Assessing market (dis)integration
in early modern China and Europe[*]

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Abstract: We introduce new empirical strategies for the study of price convergence dynamics which account for general equilibrium effects arising from common shocks and network effects. We employ these methods to challenge established claims of comparable degrees of market integration in Europe and China on the eve of the Industrial Revolution. Using monthly grain prices for 1740-1820, our analysis uncovers a secular process of market disintegration in 211 prefectures of Qing China. This finding is confirmed for various sub-regions, including the advanced Yangzi River Delta. Comparing our results to those for national grain price panels from England, Belgium, France, Germany and a cross-continental panel of European cities we conclude that in terms of market integration Qing China and Western Europe had already begun diverging many decades before the turn of the 19th century.

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

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

1. Introduction

Competitive markets and their supporting institutions have long been argued to have enabled the emergence of modern economic growth. Market expansions are seen as "perhaps *the* driving forces in long-run development" (Acemoglu et al 2005: 440). Markets that were integrated and thus efficient in allowing long-distance trade and arbitrage to take place were associated with the onset of the Industrial Revolution and the sustained rise in per capita income thereafter. Such markets spurred on Smithian growth in agrarian societies, generating gains from specialization and the division of labor, which made surpluses available for investment in non-farm activities. Labor, products and services were increasingly exchanged. Well-performing markets thereby helped usher in industrialization.

Comparative studies of Europe and Asia have long asked why modern economic growth took root in Europe rather than elsewhere. Relative to Europe, China and India were vast economies with (in output terms) large handicraft-based industrial sectors. They also had vibrant markets. But they fell behind Europe starting from sometime between the middle of the 18th and the early 19th centuries: Europe and its settler offshoots industrialized and became rich, and "the rest", most notably India and China, remained agrarian and poor. The gap between Europe – England in particular – and the rest has become known as the "Great Divergence", after a book of that title by Kenneth Pomeranz (2000).[1]

Well-performing markets are only part of the story behind the escape from Malthusian stasis that had hitherto characterized human history to a new world of economic growth and rising living standards. Markets may well be less than essential, with political institutions and the capacity of the state perhaps more important for industrialisation.[2] The presence or absence of markets, as we show in this paper, tells us little about the timing of industrialization. But their efficiency measured in terms of the degree of integration as well as the evolution of this efficiency over time may tell us

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[1] The literature on the Great Divergence is large. The work seminal to the debate is Pomeranz (2000), along with critiques by Brenner and Isett (2002) and Huang (2002). For an extensive recent survey, see Vries (2015), and for an overview of Chinese economic history, von Glahn (2016).

[2] The literature on the role of institutions and modern economic development includes notable studies by North (1990), North and Weingast (1989), Acemoglu et al (2001, 2002, 2005), Acemoglu and Robinson (2012), among others. Brandt, Ma and Rawski (2014) review of the literature on China's divergence and modern convergence emphasized the role of state institutions.

something about the character of economic exchange in an early modern society and the latent potential of the infrastructure and institutional environment to support modern economic growth.

In a seminal study, Shiue and Keller (2007: 1190) find that "as late as 1780, markets in China were comparable to most of those in Western Europe",[3] though English markets performed better than continental Europe or China. Their finding of well-performing markets gave empirical support to the assertion of Pomeranz (2000: 70) that not only was China on par with Europe, but that "eighteenth-century China … came closer to resembling the neoclassical ideal of a market economy than did Western Europe." Pomeranz argued that the advanced regions of Europe and China were "a world of surprisingly resemblances" (29) and that both regions were broadly comparable in their level of development (life expectancy, consumption and living standards, commercialization and markets) and that they faced similar constraints on continued Smithian growth (especially the need for new sources of energy, but also food and fibre for clothes).

Our paper makes two contributions. First, we introduce a new econometric methodology to analyse price convergence in long panel time series. Our approach recognises that markets are part of a network of trade in which location-specific prices are determined within a general equilibrium system. It also recognises that markets are subject to local and global shocks, which induce common price movements unrelated to trade and spatial arbitrage. Our model of grain price behaviour incorporates both the network dependence aspect of trade (and thus prices) and exogenous shocks to production by means of a multifactor error structure.

Our empirical implementation builds on the Pesaran (2006) common correlated effects (CCE) estimator to investigate heterogeneous price convergence to specified equilibrium proxies. Our approach is linked to existing work on market integration (Parsley and Wei, 1996; Cecchetti, Mark and Sonora, 2002; Goldberg and Verboven, 2005; Fan and Wei, 2006), but extends their common framework by incorporating general

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[3] Shiue and Keller's (2007) choice to single out 1780 is curious. Their comparison between East and West using cointegration analysis is *cross-sectional* (static) in nature, and therefore does not allow them to make any claims about the *changes* in market integration as implied by this quote: while they do provide European results for 1825-49 they do not analyse any Chinese data after 1795. With their Chinese sample running from 1742 to 1795 they could thus either claim that the level of market integration *for this entire period* or *for the mid-point of 1769* was deemed on par with that of Western Europe.

equilibrium effects. In contrast to the pairwise cointegration (e.g., Shuie and Keller, 2007) or first-order autoregressive model (e.g., Crucini and Shintani, 2008) approaches, our estimator is robust to stationary or non-stationary price series.[4]

Our conceptual framework of price behaviour incorporates a mechanism akin to multilateral resistance in the gravity model of bilateral trade flows (see 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 between global and local shocks in recent work on price dynamics (Andrade and Zachariadis, 2016; Beck, Hubrich and Marcellino, 2016). The network aspect of price movements manifests itself in observed price series in what econometricians call 'cross-section dependence' (Andrews, 2005; Chudik and Pesaran, 2015a). 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).[5]

Second, our analysis reveals the *dynamic patterns* of grain market integration in 18th century China and Western Europe. The new methodology is implemented using 20-year rolling windows applied to a rich dataset of prefectural monthly grain prices in China (1740-1820), monthly grain prices for Belgian markets (1765-1794), English counties (1770-1820), French *départements* (1800-1872), as well as annual data for German cities (1700-1800) and a cross-European sample of markets (1700-1820). The econometric estimates uncover a *prolonged process* of market disintegration for China. While the level of integration in China around 1750 was *statically* comparable to that in Europe, it was *dynamically* diverging. By the early 19th century, Chinese markets were functionally disintegrated. This finding holds for South and North China on the whole, as well as sub-regions of similar geographical size to national markets in Western Europe, including the most advanced Lower Yangzi region and the Southern Lingnan region. By applying identical methodology for the European data to that used for our Qing price analysis, and

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[4] Deaton and Laroque (1992: 3) argue that for commodity prices like those studied in our empirical application a random walk process inducing non-stationary price series "seems very implausible, at least for commodities where the weather plays a major role in price fluctuations", since this property implies that all shocks to harvests have a permanent impact.

[5] 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, 2016). Ignoring the former can lead to bias whereas ignoring the latter will merely lead to misleading inference (Chudik and Pesaran, 2015a). Our empirical implementation can account for both types of dependence.

(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.

Our revealed dynamic patterns of (dis)integration challenge the conclusions of the influential Shiue and Keller (2007) paper, which is based on a *static cross-sectional comparison* of bilateral market locations across different distance categories over the 54-year period from 1742 to 1795.[6] We empirically demonstrate that addressing both the general equilibrium effects and the dynamics of integration explain the qualitative difference between our results and theirs.[7]

Our results furthermore confirm past narratives that market integration in South 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 (Rawski, 1972; Elvin, 1973; Eastman, 1988; Evans, 1984; Kim, 2008). The revealed weakening in market integration over time also lends support to earlier narratives that integration between regions was relatively weak and already in decline, "especially after about 1780" (Pomeranz, 2000: 22). Explanations for this include the segmentation of China's regional economies (Skinner, 1977a), the presence of vibrant local markets without integration between regions (Rawski, 1972), and environmental-technological constraints arising 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, 2014; Rawski, 1972; Skinner, 1977b; Sng, 2014).

We subject our findings of Chinese market disintegration to several robustness checks related to alternative crops, the sample of prefectures analysed, and the reference

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[6] Shiue and Keller (2007) employ data for February and August in each year, resulting in a total of 108 time series observations in 121 prefectures of Southern China.

[7] In a companion paper (Bernhofen, Eberhardt, Li and Morgan, 2017), we adopt Shiue and Keller's (2007) pairwise cointegration methodology, albeit with monthly data and a rolling window of analysis, to find *secular decline* in Southern Chinese market integration. The cointegration approach to the analysis of market integration is however subject to several serious caveats, including the assumptions of non-stationary and cross-sectional independent price series, neither of which are likely to hold in the present context. In an Online Appendix we present panel unit root tests, which strongly reject the null of non-stationary prices. Prefecture-specific tests indicate that the data can only not reject the null of nonstationarity if we specify a model without an intercept. Given the widely acknowledge price inflation over the 18th century (e.g., von Glahn, 2016), this specification seems deliberately misspecified. We further present a number of tests for cross-section dependence for the seasonally adjusted data as well as data filtered using regional, Skinner macro-regional, and agro-climatic regional averages. These indicate the strong cross-section dependence in the former and suggest we can reject strong dependence in the latter.

price adopted in the convergence regressions. We also investigate whether nonlinear adjustment dynamics had distorted our linear convergence analysis (Taylor, 2001) and consider alternative specifications to capture common shocks and network effects.

The remainder of this paper is organised as follows: Section 2 lays out the theoretical model and our empirical methodology. Section 3 briefly discusses the data and sources. Section 4 presents the empirical findings and provides robustness checks. Section 5 concludes.

2. Empirical Framework and Implementation

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 $\Phi(h, H) = \Pr\left(h_{i,t+1} \leq H_{it} \mid h_{it} = h_i\right)$. The price P_{it} in market i at time t is *not exclusively* determined by local harvest output h_{it} but also by 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 non-zero factor loading in markets i and j would suffice to induce cross-sectional price dependence. For example, if the component k of $\boldsymbol{f}_t$ pertains to 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. Here we make no assumptions about the geographical reach of such shocks.

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[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). Our own investigation of the price series (see Online Appendix) provides strong evidence against unit root behaviour and against weak cross-section dependence.

Our empirical implementation is robust to localised shocks as well as shocks that affect all locations in the entire sample (Chudik, Pesaran and Tosetti, 2011). 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 with its neighbors or markets further afield. For instance, a remote prefecture on the periphery of Sichuan in China's southwest will have a higher λ than a prefecture along the Pearl River Delta of Guangdong. The relative magnitudes of factor loadings λ_i^k across locations could arise from many causes (e.g., remoteness, river access, terrain, local climate, security of roads, and availability of porters). Our common factor framework allows us to remain agnostic about which of these determinants are present in the data. [10]

In a pre-modern agrarian economy such as Qing China with little technological progress we assume that shocks to harvest output (e.g., weather shocks) are exogenous. However, our setup recognizes that widespread flooding, civil strife or other shocks to market i are likely to extend beyond prefectural or other political boundaries to affect the harvest in close-by market j as well: harvest outcomes *themselves* are correlated across locations. [11] Since local Qing officials intervened in grain markets through the management of granaries our setup also captures the effect of correlated public granary management across prefectures in response to common harvest shocks.

The local commodity 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 appeal to transaction cost dynamics: in standard price models transaction costs are captured by a_i and are assumed time-invariant but the inclusion of $\boldsymbol{\lambda}'_i \boldsymbol{f}_t$ would allow transaction costs to follow a more complex dynamic evolution. We assume that there is no speculation[12] and that price behavior is driven by production decisions and stochastic harvest outcomes.

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[10] Further details on this model and its implementation can be found in Eberhardt, Helmers and Strauss (2013) and Eberhardt and Presbitero (2015).
[11] We assume that Cov(h,**f**)>0 in each market *i*, which creates a direct link between harvest output and the unobserved common factors.
[12] 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.

Following a long empirical tradition (Parsley and Wei, 1996; Cecchetti, Mark and Sonora, 2002; Goldberg and Verboven, 2005; Fan and Wei, 2006)[13] we conceptualize the *degree* of market integration as a price 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 then modeled as:

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

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 movements and β_i will be zero. Convergence implies that β_i will be negative. 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 that result in faster convergence. The speed of convergence can also be measured in terms of 'half-life,' calculated as $\ln(0.5)/\ln(1 + \beta_i)$ for β_i from equation (2), which is the number of time periods until half the effect of a shock has dissipated.

If nominal prices follow a multifactor error structure, as we assume 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.[14]

The inclusion of the multifactor error structure distinguishes our convergence equation from that in other papers, most notably Goldberg and Verboven (2005) and Fan

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[13] See also related work on purchasing power parity by Imbs, Mumtaz, Ravn and Rey (2005) and Bergin, Glick and Wu (2013, 2014).

[14] 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 Wei (2006), who assess market integration in 20th century Europe and China, respectively, using variants of the model in (2) without the factor structure.

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 (see Online Appendix), with qualitatively identical outcomes, our results here primarily focus on two proxies: the average grain price for North and South China respectively, and the average grain price in each of Skinner's (1977a) "physiographic macro-regions", which correspond to the major river basins with watersheds and mountain ranges as boundaries (see Section 3 for details).

Our variable of interest is the relative grain price or price gap (in logs) $LPR_{it} = ln\,(P_{it}/\bar{P}_{rt})$, where P_{it} is the price in prefecture i and $\bar{P}_{rt}$ is the average price over the respective region (North or South China) or macro-region at time t. Our main estimating equation is 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}.[15] The parameter α_i captures location-specific time-invariant heterogeneity, which will help explain permanent 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.[16] 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 (2005), 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.

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[15] 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).

[16] 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.

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, and so on are likely to be better captured within these larger geographic units. 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). 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. We provide some simple algebra in the Online Appendix, which conveys intuitively why this approach captures the unobserved time-varying heterogeneity. Theoretical work and simulations have shown that the augmentation with averages is extremely powerful, providing consistent estimates in the presence of non-stationary factors, structural breaks, and cointegration or non-cointegration of the model variables (Kapetanios, Pesaran and Yamagata, 2011; Pesaran and Tosetti, 2011).

In our analysis of Qing prefectural 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 location) 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.[17] 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). The Mean Group estimate, an average of location-specific convergence terms, is an economy-wide measure of the degree of overall market integration. As an alternative to estimating the speed of convergence and associated half-

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[17] Our Mean Group estimates of price convergence are unbiased but inefficient if our assumption of heterogeneous convergence is false. A pooled version of the CCE estimator (see Online Appendix) yields uniformly *lower* speeds of convergence and the same secular decline we find in our main results below.

life we can draw inference on β_i^{LPR} in equation (3) and interpret this empirical setup as a panel unit root test.

The CCE estimator can accommodate an *infinite* number of weak common factors to represent localised shocks confined to a small number of markets (Chudik, Pesaran and Tosetti, 2011): this accounts for the plausible setup that a peripheral market i is perhaps not only affected by common shocks to its macro-region or agro-climatic region, but also by 'local' shocks to a small group of markets surrounding it. Just like serial correlation merely affects inference and not consistency of an estimate, this (weak/spatial) dependence also does not affect our Mean Group estimate $\hat{\beta}_{MG}^{LPR}$. Since inference for this Mean Group estimate is not based on standard errors of the individual β_i^{LPR} the inefficiency has no bearing on the empirical result, hence the ability of the CCE to accommodate infinite local shocks and spillovers.

The length of our time-series data (on average more than 700 monthly observations) permits us to use 20-year rolling windows instead of analyzing price convergence over the entire time period in a single cross-section regression model. 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 30-, 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 structural change in the convergence process over time and also allows the factor loadings γ_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 4.2.

3. 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 11 provinces of South China, and for wheat from 80 prefectures in six provinces of North China between 1740 and 1820. Our data capture all of the 18 provinces of Qing China Proper with the exception of Yunnan. The Qing state collected these data as part of an elaborate commodity price reporting system, which began tentatively 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 (1735-95). We use the subset of medium-grade rice and wheat prices, recorded in taels (*liang*, ounces of silver) per granary bushel (*cang shi,* around 104 litres), compiled by Wang Yejian [Yeh-Chien] and collaborators.

These price data are generally agreed to 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; Keller, Shiue and Wang, 2015). Simple analyses of the pairwise correlation of mean prices using rolling 20-year windows (available on request) conform with expected spatial price behaviour (nearby pairs have higher degrees of correlation than more distant pairs) and go some way to dispel concerns over differential or deteriorating data quality over time. The share of prefectures in which prices change from month to month *declines* over time – in our minds this is just as likely a manifestation of the decline in market integration as it is purported evidence for declining data quality.

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). The sample covers January 1740 to December 1820 (on average 19% of observations were missing in each regional sample).[18] During this period changes in market integration were mostly

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[18] Our heterogeneous panel econometric approach avoids the undesirable weighting implicit in pooled regressions of unbalanced panel data and is robust to this data feature. We carried out robustness checks to demonstrate that varying data availability across prefectures and time does not drive our empirical results (see Online Appendix).

related to internal factors rather than external-related political, technology and trade shocks that increasingly affected China during the 19th 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).

We use information on boundaries for eight 'physiographic macro-regions' (Skinner, 1977a), shown in the top panel of Figure 2. At its core each macro-region has a concentration of arable land, population, and urban centres, which thin out toward the periphery. Skinner (1977a) argued that the macro-regions developed separately and that most trade in volume and transaction value took place *within* rather than between macro-regions.[19] An estimated 10.5% of grain output became commodity grain sold on markets, but only a fifth of that entered into long-distance trade before the 1839-42 Opium War – or just 2.1% of total output (Xu and Wu, 2007 [1985]: 211, 215). Nonetheless, the volume of China's long-distance trade in grain was huge and "dwarfed" the Baltic trade, the largest in Europe (Vries, 2013: 159-60). Recent estimates are that up to 62 million *shi* (piculs, about 71.6kg) entered into long-distance trade in the 18th century (von Glahn, 2016: 331).

European Markets

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

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[19] In robustness checks we employ as an alternative the agricultural areas developed by Buck (1937).

Figure 1: Sample of Prefectures for North (shaded) and South China
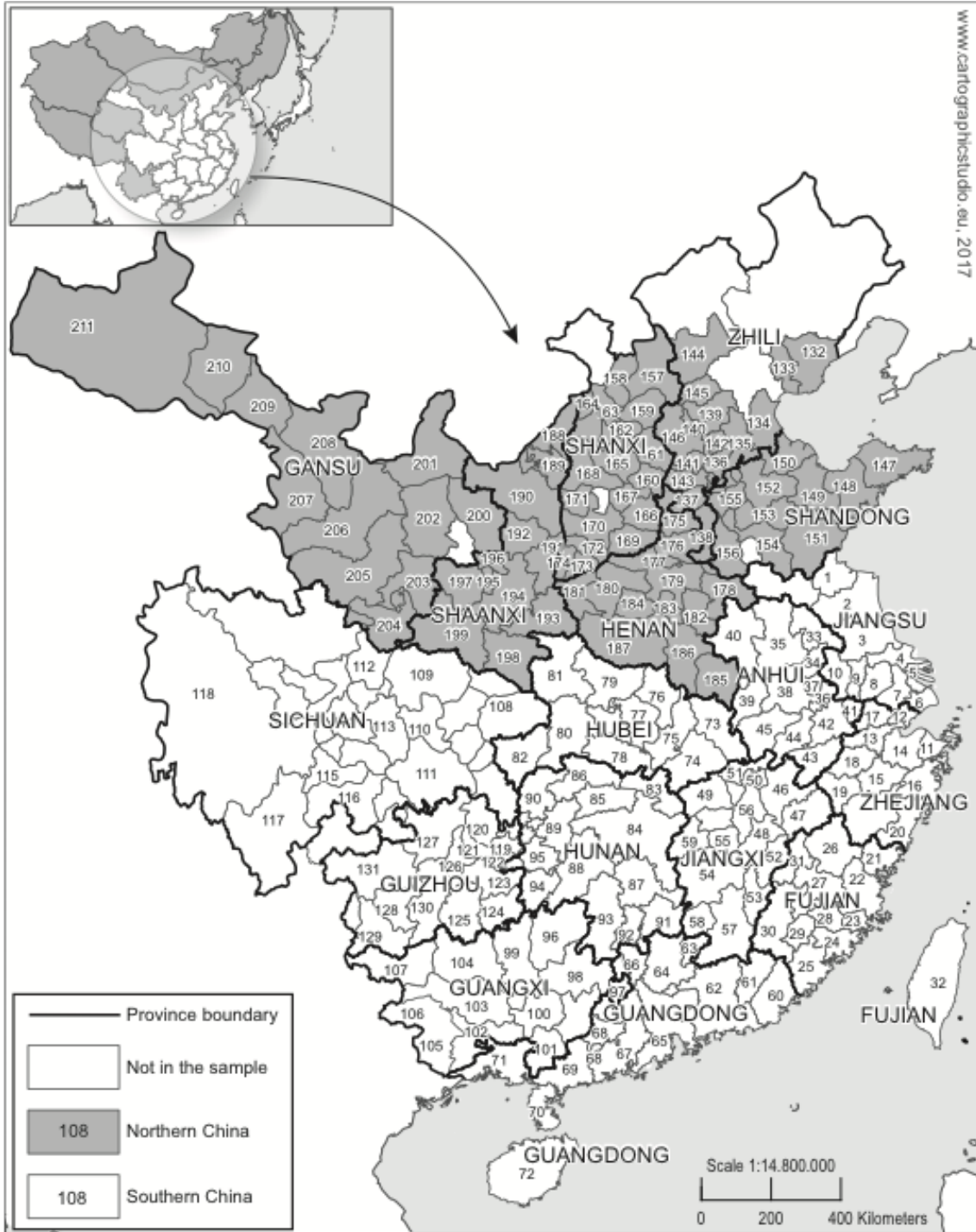
Notes: The prefectures included in the Chinese samples are those numbered. The Northern sample is shaded. The prefectures without data are un-numbered and blank. The thick black lines signify provincial borders and the thin grey lines the prefectural borders. All borders are for 1820.
Source: GIS Data from the China Historical GIS project (CHGIS, Harvard), Version 4.

For England, we use the *Corn Returns*, a weekly price series for selected grains published in the *London Gazette* between 1700 and 1914. Our analysis uses the weekly wheat prices covering 40 counties (all of England excluding London) from November 1770 to September 1820, collected and digitized by Brunt and Cannon (2013, 2014). The data (0.3% missing observations) are prices in shillings and pence per Winchester bushel of wheat (about 35.2 litres), 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.[20]

From Labrousse, Romano and Dreyfus (1970) we obtain monthly average wheat prices in francs per hectoliter for 85 French *départements* from September 1800 to December 1872 (below we limit our presentation to results 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.

From Rahlf (1996) we obtain average annual rye prices in grams of silver per hectoliter for 12 German cities. The geographic distribution is skewed towards the Rhineland and surrounding areas as well as Southern Germany, with only two markets in the North and East of the country. The series cover 1500 to 1800 (17% missing observations); we limit our results to the 18th century (9% missing). We adjusted for differences among the city-level data between harvest year and calendar year reporting.

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.

The comparison of European and Chinese markets raises concerns over significant differences in geographic scale. However, even though the provinces which make up 'Qing China proper' amount to around 1.5m square miles, the areas and distances in East and West are on much more comparable scales for Skinner macro-regions. This is illustrated in Figure 2.

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[20] Temporal aggregation of prices biases estimates of convergence and half-lives (Taylor, 2001; Brunt and Cannon, 2014). We therefore use prices for the first week of every month instead of a monthly average of weekly prices. Using any other week yields qualitatively identical results (available on request).

Figure 2: Chinese macro-regions and European nations
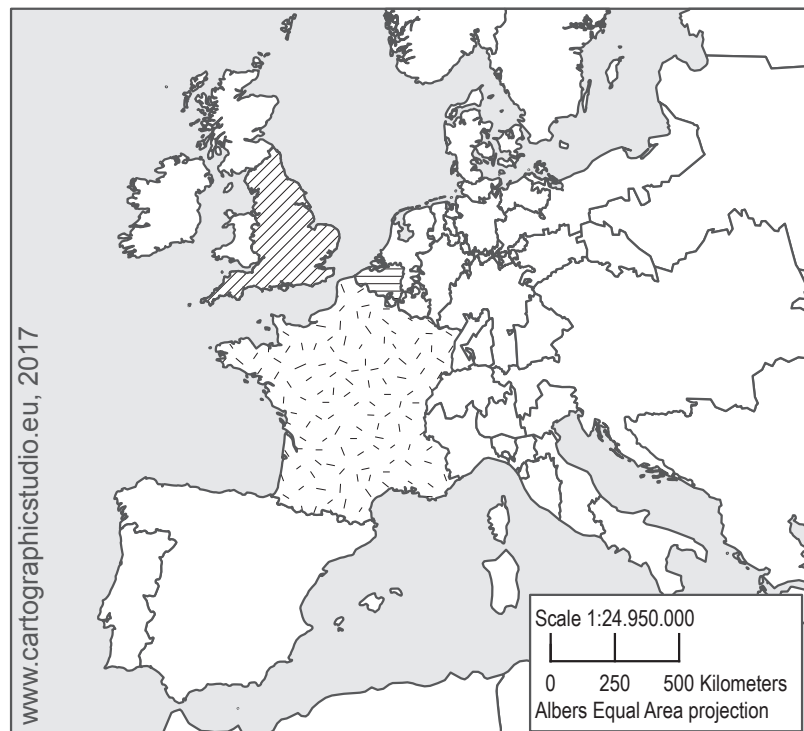
Notes: Skinner macro-regions are based on data from CHGIS. In the lower panel we highlight the samples for three European economies (England, France and Belgium – monthly data) but not the locations in the German or cross-European samples (see Online Appendix for more details on these).
Source: GIS Data from the China Historical GIS project (CHGIS, Harvard), Version 4.

We chart Chinese macro-regions in the upper panel alongside European states in the lower panel using the same scale: the Lower Yangzi region is roughly on par with England; France is slightly smaller than the Middle Yangzi and the two Northern macro-regions, but bigger than the Lower Yangzi, Lingnan and Southeast Coast. Our analysis shows that Chinese market disintegration holds in these smaller geographical units.

Comparative Price Analysis across Countries and Continents

Some of the above sources are identical to the data used in Shiue and Keller's (2007) seminal study and other studies (e.g. Keller, et al, 2015). An important caveat for any economist or economic historian wishing to study market integration comparatively across countries and continents is the specific nature of the grain price record. Differences matter. In our data we can distinguish (i) a temporal and geographic average for the English county data, (ii) a monthly high and low for the Chinese prefectural data, (iii) a market-specific price for the first market day of every month in the Belgian data, (iv) a monthly average across the French *départements*, and (v) a market-specific harvest or calendar-year average for the German and European city data. These small differences do matter for empirical analysis (see Brunt and Cannon, 2014), but there is no reason why different methods of collection should affect our analysis of *dynamic change* over time across countries and continents. It is the dynamic secular trend we focus on in this study.

4. Empirical Results

4.1 Price Convergence in China and Western Europe

We begin with our analysis of market integration in Qing China. We first focus on the large geographic regions of China (North and South), which are later compared with Western European economies. As emphasized in the previous section we also report results for geographical sub-regions of China, e.g., Jiangnan [Yangzi delta], Lingnan [Guangdong-Guangxi], or the Middle Yangzi Region, in order to make the comparison with Western Europe on a similar footing in terms of geographical area and average distance between markets (Pomeranz, 2000).

Figure 3 presents three sets of results for the evolution of price convergence in North China (dashed line in each plot) and South China (solid line). The first of our 20-

year rolling windows is for the period 1740-59, thus the first speed of convergence estimate in Figure 3 is dated at 1740-59, the second estimate 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. Secondly, regional convergence estimates in both regions trend upward (smaller negative coefficients), which implies regional markets became *less* integrated over time.

We quantify this decline by computing 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 slowed to 19 months over the two decades before the turn of the 19th century, while a decade later it was 54 months, before partial recovery to about 28 months by 1820. For North China, the equivalent half-lives at these time points are: 13, 34, 64 and 47 months.

Comparison of these half-lives with results reported in the literature is difficult because none of the latter account for cross-section dependence or 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 for relative price deviations of automobiles in European markets as between 16 and 19 months. [21] Analyzing a large range of consumer products across Chinese cities, Fan and Wei (2006) find far lower half-lives between 0.3 and five 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 the averaged *t*-statistics on β_i^{LPR} (following Pesaran, 2007).

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[21] Similarly, Crucini and Shintani (2008) estimated persistence in the law of one price deviations for many 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.

Figure 3: Regional and Macro-Regional Convergence in North and South China
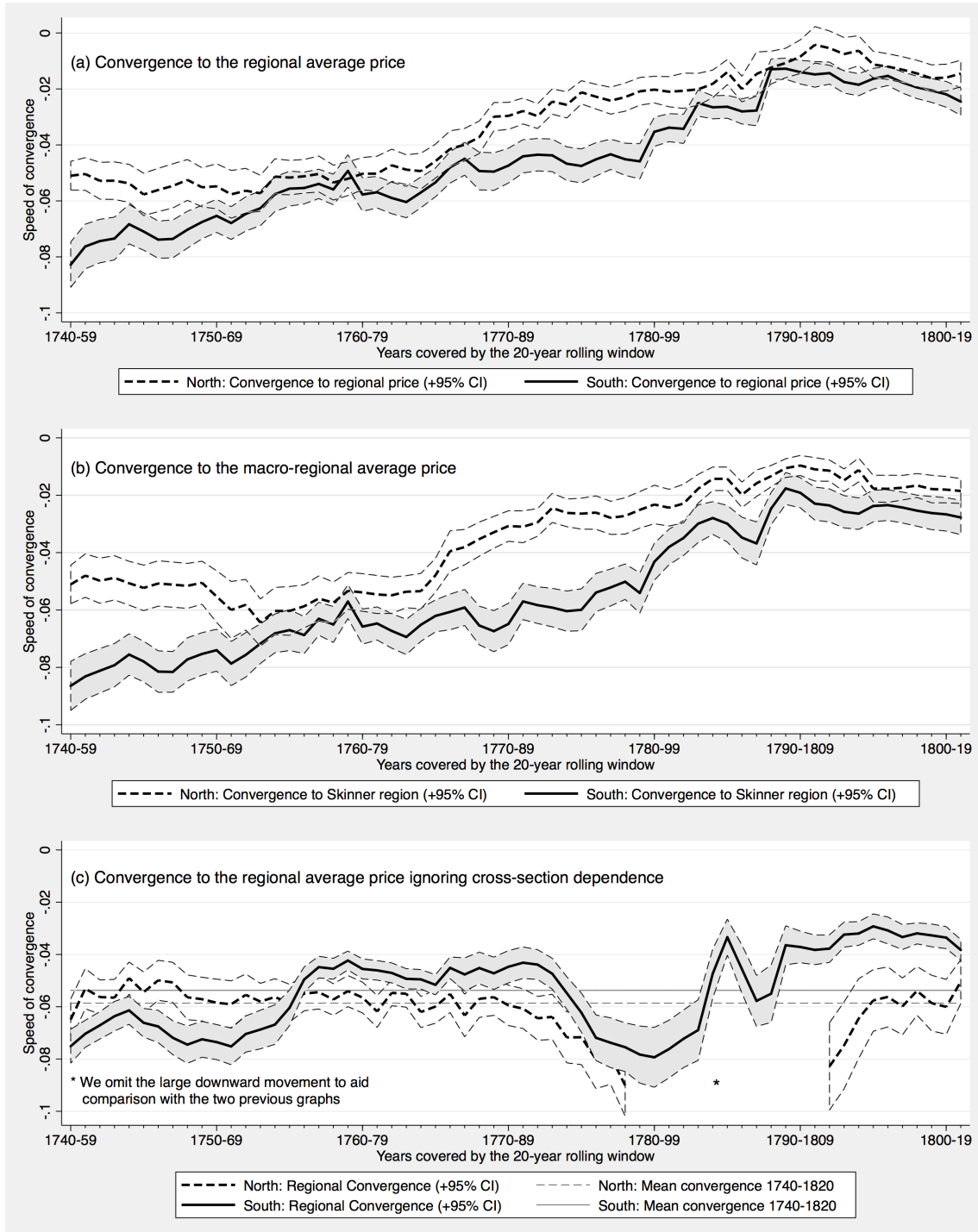
Notes: We plot average convergence coefficients (and their 95% confidence intervals) from the analysis of South (solid line) and North China (dashed line) grain prices in 131 and 80 prefectures, respectively, using a 20-year rolling window. We indicate the start and end year of a number of rolling data windows along the *x*-axis. Specifications in the top and middle panels account for cross-section dependence arising from trade network effects and common shocks, while the bottom panel ignores these forces. In the middle panel we drop two prefectures in the Northern sample since these represent the only observations in respective macro-regions ('isolets'). The results in the bottom panel highlight that the speed of convergence in North and South China shows very different dynamics if we ignore the common correlated effects. Here, the thin grey lines indicate the average results across all time periods.

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 end-years 1785 and 1790 onwards, respectively (i.e., the end years of the 20-year rolling windows), which implies 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 the Skinner (1977a) macro-regions framework. Pomeranz (2000: 22, emphasis added) maintains that until the 1780s "markets worked well *within* China's eight or nine macro-regions"; Eastman (1988: 102-3) argues that while 20-30% of farm output was marketed, "most goods sold close to their place of origins"; and Rawski (1972: 99) states "much of China was enclosed in a system of small, fairly autonomous market areas", especially in the absence of access to waterways. Figure 3(b) explores 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 sample, comprising six macro-regions, compared with the Northern sample, which has only two macro-regions. The South's many waterways also made for better transport than in the North.

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 that 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 previous two 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-

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[22] The analysis Figure 3 is based on convergence to the regional average price. An Online Appendix provides Mean Group estimates with and without cross-section average augmentation for each window.

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 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 over the course of the 18th century. Price convergence results for individual provinces as well as individual macro-regions confirm that these 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.

The decline in market integration uncovered is clearly substantial, but is it perhaps *too substantial to be credible*? We have two answers to this question. In econometric terms, as the speed of convergence approaches zero, the implied half-life approaches infinity: once markets become fragmented, the half-life *has to explode*. In economic terms, it is immaterial whether the half-life is 60 months or 600 months, since either estimate means that no price arbitrage is taking place and that markets are functionally disintegrated.

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 in the Chinese data. In order to make results from samples with different data frequency comparable, Figure 4 plots the implied half-lives (in months) for each convergence result. In this figure the *x*-axis reports the start-year of each rolling window and we dispense with confidence intervals to aid illustration. The detailed convergence plots for each European sample adopting various window lengths are contained in an Online Appendix.

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

Figure 4: Comparison of Chinese and European Grain Price Convergence
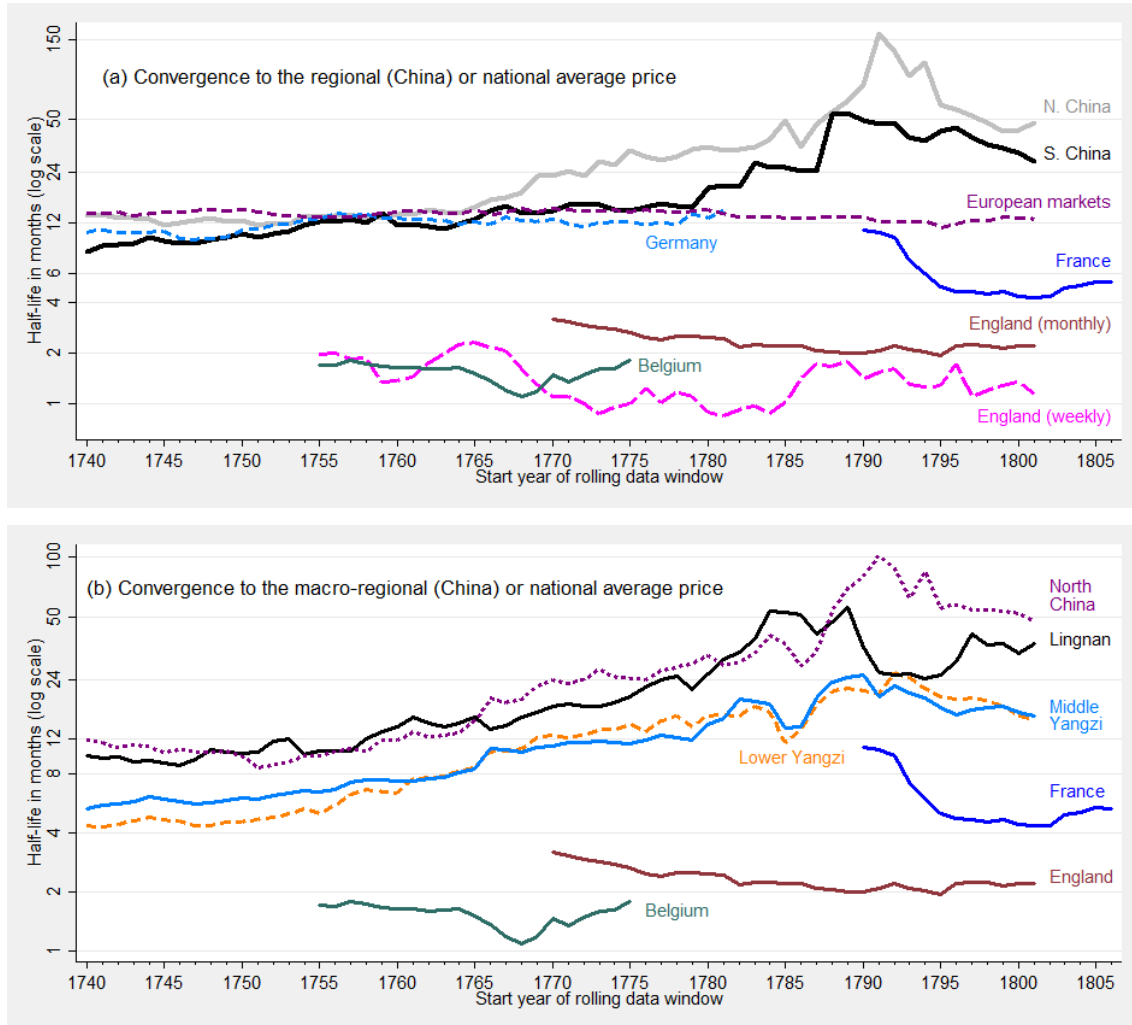
Notes: We plot the half-lives (in months) implied by the robust mean convergence estimates from the analysis of various samples comparing Chinese regions and European market integration – note that the *y*-axis is on a logarithmic scale and that for illustrative purposes the scales differ between the graphs (a) and (b). We omit confidence intervals. The *larger* 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. Results are derived from rolling data 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. In contrast to the presentation in Figure 3, the *x*-axis values here are the *start year* of the rolling window. We exclude convergence plots for the Upper Yangzi and the Southeast Coast macro-regions in graph (b) to aid illustration – these results 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. Graph (b) exclusively uses data available at monthly frequency. We provide some figures for the geographic size of some macro-regions and European countries in the text.

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. Results for the Belgian price series show 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 small 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 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 across 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 covers only 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 North and South China samples differ in their secular evolution of market integration from the European 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, market integration was declining sharply in China from the 1770s to 1820, with a 'nadir' 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 between China and Belgium, England and France. 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. By 1810, these ratios had increased to half-lives roughly 78 and 22 times those of the English markets. Shiue and Keller's (2007) estimates represent *a cross-section*, while our approach, which uses high-frequency data and accounts for cross-section dependence, reveals the *dynamically different trajectories* between China (disintegration) and Europe (high and stable integration).

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 most advanced Lower Yangzi macro-region. This analysis by Skinner macro-region should address concerns that the above cross-continental comparison is misleading, since the geographical dimensions of North and South China are by an order of magnitude larger (580,000 and 930,000 square miles, respectively) than the European economies studied. The Lingnan (Guangdong and Guangxi) and Lower Yangzi (Jiangsu and Zhejiang) macro-regions cover around 164,000 and 74,000 square miles, respectively (Skinner, 1977a: 213), which makes them directly comparable in scale to France (210,000 square miles) and England (50,000 square miles).

Most of the recent literature on the Qing economy holds a positive view of the level of market integration as exemplified by von Glahn (2016: 334): "long-distance trade in China operated more efficiently than Europe". Vries (2015: 141) among others (Perkins, 2014: xviii), disagrees, stating that claims of Qing China as "a highly integrated market economy strike me as optimistic." Earlier historical 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, 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, 2014; 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, 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 transport technology or infrastructure (Kim, 2008: 231; Rawski 1972: 4-5, 99, 106; Wiens, 1955: 248f) and agricultural technology (Elvin, 1973; Eastman, 1988; Perkins, 2014; Pomeranz, 2000: 22) in the face of an increasingly challenging hydraulic environment. 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' in order to avoid civil strife (Cheung, 2008: 116; Marks, 1998: 12; Pomeranz, 2000: 250; Shiue, 2015; Sng, 2014; Sng and Moriguchi, 2014).

In summary, our findings suggest that if integrated markets are indeed a necessary condition for industrialisation, China at the turn of the 19th century *did not fulfil this condition*. At the same time, our finding of stable and high levels of integration in Europe suggest that market integration *on its own* cannot be a sufficient condition for industrialisation either. Britain began to industrialise earlier than Belgium, France and other economies in Europe.

4.2 Robustness Checks

Since the results for Qing China clearly deviate from those for European markets we conducted robustness checks for our finding of secular market disintegration. These can be grouped into five 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 convergence process, namely linear or nonlinear; (iv) related to the cross-section dependence we capture in our cross-section average-augmented convergence regressions; and (v) related to concerns over variable data availability. We discuss these in turn below. Detailed results for all robustness checks are in the Online Appendix.

(i) 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 that millet and sorghum were the staple of Northern Chinese (see also Perkins, 2014: 6), while Marks (1991: 70) asserts that common (3rd) grade rice comprised "the bulk of grain traded" in Lingnan (South

China). 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 produced qualitatively identical results of disintegration for millet as well as superior (1ˢᵗ) and common grade rice. 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 obtained equivalent plots to Figure 3 for high and low price series, respectively, which are indistinguishable from those for the mean price series we discussed above.

(ii) Is the equilibrium proxy endogenous to the level of market integration, such that at different points in time the identity of this proxy might change? This is plausible, but if market integration was quite high, as is claimed in the literature, the many robustness checks we carried out on sub-regions and specified locations as equilibrium proxies, ought to have provided *some* patterns out of line with the market disintegration narrative we found. We briefly describe these findings in the following.

Our analysis of price convergence to the *macro-regional* average may distort results because the commercially advanced core differs from the 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 (1990: 445-6) 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 similar results to adopting the regional mean as reference price. We further investigated the macro-region of Lingnan, analyzing convergence to the macro-region average and to the dominant urban centre Guangzhou,

respectively, with results qualitatively identical to those in the larger samples discussed above. These implementations using a specific benchmark price 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 in South China, 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 very similar 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 accounting for cross-section dependence.[24] These tests suggest that from around 1790 onwards (referring to the end-year of a 20-year window) we cannot reject the null of nonstationary relative prices in our samples. Thus from this date grain markets in North and South China were 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 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 (2015b) 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

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[24] In spirit this approach is of course closely related to the widespread empirical practice of using threshold regression models to identify nonlinear price convergence (e.g. Jacks, 2005, 2006).

provide clear evidence for secular decline in market integration in South and North China in line with our previous findings.

(v) Our Chinese data represent an unbalanced panel with missing observations, and the concern that patterns in the data availability may be driving our results needs to be addressed. We can demonstrate that in periods when sample coverage declines (around the turn of the 19th century) the convergence estimates from prefectures with *fewer* observations are *higher* (in absolute terms), thus implying higher levels of market integration, rather than the decline we find in our results above. In separate analysis we vary the rolling window length, so as to estimate each window with a similar number of observations to ensure our estimates are comparable over time: the resulting convergence plot is qualitatively identical to those we presented throughout this study. Finally, the data availability between 1740 and 1790 is high and virtually unchanged, so that a comparison of the convergence estimates and associated half-lives for these points in time give a sound indication of whether the disintegration process is driven by data availability. Our estimates for 1740-59 indicate half-lives of 8 ($\hat{\beta} = -0.051$) and just over 13 months ($\hat{\beta} = -0.083$) in South and North China, respectively. The results for 1771-90 are 15.4 ($\hat{\beta} = -0.044$) and 24.5 ($\hat{\beta} = -0.028$), thus half-lives roughly *doubled* in both regions of China even half a dozen years before the abdication of the Qianlong Emperor – again our results are even stronger for some of the sub-regions such as Jiangnan.[25] The full set of annual results are presented in an Online Appendix.

All of the above results use cross-section averages within Skinner (1977a) macro-regions to capture cross-section dependence. Our findings are qualitatively unchanged 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.

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[25] From Figure 4(b) we can see that during the first 50 years of our sample (comparing 1740-59 and 1771-90) the half-lives in the Jiangnan, the Middle Yangzi and Lingnan regions roughly *tripled* (from 4.3 to 12.1 months), *doubled* (from 5.3 to 11.5 months) and *doubled* (from 9.8 to 18.1 months), respectively. In the North and Northwest China macro-regions over this period half-lives *doubled* (11.8 to 22.8 months) and *increased by one third* (16.1 to 21.6 months), respectively.

5. Concluding Remarks

This paper introduced a new empirical approach to price convergence that accounts for general equilibrium effects as well as common shocks with heterogeneous impact across markets. Our common factor framework is conceptually close to the notion of multilateral resistance in the trade gravity literature, the distinction between local and global shocks in recent work on price dynamics, and third country effects in the analysis of exchange rate movements.

Trade – and thus the efficiency of markets – is important for the transition to modern economic growth, because it allows increasing division of labor and specialization, as noted by the classical economists such as Adam Smith. Using grain prices for the 18th century from China and Europe, the application of our new empirical approach reveals divergent trends in the level of market integration at either end of Eurasia. From around 1750 grain markets progressively disintegrated in China whereas integration in Europe remained stable. This trend was not only apparent for less developed areas such as Northern China, but also for the advanced Yangzi River Delta region, where the half-live in the 1810s is six times that of the 1750s, and roughly three times that of France and 12 times that of England. These results challenge the conventional wisdom that markets in Qing China were 'comparable' in efficiency to those in Europe on the eve of the Industrial Revolution (Shiue and Keller, 2007; von Glahn, 2016).

Our results differ from earlier empirical studies for two 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 monthly price series coupled with the use of rolling windows instead of single period cross-section analysis. These differences mean we are able to dynamically model price change over the course of the 18th century, which shows that secular market disintegration of markets occurred in both North and South China. The level of integration in China was comparable to those of Western Europe in the 1750s, but by the 19th century a big gap had opened up.

What do our findings of declining market integration imply for the study of potential causes of the Great Divergence? Firstly, at the turn of the 19th century China was characterized by fragmented grain markets, which given the centrality of the agricultural sector in the pre-modern economy (grain output accounted for around 40%

of GDP, Peng, 2006; Xu and Wu, 2007 [1985]) challenges the suggestion that the forces of demand and supply were at play over a vast territory (e.g., Eastman, 1988). If integrated markets were a pre-condition for industrialization, early 19th century China did not fulfil this condition. Secondly, our findings of high and stable levels of integration in Western Europe in turn imply that market integration *on its own* cannot be a sufficient trigger for industrialization either. Nor is it a pointer to the timing of industrialization. Indeed, despite the "competitive markets … for land, labor and goods", which made 18th century China "remarkably free compared with Europe" (von Glahn, 2016: 349), other elements necessary for the transition to modern economic growth were clearly absent. These most likely are to be found in the nature of political institutions that shaped and constrained economic actors in China (Brandt et al, 2014; Sng and Moriguchi, 2014).

The present study focuses on the macro-economic evolution of market integration. Our robustness checks suggest that the process of secular disintegration we uncover was pervasive, but our analysis does not uncover the micro patterns of disintegration or provide detailed qualitative or quantitative support for potential causes for this disintegration process. We seek to address these matters in future research.

Acknowledgements

Online Appendix

A detailed Online Appendix is available at http://tinyurl.com/qyqzj96.

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