integrated markets are associated with more arbitrage activities resulting in a higher speed of convergence. The speed of convergence can also be measured in terms of 'half-life,' calculated as $\ln(0.5)/\ln(1+\beta_i)$, which represents the number of time periods until half the effect of a shock has dissipated.

If nominal prices follow a multifactor error structure, as we assumed in equation (1), the convergence dynamics of the relative price $\tilde{p}_{it}$ will also follow this error structure: the second term in equation (2), $\boldsymbol{\gamma}_i'\boldsymbol{f}_t$, accounts for the fact that changes in relative prices will also be affected by location-specific responses to common shocks.[16]

The inclusion of the multifactor error structure distinguishes our convergence equation from that in other papers, most notably Goldberg and Verboven (2005) and Fan and Wei (2006), who assess market integration in 20th century Europe and China, respectively, using variants of equation (2) without the factor structure. Our empirical implementation uses novel techniques from the panel time series literature, which allow us to study price behavior in diverse sets of markets while accounting for the network effect of trade and the heterogeneous impact of common price shocks such as floods, droughts, or civil unrest. In addition, the length of the time series enables us to study the dynamic evolution of price convergence over time.

The empirical implementation of the convergence equation (2) requires us to specify an 'equilibrium proxy' to which a prefectural price is assumed to converge. Although we examined many candidates, our results primarily focus on two proxies: the average grain price for North and South China respectively,

[16] The factor loading $\boldsymbol{\gamma}_i$ in equation (2) naturally differs from that in equation (1), $\boldsymbol{\lambda}_i$, as a result of the derivation of the relative price equation (available on request). Note further that our multi-factor error structure encompasses the inclusion of a location-specific intercept.

and the average grain price in each of Skinner's (1977a) physiographic macro-regions. Our variable of interest is the relative grain price (in logs) defined as $LPR_{it} = ln(P_{it}/\bar{P}_{rt})$, where P_{it} is the prefectural price and $\bar{P}_{rt}$ is the average prefectural price over the respective region (North or South China) or macro-region at time *t*. Our main estimating equation is given by a Dickey and Fuller (1979) type regression of the form:

$$\Delta LPR_{it} = \alpha_i + \beta_i^{LPR} LPR_{i,t-1} + \sum_{\ell=1}^{p_i} \delta_{i,\ell} \Delta LPR_{i,t-\ell} \qquad (3)$$

$$+\phi_i \overline{\Delta LPR}_t + \varphi_i \overline{LPR}_{t-1} + \sum_{\ell=1}^{p_i} \xi_{i,\ell} \overline{\Delta LPR}_{t-\ell} + e_{it},$$

where the dependent variable is defined as $\Delta LPR_{it} = ln(P_{it}/\bar{P}_{rt}) - ln(P_{i,t-1}/\bar{P}_{r,t-1})$ and our speed of convergence parameter is denoted by β_i^{LPR}. The parameter α_i captures location-specific time-invariant heterogeneity, which will help explain price wedges across diverse locations (e.g. due to remoteness). The last term on the first line of (3) contains lags of the dependent variable, which account for possible serial correlation and capture short-run behavior as is standard in 'Augmented Dickey-Fuller' regressions.[17] Note that parameter heterogeneity aside (β_i^{LPR} versus β^{LPR}) the first line of equation (3) is *identical* to the implementations in Parsley and Wei (1996), Goldberg and Verboven (2006), and Fan and Wei (2006). The second line contains cross-section averages of the dependent and independent variables following Pesaran's (2006) Common Correlated Effects (CCE) approach to capture the impact of common shocks and the trade network.[18] The cross-section averages ($\overline{\Delta LPR}, \overline{LPR}$) included in (3) are the averages based on physiographic macro regions of China (Skinner, 1977a), since unobserved heterogeneity due to weather patterns, flooding, etc. are likely better captured

[17] The number of lags p_i in each prefecture regression is determined by the Schwarz-Bayesian Information Criterion (IC). The alternative Akaike IC does not affect results significantly. Use of common lag lengths in all prefectures similarly has no bearing on the overall results.

[18] We also include centered seasonal (monthly) dummies to capture the effect of heterogeneous harvest seasons across China's agro-climatic areas. The construction of these (orthogonalized) seasonal dummies follows the suggestion in Juselius (2006).

within these units.[19] Taken together the $\overline{\Delta LPR}$ and $\overline{LPR}$ terms capture the unobserved common factors, while the prefecture-specific parameters (ϕ_i, φ_i and $\xi_{i,\ell}$) allow for their heterogeneous factor loadings. Further details of this implementation are provided in the Online Appendix.

In our analysis of Qing grain prices we investigate convergence to the *regional* (South, North) or the *macro-regional* average price and adopt *regional*, *macro-regional* or *agro-climatic regional* cross-section averages to account for common factors. In the analysis of European markets we investigate convergence to the *national* average price (or the *cross-national* average for the cross-European sample) and adopt cross-section averages for the respective full sample.

Equation (3) yields a total of N heterogeneous convergence coefficients (one for each prefecture/market) and we report the (Common Correlated Effects) Mean Group estimate $\hat{\beta}_{MG}^{LPR} = \sum_{i=1}^{N} \omega_i \hat{\beta}_i^{LPR}$ of this set of coefficients (Pesaran and Smith, 1995; Pesaran, 2006) together with its 95% confidence interval.[20] We follow the standard in the literature and employ robust regression methods to estimate weighted averages which are robust to outliers (Hamilton, 1992). Standard errors are computed non-parametrically following Pesaran and Smith (1995). Because this Mean Group estimate is an average of location-specific convergence terms, it as an economy-wide measure of the degree of overall market integration. As an alternative to estimating the speed of convergence and associated half-life we can draw inference on β_i^{LPR} in equation (3) and thus interpret this empirical setup as a panel unit root test.

[19] Using cross-section averages for the entire region (South, North) or by agro-climatic region (Buck, 1937) produces qualitatively identical results of secular market disintegration (see Online Appendix).

[20] Our Mean Group estimates of price convergence are unbiased but inefficient if our assumption of heterogeneous convergence is false. Adopting a pooled version of the CCE estimator (see Online Appendix) yields uniformly *lower* speed of convergence and the same secular decline we find in our main results below. Our findings are robust when we adopt a 30-year rolling window (results available on request).

Instead of analyzing price convergence over the entire time period in a single regression model, the length of our time-series data permits us to use 20-year rolling windows. The window moves one year at a time to avoid seasonal effects. The choice of 20 years is arbitrary, but results are qualitatively identical for 15- or 10-year windows. Five-, 10-, and 20-year windows are used for the monthly European data and a 60-year window for the annual data (see Online Appendix). The rolling window enables us to capture any structural change in the convergence process over time and also allows the factor loadings $\boldsymbol{\gamma}_i$ to vary across subsample periods. Results are presented in graphical form and we carry out a wide range of robustness checks detailed in Section III.2.

III. Empirical Results

III.1 Price Convergence in China and Europe

We begin with our analysis of market integration in Qing China. Figure 3 provides three sets of results for the evolution of price convergence in North (dashed line in each plot) and South China (solid line). Since the first of our rolling windows is for the period 1740-59, the first speed of convergence estimate in Figure 3 is dated at 1759. The second speed of convergence estimate at 1760 is for the period 1741-1760, and so on.

In Figure 3(a) we present robust (CCE) Mean Group estimates for *regional* convergence, $\hat{\beta}_{MG}^{LPR}$, where region refers to the entire North or South. Recall that the larger (in absolute terms) the convergence estimate, the faster prefectural prices converge to the regional average price. We make two observations. Firstly, the convergence speed is higher for the South than the North, and secondly, regional convergence estimates in both regions trend upward, which implies regional markets became *less* integrated over time.

We quantify this decline by estimating the half-life of the price convergence process. For South China, the speed of convergence in the mid-

18th century implies that half the effect of a given shock would dissipate in around eight months. This had slowed to 19 months over the two decades before the turn of the 19th century, while a decade later it was 54 months, before some recovery to about 28 months by 1820. For North China the equivalent half-life at these points in time are 13, 34, 64 and 47 months.

It is somewhat difficult to compare these half-lives to existing results in the literature, given that the latter neither account for cross-section dependence nor for changes in convergence over time. Using price convergence regression models akin to those in the first line of equation (3), Goldberg and Verboven (2005) estimate median half-lives of relative price deviations for automobiles in European markets between 16 and 19 months.[21] Analyzing a large range of consumer products across Chinese cities, Fan and Wei (2006) find dramatically lower half-lives between 0.3 and 5 months.

An alternative interpretation of our setup is that of a unit root test for relative price movements: if the null of a unit root is rejected, prices do converge (without any concern over the predicted time horizon for convergence). We apply this interpretation in the Online Appendix, using Monte Carlo simulations to provide critical values for an averaged *t*-statistic on β_i^{LPR} (following Pesaran, 2007). We find that we can no longer reject a unit root for the relative price series (10% level of significance) for North and South China from 1785 and 1790 onwards, respectively (end years of 20-year rolling windows), which implies that from these dates grain markets in North and South China were fragmented.

Our empirical implementation assumes that common shocks and the network effect primarily operate *within* geographical bounds, an approach that fits into Skinner (1977a) macro-regions framework. Pomeranz (2000: 22, emphasis added) argues that until the 1780s "markets worked well *within*

[21] Their results echo those of Crucini and Shintani (2008) who estimate persistence in law of one price deviations for a large number of goods and cities using auto-regressions of stationary price series, finding a half-life of 19 months for the median good in OECD cities, 12 months for cities in less developed countries and 18 months for US cities.

China's eight or nine macro-regions", while Eastman (1988: 120) similarly argues that commercial interaction *between* macro-regions was slight. These views imply price convergence at the macro-region level rather than the regional (South/North) level that we investigated above. In Figure 3(b) we study this possibility, using the mean price for each Skinner macro-region at time *t* as the reference price.

The overall patterns in the convergence graphs supports the view that within-region integration deteriorated from the 1780s. For North China, the observed convergence for the broad region in Figure 3(a) is similar to the values for the macro-regions in Figure 3(b), but less so for South China. Here within-region integration was stronger until late in the 18th century: the geographical area at which convergence is hypothesized to take place is smaller for the Southern macro-region sample, where we distinguish six macro-regions, compared with the Northern sample, which has only two macro-regions.

What happens to our finding of market disintegration if we (i) do not account for cross-section dependence (common shocks and trade network effects), and (ii) calculate a single estimate of the average speed of convergence for the entire time horizon? Figure 3(c) shows that ignoring cross-section dependence leads to convergence estimates which are *significantly higher* than those in our previous specifications.[22] Note that we omit the substantial downward movement in the convergence estimate for North China (i.e. an increase in market integration) to maintain the same scale on the vertical axis as in the two previous graphs. Implicit half-lives for the augmented models in 3(a) and (b) are up to 25 (North) and four (South) times larger than those for the models ignoring cross-section dependence in 3(c) – detailed comparisons are provided in an Online Appendix. Additionally ignoring changes in the speed of convergence over time we can obtain robust

[22] The analysis in this graph is based on convergence to the regional average price. An Online Appendix provides the Mean Group estimates with and without cross-section average augmentation for each time window.

mean estimates (implied half-lives) of -0.059 (11.5 months) in the North and -0.054 (12.6 months) in the South.[23]

In summary, Figure 3 supports the view that grain markets in China were more integrated in the South than the North, and that both regions suffered prolonged market *dis*integration in the later part of the 18th century. Price convergence results for individual provinces as well as individual macro-regions confirm that these average results are not a product of individual outlier provinces or macro-regions (see Online Appendix). Further, the two core elements of our empirical strategy, namely accounting for cross-section dependence and the analysis of changes in market integration, are shown to be instrumental in establishing this result.

Although the recent literature on market integration in Qing China sides with Shiue and Keller (2007), that for market integration "all was well and good with China in the eighteenth century" (Sng, 2014: 108), there is a variety of historical accounts that describe a decline during the second half of the 18th century. These narratives suggest four intertwined factors that potentially explain a decline in market integration. Firstly, population pressure on arable land, especially in grain surplus interior provinces, which led to a decline in the grain surplus available for trade between these and the advanced regions on the Eastern Seaboard (Eastman, 1988: 242; Li, 2007: 109; Perkins, 1969; Pomeranz, 2000: 13, 22, 85, 184). Secondly, environmental degradation that affected farming and transport, primarily stemming from the "inherently instable" water control systems which were in an "adversarial" relationship with the environment (quotes from Elvin, 2004: 115 and 120-8; see also: Li, 2007: 109; Fairbank and Goldstein, 2006: 171; Marks, 1998; Pomeranz, 2000: 228; Richardson, 1999: 22f). Thirdly, technological factors, which in part relate to the second factor, namely the absence of significant advances in

[23] We compute these estimates as robust means across the 62 estimates from our 20-year rolling window analysis. If we instead estimate a single coefficient from the entire 81-year panel we find somewhat higher half-lives of 15-18 months (depending on specification of the short-run dynamics) in the South and 19-21 months in the North.

transport technology or infrastructure (Kim, 2008: 231; Rawski 1972: 4-5; Watson, 1972; Wiens, 1955: 248f) and agricultural technology (Elvin, 1973; Eastman, 1988; Perkins, 1969; Pomeranz, 2000: 22). And lastly, a decline in the capacity of the Qing state to invest in development and promote further market integration, in part driven by fiscal weakening and in part by "grain protectionism" among local officials whose paramount concern was to 'nourish the people' to avoid civil strife (Cheung, 2008: 116; Marks, 1998: 12; Pomeranz, 2000: 250; Shiue, 2015; Sng, 2014)

The decline in market integration we uncover is clearly substantial, but is it perhaps *too substantial to be credible*? There are two answers to this question: firstly, from an econometric point of view, it bears reminding that as the speed of convergence approaches zero, the implied half-life approaches infinity. In economic terms, it is immaterial whether the half-life is 60 months or 600 months, since either estimate suggests that no price arbitrage is taking place and that markets are functionally disintegrated. Secondly, reviewing the discussion of the significant difficulties associated with transporting a low value to weight good like grain over vast distances (Evans, 1984; Eastman, 1988; Cheung, 2008; Kim, 2008)[24] one should perhaps be surprised that high levels of market integration *had ever been achieved* in early modern China.[25]

How does China's experience compare with price convergence in European markets? Figure 4(a) reports convergence estimates for North and South China alongside those for national grain price samples from Belgium, England, France, and Germany, and a cross-European wheat price sample. These samples were analyzed using the same methodology as the Chinese data. In order to make results from samples with different data frequency

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[24] The cost of rice to transport rice in land transport zones amounted to 6-7% a day (Evans, 1984: 286), indicating that "self-sufficiency was of necessity the dominant economic reality" (ibid, 296) in these parts of the country. The notion that the maladministration of rivers and canals, and ensuing decline in inland waterway navigability had already set in during the late Qianlong era is also widely documented (Hinton, 1952; Li, 2000; Elvin, 2004; Rowe, 2011).

[25] In separate work (available on request) we establish that over the course of the next 170 years (1740-1911) market integration in Southern China did not return to the levels experienced in the mid-18th century.

comparable we plot the implied half-lives (in months) for each convergence result. Figure 4 is limited to results for the 18th and early 19th centuries and we dispense with confidence intervals to aid illustration. The detailed convergence plots for each European sample adopting various rolling window lengths are contained in an Online Appendix.

Figure 4(a) shows the highest level of market integration for the English counties (weekly data), followed by Belgium, France and Germany, and finally the cross-European market sample. Although results for English weekly and monthly data differ, the monthly data do not vastly overestimate the half-life of grain price integration. The Belgian monthly price series suggest market integration in the late 18th century was superior to the English counties. This result reflects Belgium's high quality road network (Buyst et al, 2006: 193), missing price series for markets in underdeveloped regions (Limburg and Luxembourg) and the comparatively small geographic size of the country: the East-West distance from Tienen to Nieuwpoort is under 100 miles, compared with 350 miles from Norfolk to Cornwall; the North-South distance from Antwerp to Binche is about 50 miles, compared with 320 miles from Northumberland to Devon. When we restrict the English sample to the 15 counties of the Southeast, the convergence rate is on par with that of Belgium (results available on request). The difference in the price reporting cycle for Belgium and England as well as the averaging of prices cross time (week) and space (county) for England will also contribute to an upward bias in the English half-lives (Taylor, 2001). The higher half-life for French départements compared with English counties can be linked to "higher trade costs [in France] than Britain due to smaller density, geography, internal barriers, limited development of new methods of distribution and more limited investment in transport infrastructures" (Daudin, 2010: 717). The German sample only covers 12 cities, spread over a large area, which may explain the larger half-life compared with other national markets. The cross-European markets show lower levels of market integration than in the separate national markets, which is not surprising given the significant cultural, political and climatic heterogeneity, and greater distances. The use of *annual* averages for the German and cross-European price series would also bias upward the half-lives compared with those economies for which we are able to use monthly data (Brunt and Cannon, 2014; Taylor, 2001).

Our two Chinese samples clearly differ in their secular evolution of market integration from the other samples, even though for the analysis of English (monthly), Belgian and French price series, the methodologies and data frequency are identical to the Chinese sample. Although the levels of market integration in the 1750s were similar between China's North and South on the one hand and European markets on the other, China witnessed a secular decline in market integration from the 1780s to 1820, with a 'peak' in the early 19th century, when Northern and Southern Chinese markets had estimated half-lives roughly 15 and five times those of European markets, respectively. The contrast is even starker if we compare China with Belgium, France and England. At the end of the Qianlong reign in 1795, which marks the end of the sample period in Shiue and Keller (2007), the North and South China markets had half-lives around 12 and six times those of English markets, respectively. By 1810, these ratios had increased to half-lives roughly 78 and 22 times those of the English markets.

Figure 4(b) reports estimated half-lives for selected Chinese macro-regions alongside some of the European markets to illustrate that market disintegration in the second half of the 18th century was pervasive across all regions of China, including the commercially most advanced Lower Yangzi macro-region. This macro-region analysis further addresses concerns that the above cross-continental comparison is misleading, since the geographical dimensions of North and South China are very much larger (586,000 and 1.7m square miles, respectively) than the European economies studied. The Lingnan (essentially Guangxi and Guangdong) and Lower Yangzi macro-regions cover around 164,000 and 74,000 square miles, respectively (Skinner, 1977a: 213), which makes them more readily comparable to France (210,000 square miles) and England (50,000 square miles).

III.2 Robustness Checks

Since the results for Qing China clearly deviate from those for European markets we carry out various robustness checks for our finding of secular market disintegration. These can be grouped into four categories: (i) related to alternative crops; (ii) related to the sample of prefectures analyzed or the reference price adopted in the convergence analysis; (iii) related to the nature of the convergence process, namely linear or nonlinear; and (iv) related to the cross-section dependence we capture in our cross-section average-augmented convergence regressions. We discuss these in turn below. Detailed results for all robustness checks are confined to an Online Appendix.

(i) In the above analysis we use prices for wheat in the North and medium (2nd) grade rice in the South. Li (2000, 2007) reports wheat was a luxury good and suggests that millet and sorghum were Northern Chinese staple crops (see also Perkins, 1969: 6), while Marks (1991: 70) asserts that common (3rd) grade rice "represented the bulk of grain traded in the markets" of Lingnan. Millet prices are available for 72 prefectures of the North and 1st and 3rd grade rice prices for 110 and 108 Southern prefectures, respectively. Our price convergence analysis for millet as well as superior (1st) and common grade rice produce qualitatively identical results of disintegration. We also compared the convergence speeds for 1st and 3rd grade rice price series. The higher value-to-weight ratio for 1st grade would predict it to converge faster and indeed this was the case in our sample.

Following Shiue and Keller (2007) our analysis uses the monthly *average* grain price computed from the prefectural low and high price reported in the historical records. Over time high and low prices may consistently come from specific locations within the prefecture, e.g. the high price may refer to the prefectural capital (Marks 1998: 11) and the low price to a remote county, such that their separate analysis may indicate whether the use of the average grain price and thus the level of aggregation misses important *within*-prefecture variation. We compute equivalent plots to Figure 3 for high and low price series, respectively, which are indistinguishable from those for the mean price series presented.

(ii) Our analysis of price convergence to the *macro-regional* average may provide distorted results because of differences between commercially advanced core and comparatively backward periphery prefectures within each macro-region. We analyzed convergence of the periphery prefectures to the core average price as well as price convergence in a sample comprised only of core prefectures. Results are again in line with those reported.

Motivated by the suggestion in Wang (1989: 445-6) and elsewhere that Suzhou in Jiangsu province was the center of a single integrated rice market for the macro-regions of Central and Southern China, we also compute the relative price ratio taking the Suzhou prefecture price as reference price. We find this yields statistically very similar results to adopting the regional mean as reference price. We further investigated the macro-region of Lingnan in South China, analyzing convergence to the macro-region average and to Guangzhou, respectively, with results qualitatively identical to those in the larger samples discussed above. These implementations using a specific benchmark price (for Guangzhou or Suzhou) to construct the 'equilibrium proxy' variable LPR_{it} are in the spirit of the specifications in Goldberg and Verboven (2005), Fan and Wei (2006) and Bergin, Glick and Wu (2013).

Although wheat was not the staple crop in South China (Marks, 1998), the availability of wheat prices in the South enables us to investigate price convergence in 156 prefectures of North and South China. Convergence analysis in a 20-year rolling window shows identical patterns to those described above.

(iii) Our empirical analysis assumes that prices either diverge (i.e. relative prices follow a unit root process) or that they converge *in a linear* *fashion*. Taylor (2001) has highlighted that a violation of this linearity assumption can lead to significant bias in the estimated convergence parameter and the implied half-life. We adopt a procedure developed by Cerrato, de Peretti, Larsson, and Sarantis (2011) that tests the relative price series under the null of a unit root but allows for a nonlinear stationary process under the alternative, while also accounting for cross-section dependence. These tests suggest that from around 1790 onwards we can no longer reject the null of nonstationary relative prices in either our North or South China samples. From this date grain markets in North and South China were thus fragmented.

(iv) Does our empirical approach capture sufficient unobserved heterogeneity? Following Pesaran, Smith, and Yamagata (2013), we add the cross-section averages of prefectural *wheat* prices (in lagged levels and first differences according to the lag structure of the specification) to the cross-section averages for the *rice* prices in convergence regression models for 76 Southern Chinese prefectures where these data are available. The common shocks and network effects driving rice prices in the South are likely also to affect wheat prices in the same prefectures, and the methodology applied here exploits this commonality to allow us to potentially improve our estimates for rice price convergence by constructing improved proxies for the unobserved factors. The (CCE) Mean Group estimates for this specification confirm the secular decline in the average level of Southern market integration. We also followed the suggestion in Chudik and Pesaran (2015) to investigate the inclusion of further lags of the cross-section averages to the model along with a bias-correction in form of a half-panel jackknife. Results provide clear evidence for secular decline in market integration in South and North China in line with our previous findings.

All of the above results are based on using cross-section averages within Skinner (1977a) macro-regions to capture cross-section dependence. When we alternatively use Buck's (1937) agro-climatic regions or the entire sample of prefectures in the South or North to construct the cross-section averages our findings are qualitatively unchanged.

IV. Concluding Remarks

In this paper we analysed the extent and dynamics of market integration during the 'Golden Age' of the Qing Dynasty, and contrasted our findings with those from several European economies as well as a cross-European sample of markets. Our empirical results challenge the conventional wisdom developed in the recent literature of Chinese market efficiency on the eve of the Industrial Revolution (Shiue and Keller, 2007). While we use the same data for Qing China as these authors, albeit with higher frequency data (monthly) for an extended time period (we include 1796-1820) and an expanded geographical area (we include wheat prices for a sample of Northern prefectures), our results are fundamentally different for two important reasons. Firstly, our analysis of price convergence accounts for the impact of common shocks and the network effect of trade. Secondly, we allow for market integration to evolve over time by adopting the monthly price series and shifting the analysis to rolling windows of 20 years.

Our price convergence analysis establishes that secular market disintegration occurred in North and South China. While levels of integration in China were comparable to those of Western Europe in the 1750s, by the end of the 18th century a substantial gap had opened up. In terms of market integration, the Great Divergence was well and truly under way.

The present study focuses on the *macro*-economic evolution of market integration. It uses a simple model for price behavior in a general equilibrium framework, which recognizes that trade, and thus price behavior, is subject to network effects and common shocks. Our robustness checks suggest that the process of secular market disintegration we uncover was pervasive, from the North China macro-region to that of Lingnan in the far South and the highly commercialized Lower Yangzi region in the East. But our analysis does not uncover the patterns of disintegration *within* these units of analysis. How did integration fare within geomorphological or political boundaries as compared with across these units? Did peripheral prefectures drop out of the network of integration first? In a companion paper we shift the focus to the *micro*-economic experience of market dynamics to answer these questions. This also enables us to chart some of the narrative in the rich literature on social and economic history of Qing China, which had to be left by the wayside in the present study.

Online Appendix

A detailed 90-page Appendix is available at http://tinyurl.com/qyqzj96. If you experience difficulties downloading this document please contact Markus Eberhardt (markus.eberhardt@nottingham.ac.uk) for a copy.

Sources (Price data)

Chinese grain prices

Qing dai liangjia ziliao ku [Qing Dynasty Grain Price Database]. Institute of Modern History, Academia Sinica, Taiwan. Available online at: http://mhdb.mh.sinica.edu.tw/foodprice.

English wheat prices

Cannon, Edmund and Liam Brunt (2004). *Weekly British Grain Prices from the London Gazette, 1770-1820* [computer file]. Colchester, Essex: UK Data Archive [distributor], July 2004. SN: 4383. Available online at: http://dx.doi.org/10.5255/UKDA-SN-4383-1.

Belgian wheat prices

Vandenbroecke, Chris (1973). 'Het prijsonderzoek van de regering voor de steden van de Oostenrijkse Nederlanden voor graangewassen, vlas en garen (1765-1794)', in C. Verlinden (ed.) *Dokumenten voor de geschiedenis van* *prijzen en lonen in Vlaanderen en Brabant (XIIIe-XIXe eeuw)* Vol. IV. Bruges: De Tempel, pp. 1-49. Available online in due course.

French wheat prices

Labrousse, Ernest, Ruggiero Romano and F.-G. Dreyfus (1970). *Le Prix du froment en France au temps de la monnaie stable 1726-1913*. Paris: S.E.V.P.E.N. Available online in due course.

German rye prices

Rahlf, Thomas, (1996 [2005]) *Getreidepreise in Deutschland 1500-1800* [computer file]. GESIS (Leibniz Institut für Sozialforschung) Datenarchiv, Köln. histat. Studiennummer 8140. Datenfile Version 1.0.0. Available online at: www.gesis.org/histat.

European wheat prices

Allen, Bob and Richard Unger (accessed July 2015) *Global Commodity Prices Database*. Available online at: www.gcpdb.info.

References

Andrews, Donald W. 2005. "Cross-section Regression with Common Shocks." *Econometrica*, 73(5): 1551-85.

Andrade, Philippe, and Marios Zachariadis. 2016. "Global versus local shocks in micro price dynamics." *Journal of International Economics*, 98: 78-92.

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

Bailey, Natalia, George Kapetanios, and M. Hashem Pesaran. 2015. "Exponent of Cross-Sectional Dependence: Estimation and Inference." *Journal of Applied Econometrics*, forthcoming.

Beck, Guenter W., Kirstin Hubrich and Massimiliano Marcellino. 2015. "On the Importance of Sectoral and Regional Shocks for Price-Setting." *Journal of Applied Econometrics*, forthcoming.

Berg, Kimberly A. and Nelson C. Mark. 2015. "Third-country effects on the exchange rate." *Journal of International Economics*, 96(2): 227-43.

Bergin, Paul R., Reuven Glick, and Jyh-Lin Wu. 2013. "The micro-macro disconnect of purchasing power parity." *Review of Economics and Statistics*, 95(3): 798-812.

Bergin, Paul R., Reuven Glick, and Jyh-Lin Wu. 2014. "Mussa redux and conditional PPP." *Journal of Monetary Economics*,68: 101-114.

Brenner, Robert, and Christopher Isett. 2002. "England's divergence from China's Yangzi Delta: Property relations, microeconomics, and patterns of development." *The Journal of Asian Studies*, 61(2): 609-62.

Bernhofen, Daniel, Markus Eberhardt, Jianan Li, and Stephen Morgan. 2016. "The Evolution of Markets in China and Europe on the Eve of Industrialisation." Unpublished mimeo.

Brunt, Liam and Edmund Cannon. 2013. "The truth, the whole truth and nothing but the truth: the English Corn Returns as a data source in economic history, 1770-1914." *European Review of Economic History* 17(3): 318-339.

Brunt, Liam and Edmund Cannon. 2014. "Measuring market integration in the English wheat market, 1770-1820: New methods, new answers." *Explorations in Economic History* 52: 111-130.

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

Buyst, Erik, Stefan Dercon, and Bjorn van Campenhout. 2006. "Road Expansion and Market Integration in the Austrian Low Countries during the Second Half of the 18th Century." *Histoire & Mesure* 21(1):185-219.

Cecchetti, Stephen G., Nelson C. Mark, and Robert J. Sonora. 2002. "Price index convergence among United States cities." *International Economic Review*, 43(4), 1081-99.

Cheung, Sui-Wai. 2008. *The Price of Rice: Market Integration in Eighteenth-Century China*. Bellingham: Western Washington University Press.

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

Chudik, Alexander, and M. Hashem Pesaran 2013. "Large panel data models with cross-sectional dependence: a survey." CESifo Working Paper No. 4371.

Chudik, Alexander, and M. Hashem Pesaran 2015. "Common correlated effects estimation of heterogeneous dynamic panel data models with weakly exogenous regressors." *Journal of Econometrics*, 188(2): 393-420.

Coakley, Jerry, Ana-Maria Fuertes, and Ron P. Smith. 2006. "Unobserved heterogeneity in panel time series models." *Computational Statistics & Data Analysis*, 50(9): 2361-80.

Crucini, Mario J., and Mototsugu Shintani. 2008. "Persistence in law of one price deviations: Evidence from micro-data." *Journal of Monetary Economics* 55: 629-44.

Daudin, Guillaume. 2010. "Domestic Trade and Market Size in Late-Eighteenth-Century France." *Journal of Economic History* 70(3): 716-43.

Deaton, Angus, and Guy Laroque. 1992. "On the Behavior of Commodity Prices." *Review of Economic Studies*, 59: 1-24.

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

Dickey, David A., and Wayne A. Fuller. 1979. "Distribution of the Estimators for Autoregressive Time Series with a Unit Root." *Journal of the American Statistical Association*, 74(366): 427-31.

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

Eberhardt, Markus, Christian Helmers, and Hubert Strauss. 2013. "Do spillovers matter when estimating private returns to R&D? *Review of Economics and Statistics* 95(2): 436-48.

Eberhardt, Markus, and Andrea Presbitero. 2015. "Public debt and growth: Heterogeneity and non-linearity". *Journal of International Economics*, 97(1): 45-58.

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

Elvin, Mark. 2004. *The Retreat of the Elephants: An Environmental History of China*. Yale University Press.

Fan, C. Simon, and Xiaogdong Wei. 2006. "The Law of One Price: Evidence from the Transitional Economy of China." *Review of Economics and Statistics*, 88(4): 682-97.

Fairbank, John K. and Merle Goldstein. 2006. *China: A new history*. Belknap Press of Harvard University Press, 2nd edition.

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

Goldberg, Pinelopi K. and Frank Verboven. 2005. "Market Integration and Convergence to the Law of One Price: Evidence from the European car Market." *Journal of International Economics*, 65(1): 49-73.

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

Head, Keith, and Thierry Mayer. 2014. "Gravity equations: Workhorse, toolkit, and cookbook." In: Gita Gopinath, Elhanan Helpman, and Kenneth Rogoff (eds) *Handbook of International Economics*, Vol. 4. Amsterdam: Elsevier North-Holland.

Hinton, Harold C. 1952. “The Grain Tribute System of the Ch’ing Dynasty.” *The Far Eastern Quarterly*, 11(3): 339-54.

Huang, Philip C.C. 2002. “Development or involution in 18th century Britain and China?” *The Journal of Asian Studies*, 61(2): 501-38.

Imbs, Jean, Haroon Mumtaz, Morten O. Ravn, and Helene Rey. 2005. “PPP Strikes Back: Aggregation and the Real Exchange Rate” *Quarterly Journal of Economics*, 120(1): 1-43.

Juselius, Katarina. 2006. *The Cointegrated VAR Model: Methodology and Applications*. Oxford University Press.

Kim, Nanny. 2008. “Transport im China der spaeten Kaiserzeit, 1500-1900: Eine Bestandsaufnahme.” In: Stieferle, Rolf Peter (Ed) *Transport-geschichte*. Berlin.

Li, Lillian M. 2000. “Integration and Disintegration in North China’s Grain Markets, 1738-1911.” *Journal of Economic History*, 60(3): 665-99.

Li, Lillian M. 2007. *Fighting famine in North China: state, market, and environmental decline, 1690s-1990s*. Stanford University Press.

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

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

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

Parsley, David C., and Shang-Jin Wei. 1996. “Convergence to the law of one price without trade barriers or currency fluctuations.” *Quarterly Journal of Economics*, 111(4): 1211-36.

Perkins, Dwight H. 1969. *Agricultural development in China, 1368-1968*. Edinburgh University Press.

Pesaran, M. Hashem. 2006. "Estimation and inference in large heterogeneous panels with cross-section dependence." *Econometrica*, 74(4): 967-1012.

Pesaran, M. Hashem. 2007. "A simple panel unit root test in the presence of cross-section dependence." *Journal of Applied Econometrics*, 22(2): 265-312.

Pesaran, M. Hashem and Ron P. Smith. 1995. "Estimating long-run relationships from dynamic heterogenous panels." *Journal of Econometrics*, 68(1): 79-113.

Pesaran, M. Hashem, L. Vanessa Smith and Takashi Yamagata. 2013. "Panel Unit Root Tests in the Presence of a Multifactor Error Structure." *Journal of Econometrics*, 175(2): 94-115.

Phillips, Peter C.B., and Donggyu Sul. 2007. "Bias in dynamic panel estimation with fixed effects, incidental trends and cross section dependence." *Journal of Econometrics*, 137(1): 162-88.

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

Rawski, Evelyn S. 1972. *Agricultural Change and the Peasant*. Cambridge, MA: Harvard University Press.

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

Sarafidis, Vasilis, and Tom Wansbeek. 2012. "Cross-sectional dependence in panel data analysis." *Econometric Reviews*, 31(5): 483-531.

Shiue, Carol H. 2002. "Transport Costs and the Geography of Arbitrage in Eighteenth Century China." *American Economic Review*, 92(5): 1406-19.

Shiue, Carol H. 2004. "Local Granaries and Central Government Disaster Relief, Moral Hazard and Intergovernmental Finance in 18th and 19th Century China." *Journal of Economic History*, 64(1): 100-24.

Shiue, Carol H. 2015. "The organization and scope of grain markets in Qing China, 1644-1911." In: R.J. van der Spek, Bas van Leeuwen and Jan

Luiten van Zanden (eds) *A History of Market Performance From Ancient Babylonia to the modern world.* Chapter 13: 339-359. London: Routledge.

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

Skinner, G. William. 1977a. "Regional urbanization in nineteenth-century China." In Skinner, G. William (ed.) *The City in Late Imperial China*. Part one, 211-49. Stanford University Press.

Skinner, G. William. 1977b. "Cities and the Hierarchy of Local Systems." In Skinner, G. William (ed.) *The City in Late Imperial China*. Part two, 275-351. Stanford University Press.

Sng, Tuan Hwee. 2014. "Size and Dynastic Decline: The Principal-Agent Problem in Late Imperial China 1700-185." *Explorations in Economic History*, 54: 107-27.

Taylor, Alan M. 2001. "Potential Pitfalls for the Purchasing-Power-Parity Puzzle? Sampling and Specification Biases in Mean-Reversion Tests of the Law of One Price." *Econometrica* 69(2): 473-98.

Vries, Peer. 2015. *State, Economy and the Great Divergence: Great Britain and China, 1680s-1850s*. London: Bloomsbury.

Wang, Yeh-Chien. 1989. "Food Supply and Grain Prices in the Yangzi Delta in the Eighteenth Century." In Yung-san Lee and Ts'iu-jung Liu (eds) *China's Market Economy in Transition*. Taipei: Institute of Economics, Academia Sinica.

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

Wang, Yeh-Chien, and Zen-yi Chen. 2002. "Grain Markets in Eighteenth-century China". In Ts'ui-jung Liu and Shou-chien Shih (eds) *Economic History, Urban Culture and Material Culture*. Nankang, Taibei:

Academia Sinica. Reprinted in Wang Yeh-Jien, *Collected Essays in the Economic History of Qing China*, Vol. 3, pp. 397-415. Taipei: Daoxiang Publisher, 2004).

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

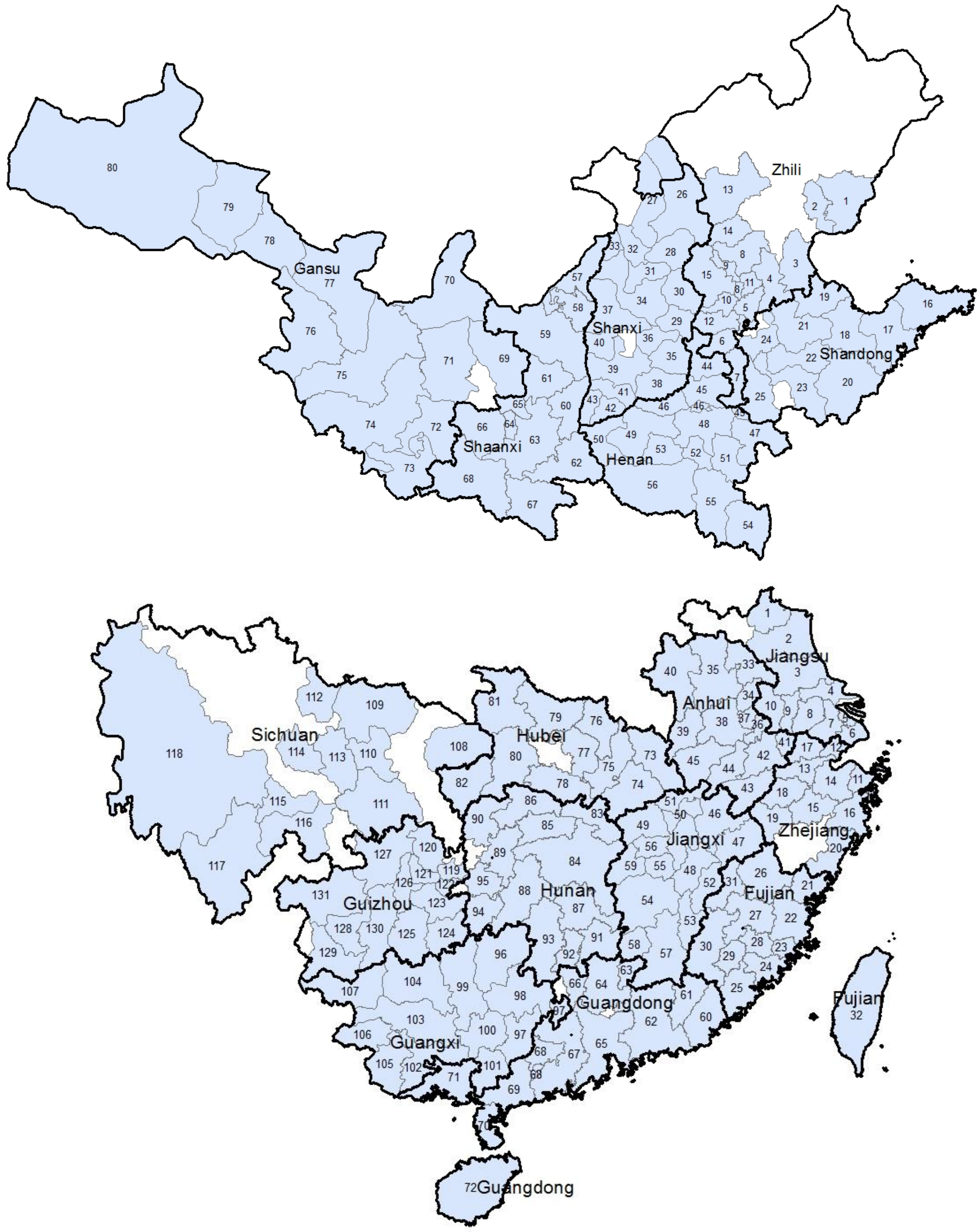
Wiens, Herold J. 1955. "Riverine and Costal Junks in China's Commerce", *Economic Geography*, 31(3): 248-64.

Will, Pierre-Etienne, and Roy Bin Wong. 1991. *Nourish the people: the state civilian granary system in China, 1650-1850.* Ann Arbor: University of Michigan Press.

Wong, Roy Bin. 1997. *China transformed: historical change and the limits of European experience*. Ithaka, New York: Cornell University Press.

Figures

Figure 1: Sample of Prefectures for North (top) and South China



Notes: Thick black lines signify provincial borders, thin black lines prefectural borders. Prefectures included in the samples for North and South China are shaded. All borders are for 1820.
Source: GIS Data from the China Historical GIS project (CHGIS, Harvard), Version 4.

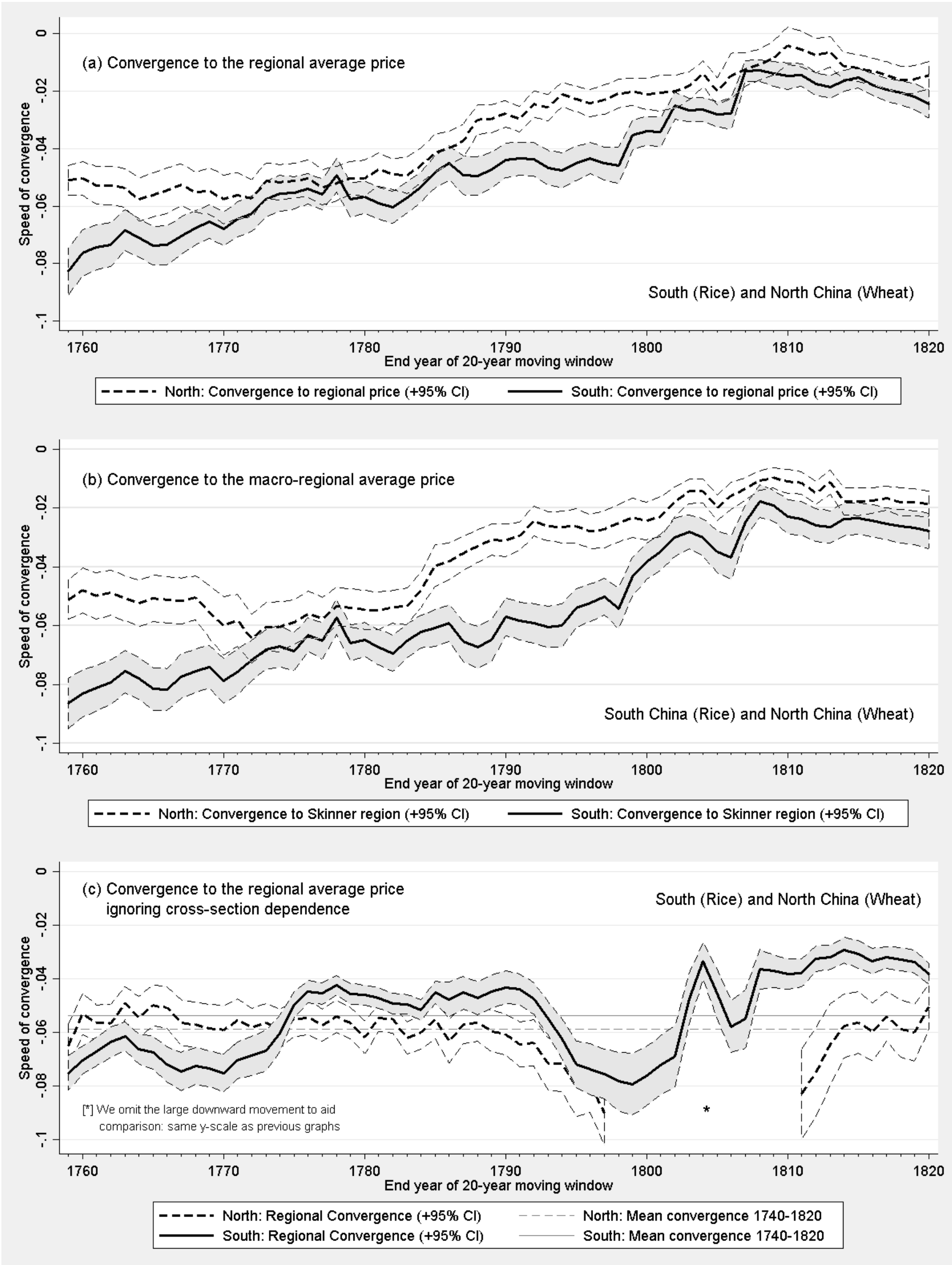
Figure 2: Geomorphological Regions of China

Sources: Skinner, G. W., Henderson, M. and Yue, Z. (no date). “A note regarding the Physiographic and Socioeconomic Macroregions of China.” The macro-regions are defined as follows (further details including Chinese names are contained in an Online Appendix):

10	Northeast China (Manchuria)*	60	Lower Yangzi
20	North China	70	Southeast Coast
30	Northwest China		71 Ou-Ling Basins
	31 Wei-Fen Basins		72 Min Basin
	32 Upper Huang Basin		73 Zhang-Quan
	33 Gansu (Hexi) Corridor		74 Han Basin
40	Upper Yangzi		75 Taiwan
50	Middle Yangzi	80	Lingnan
	51 Middle Yangzi proper	90	Yungui
	52 Gan Basin		
	53 Yuan Basin		
	54 Upper Han Basin		

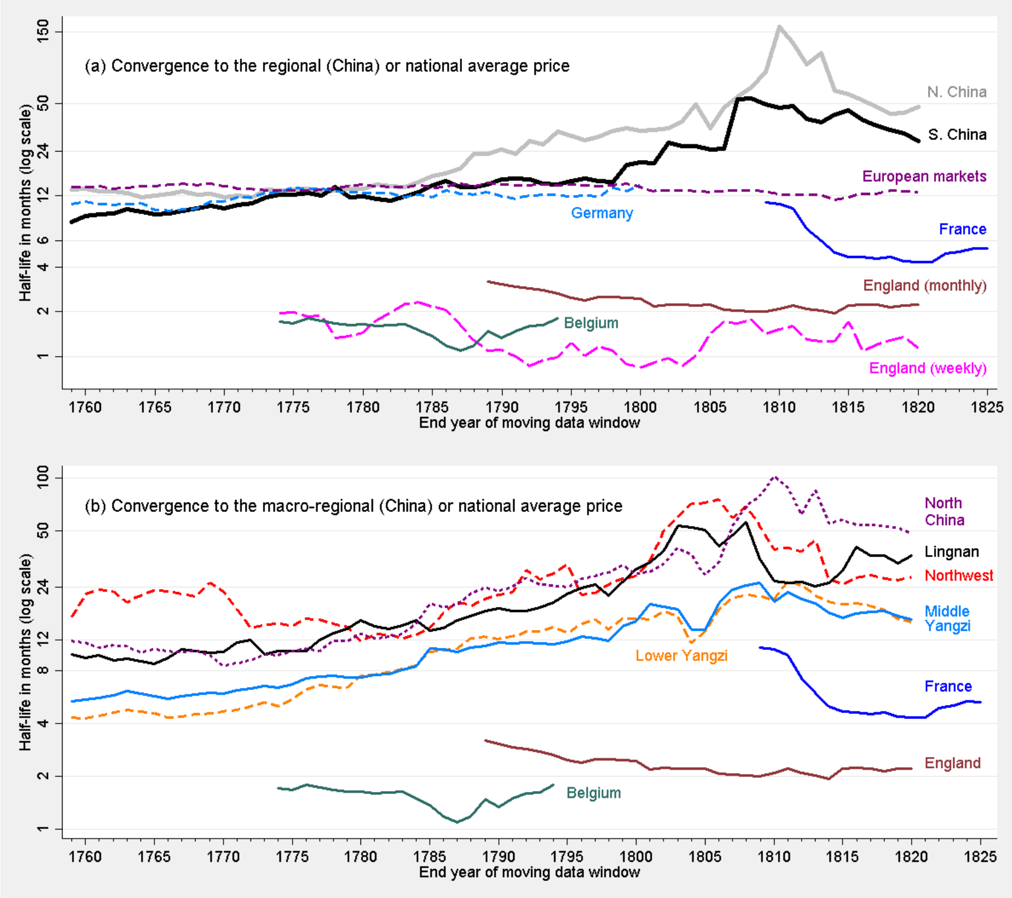
*Note that our sample does not contain prefectures in Manchuria (ID: 10) or Yunnan (parts of 90). Since the former is typically not seen as part of the ‘18 provinces of China proper’ the literature typically talks of the *eight* Skinner macro-regions. In our analysis we use the upper level of aggregation (20, 30, etc) to form cross-section averages or to define reference (equilibrium) prices.

Figure 3: Regional and Macro-Regional Convergence in China



Notes: We plot average convergence coefficients (and their 95% confidence intervals) from the analysis of Southern (solid line) and Northern Chinese (dashed line) grain prices in 131 and 80 prefectures, respectively, using a 20-year rolling window. In the specification in 1(b) we are forced to drop two prefectures in the Northern Chinese sample since these represent the only observations in respective macro-regions ('isolets').

Figure 4: Comparison of Chinese and European Grain Price Convergence



Notes: We plot the half-lives (in months) implied by the robust mean convergence estimates from the analysis of various samples comparing Chinese regions (in graph (a): North and South China, in graph (b): selected Skinner macro-regions) and European market integration (note that the *y*-axis is on a logarithmic scale and that for illustrative purposes the scales differ between the two graphs). We omit confidence intervals to aid illustration. The *longer* the half-life, the *slower* is price convergence to the equilibrium. Results for Belgium, England, European markets, France, and North China (both the region in graph (a) and the identically-named Skinner macro-region in graph (b)) are derived from wheat prices, those for South China (and all Southern macro-regions) are for rice and the German results are for rye. Data for Belgium, England, France, and China are monthly, German and European market price series are annual; we also include results for the English county series at the original weekly frequency. Graph (b) exclusively uses data available at monthly frequency. Results are derived from rolling windows of 60 (annual German and European data), 20 (Chinese and English monthly data), 10 (French and Belgian monthly data) and 5 (weekly English county data) years' length. For illustrative purposes we exclude convergence plots for the Upper Yangzi and the Southeast Coast macro-regions in graph (b) – these are available in the Online Appendix. We only have data for Guizhou province within the Yungui macro-region, so that this macro-region is also excluded. A price convergence plot for Guizhou province is contained in the Online Appendix. We provide some figures for the geographic size of some macro-regions and European countries in the text.