Sources of Market Disintegration in 18th Century China*

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Abstract: *Recent empirical work on grain market integration in China and Western Europe on the eve of the Industrial Revolution finds consistent evidence for a substantial decline in Chinese integration over time: by 1800, Qing China's grain markets were fragmented, including in the economically most advanced Jiangnan region. In this paper we provide qualitative and quantitative evidence for population growth and its economic, social, political and environmental implications as one important factor driving this process.*

One of the seminal questions in World and Chinese economic history is why China, in contrast to Western Europe, failed to industrialize during the 19th century, leading to differential development paths commonly referred to as the 'Great Divergence' (Elvin, 1973; Pomeranz, 2000). Social and economic historians have tried to tackle this issue by identifying potential

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sufficient conditions for industrialization. One candidate condition has been the degree of national or sub-national market integration within Asia and Western Europe on the eve of industrialization (Shiue and Keller, 2007; Bateman, 2011). The presence of integrated markets could point to the existence of well-functioning market institutions to advance efficient resource allocation and to provide private agents with sufficient incentives to find more productive ways to employ land, labour and capital (North, 1981). A long-held view maintained that Western Europe was characterized by integrated markets which had taken root because of state-supported property rights institutions. China, in contrast, despite her unified *political* system created by a dynastic empire, was said to have failed in creating a unified national market.[1] This hypothesis of differential levels of market integration has been seriously challenged more recently, most notably in the work of Pomeranz (2000: 16, emphasis in original), who concluded that factor and product markets in late 18th century Western Europe were "probably *further* from perfect competition… than those in most of China."

While earlier studies of Chinese market integration were primarily of a descriptive nature or focused on small geographic sub-regions during short periods of time (e.g. Wang, 1992; Li, 2000), grain price correlations in Shiue (2002) cover 121 Southern Chinese prefectures[2] during the second half of the 18th century. She finds that despite the absence of low transportation cost or significant long-distance trade "a substantial level of interregional and intertemporal market integration" (1417) already existed in this pre-modern era. Using cointegration analysis Shiue and Keller (2007) carried out a formal cross-continental comparison of rice markets in Southern China during 1742-95 with wheat markets in Europe in the 18th and 19th centuries, thus providing the first econometric evidence for Pomeranz's (2000) conjecture of equivalent goods market integration in both regions. Much of the subsequent literature has confirmed their

[1] Li (2000, p.656f) provides a detailed discussion of these arguments.
[2] The Qing system of administration uses the county (*xian*) as the basic unit, followed by the prefecture (*fu* or *zhou*) and the province (*sheng*). Our unit of analysis is the prefecture. Below we use the term 'region' to distinguish the predominantly wheat-growing North from the South dominated by rice cultivation.

results (e.g. Dobado-Gonzalez, Garcia-Hiernaux, and Guerrero, 2015) and adopted the conclusion that "in the late eighteenth century… long-distance [grain] trade in China operated more efficiently than in [continental] Europe" (von Glahn, 2016: 334).

In a series of papers (Bernhofen, Eberhardt, Li, and Morgan, 2016, 2017a, 2017b) we investigate the *changes* in grain market integration during the High Qing (1740-1820). We find that market integration in China substantially declined over time, to the extent that by the early 19th century statistical tests cannot reject the notion of fragmented markets. This finding is established adopting a range of empirical methods and specifications, different staple grains, and different geographic sub-regions (including the economically most advanced Yangtze Delta). Our empirical implementations account for general equilibrium effects widely acknowledged to have distorted earlier investigations of market integration using price data (Fackler and Goodwin, 2001: 992f; Shiue, 2002: 1407; Federico, 2012: 481f). We describe these methods, the data used and our main results in more detail in the following section.

The specific timing, origins and determinants of China's economic divergence are of course subject to a great deal of debate. Working our way backwards, the 'Daoguang Depression' (from 1820) is universally accepted as having brought about serious and measurable economic, political and social decline culminating less than two decades later in the national humiliation of Western invasion. The 'surprising resemblances' arguments of Pomeranz (2000) and others suggest that the timing of China's divergence falls in the reign of the Jiaqing emperor (1796-1820), though recent scholarship argues he instead may have managed to steady the boat (Rowe, 2011). Others remark that "the Chinese economy had seriously begun to exhaust its productive capacities by 1800" (von Glahn, 2016: 361) already, with the White Lotus Rebellion (1796-1804) a very real event of an economy hurtling towards the brink of ecological crisis (Wang, 2014). Given these doom-laden statements about China's prospects *before the turn of the 19th century*, it seems curious that national and regional markets for grains, subject to a fragile equilibrium,[3] were deemed to have been on par with those in Western Europe around the same time as religious sectarians driven by real economic hardship were running riot in central and north China (Eastman, 1989; von Glahn, 2016). Our empirical results strongly suggest that market disintegration had already set in *much earlier* than the Jiaqing reign.

In this study we bring together arguments for such an early decline from the rich economic and social history literatures, and use our estimates for market integration to empirically test one prominent factor: we investigate the role played by the unprecedented population growth and internal migration during the 18th century and its economic, social, political and environmental implications. In studies of early modern Europe (e.g. Reed, 1973; Jacks, 2004), population growth was found to go hand in hand with market expansion and increased integration. In China population growth and its uneven regional distribution not merely limited the surplus grain available for trade, but exerted severe pressure on an inherently instable water control system pitting farming against flood prevention and the waterway transportation of goods, creating increasingly insurmountable challenges for water engineering. Population growth and rigid fiscal rules constrained the ability of the Qing state to effectively govern this vast empire. Local officials reacted to rising population pressure with 'grain protectionism' leading to temporary political borders which further hampered the functioning of the market. This is *not* the narrative of a standard 'Malthusian Trap,' but of an escalating 'span of control' problem *caused by a rigid and underfunded state apparatus*.

The remainder of this study proceeds as follows: we first discuss the empirical methodology employed to obtain our estimates for market integration and the data. We then assess various direct and indirect channels between population growth and market integration before concluding and considering our results in the wider context of the Great Divergence.

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[3] Patterns of integration in pre-modern markets should be viewed as a fragile equilibrium constantly subject to dynamic responses to complex demand and supply shocks (Federico, 2012), where "a small increase in the cost of transportation could quickly drive a particular source of grain out of the market" (Evans, 1984: 295).

METHODOLOGY AND DATA

CAPTURING THE DYNAMICS OF PRE-MODERN GRAIN MARKET INTEGRATION

We conceptualize the degree of market integration in a pre-modern economy[4] as a convergence process whereby in markets that are integrated prices quickly return to their equilibrium level after a shock. In Bernhofen, et al (2016, 2017b) we compute prefecture-specific or prefecture pair-specific estimates for grain price convergence, derived from the application of novel empirical methodologies from the panel time series literature. These methodologies allow us to capture market integration by accounting for bias from two sources: (i) from common 'global' shocks, such as widespread flooding, with heterogeneous impact across locations. Although the impact of a weather shock on crop harvest can be devastating, it still varies substantially across locations depending on proximity to river, run-off area, elevation, etc. And (ii) from a general equilibrium effect of trade and exchange. This recognises that markets are part of a network and location-specific prices are determined within a general equilibrium system. The empirical trade literature has recognised the importance of accounting for changes in 'third markets' in the analysis of bilateral trade flows, and our price-based empirical framework captures an equivalent of 'multilateral resistance' for price behaviour. we capture these effects empirically by adopting a multi-factor error structure (Pesaran, 2006).

Our *panel* convergence analysis defines $\tilde{p}_{it}$ as the logarithm of the price in market *i* at time *t* relative to some benchmark price – the price in some central market of significance, e.g. Suzhou (see Wang, 1992), or the average price across a geographic region (e.g. South China). The panel convergence regression is then

$$\begin{aligned} \Delta\tilde{p}_{it} = \; & \alpha_i + \beta_i \tilde{p}_{i,t-1} + \textstyle\sum_{s=1}^{p} \gamma_{is}\, \Delta\tilde{p}_{i,t-s} \\ & + \delta_i \bar{\tilde{p}}_{t-1} + \textstyle\sum_{s=0}^{p} \theta_{is}\, \overline{\Delta\tilde{p}}_{t-s} + \varepsilon_{it}, \end{aligned} \tag{1}$$

[4] Grain output accounted for 40-45% of gross domestic product (Peng, 2006), although differential demand and supply created serious imbalances in the form of grain deficit and surplus regions (Myers and Wang, 2002).

where Δ is the difference operator. The first line of equation (1) is a standard Augmented Dickey Fuller regression as widely applied in the existing literature on price convergence. The second line is the augmentation suggested by Pesaran (2006) which captures (a) the unobserved common factors, and (b) their heterogeneous impact across locations. Here $\bar{\tilde{p}}_t$ is the cross-section average of $\tilde{p}_{it}$ at time *t* for *all* locations *i*: we add the cross-section averages of all variables in the first line together with location-specific parameters δ_i and $\theta_{is}$to the model. This is a 'common correlated effects' (CCE) estimator, which treats the factors and associated 'factor loadings' as nuisance parameters. β_i is the speed of convergence parameter, which is the object of interest in our analysis. Averages of the estimated β_i across geographic regions indicate the state of market integration at the macro-level. Our *pair-wise convergence* regressions proceed analogously, adopting $\tilde{p}_{ijt}$ $(i \neq j)$ as the log price in market *i* relative to that in market *j*. Here the object of interest is the *pairwise* speed of convergence β_{ij}.

Both empirical implementations yield estimates for the speed of convergence which in theory is a negative number with an upper bound of zero:[5] the larger the coefficient in absolute terms, the higher the speed of convergence. For our analysis below it is preferable to transform convergence estimates into 'half-lives,' which indicate the number of time periods until half the effect of an exogenous shock has dissipated. Formally, $\widehat{HL}_i = \ln(0.5) / \ln(1 + \hat{\beta}_i)$ for the *panel* speed of convergence estimate $\hat{\beta}_i$ and similarly for the *pairwise* estimate $\hat{\beta}_{ij}$. All our half-life estimates are expressed in months.

Given the long time series of our grain price data we can employ convergence regressions in a rolling 20-year window, which affords us 62 separate estimates for time periods 1740-59 to 1801-20 to assess the *dynamic* evolution of market integration.

[5] As the speed of convergence approaches zero, the half-life increases to infinity – this is a mathematical necessity. From an economic standpoint the difference between 60 months and 600 months might be immaterial since in both cases markets are functionally disintegrated.

DATA AND SOURCES

Descriptive statistics and maps for all datasets can be found in the Online Appendix. Our estimates for market integration $\widehat{HL}_{i\tau}$ and $\widehat{HL}_{ij\tau}$ for period τ are based on monthly medium-grade rice and wheat prices in taels (*liang*, ounces of silver) per granary bushel (*cang shi*, around 104 litres), for 131 prefectures of Southern China and 80 prefectures of Northern China compiled by Wang Yeh-Chien and collaborators.[6] Our period of analysis covers 1740 to 1820 as this ensures that the changes in market integration studied were predominantly driven by factors internal to Qing China rather than externally-driven political turmoil or technology and trade shocks.[7] The distinction between North and South is made to reflect differential staple crops and agricultural systems more generally (Buck, 1937). The prefectural grain price series cover all but one (Yunnan) of the 18 provinces of 'Qing China proper.' On average, we have 785 monthly prefectural observations in the North and 730 in the South.[8]

Alongside descriptive analysis of Wu's (2012) regional estimates for population and cultivated land in seven regions, we carry out regressions using Cao's (2000) prefecture-level estimates for population density in 1776 and 1820.[9]

Mountain ranges and other geomorphological features act as natural barriers to trade, and we use the borders for eight 'physiographic macro-regions' introduced by Skinner (1977) in our analysis below.[10]

[6] The grain price reporting system was initiated under the Kangxi emperor in the early years of the Qing and rolled out across Qing China proper under the Qianlong emperor in 1735. Further details including the veracity of the data are discussed in detail in Marks (1998), Shiue (2002, 2004) and Shiue and Keller (2007).

[7] The Qing economy during the reigns of the Qianlong (1735-96) and Jiaqing (1796-1820) emperors was relatively closed to external market forces and did not experience substantial advances in either transport technology or infrastructure (Wiens, 1955), agricultural technology (Perkins, 2013) or land reform (Pomeranz, 2000).

[8] We retain prefectures even where there are periods of missing observations (on average 19% of observations).

[9] A critique of population data quality is provided below. The Cao (2000) data has recently been employed in work on the adoption of maize by Chen and Kung (2016).

[10] Most boundaries follow watersheds and the crests of mountain ranges: the high-density core of each macro-region is in the river-valley lowlands, surrounded by concentric gradients of declining population density.

Prefectural and provincial (political) boundaries in 1820 and the distance between prefectures are computed using data from Harvard's China Historical GIS project (CHGIS v4 and v6). Our analysis further makes use of data for the 'grain river' network in imperial China: we gather information on all rivers and inland waterways recorded for grain trade in gazetteers and archives reported in Wiens (1955) and by Deng (1994, 1995).

MARKET (DIS)INTEGRATION IN EARLY MODERN CHINA AND EUROPE

Figure 1 presents the core results from our companion papers on panel and pairwise grain price convergence (Bernhofen, et al, 2016, 2017b).[11] In the upper panel we compare *panel* estimates for convergence to the macro-region average price for a number of Skinner macro-regions of China with results for panel convergence to the national price in France, England, and Belgium. Each line represents the series of robust means of the panel convergence estimates $\widehat{HL}_{i\tau}$ obtained from the rolling window analysis. All results are based on the empirical implementation in equation (1), the only difference is the length of the rolling window due to shorter time series for France and Belgium (10-year windows) compared with England and Chinese regions (20-years windows).[12] It can be seen that during the 1740s half-lives for the most advanced Chinese regions (Middle and Lower Yangtze) were comparable to those in England or France a few decades later. The former subsequently increased substantially: in 1800 half-lives in the two Yangtze regions were ten times those of English markets and three to four times those of French markets. Other Chinese macro regions mirror this decline.

In the lower panel we compare *pairwise* convergence estimates $\widehat{HL}_{ij\tau}$ for Southern China from our earliest window of analysis (1740-59) to those from the period covering the abdication of

[11] Results in a third companion paper (Bernhofen, et al, 2017a) are based on the pairwise cointegration analysis pursued in Shuie and Keller (2007), and demonstrate that rolling window analysis can reveal a divergence in market integration between China and Western Europe. In that paper we also discuss the shortcomings of the cointegration approach and we therefore do not use its estimates for market integration in the present study.

[12] Adopting different window lengths (5 to 30 years) for all samples yields qualitatively identical results.

the Qianlong emperor in 1795 (1789-1808). Each pixel represents the half-life estimate for a prefecture pair obtained from the pairwise regression equivalent of equation (1). Results are arranged by province from East to West on the *y*- and *x*-axes, shading signifies the length of the half-life, from 4.2-5.6 months in green to 52-69 months in red.[13] The relative decline in market integration across virtually all locations is apparent given the shift from green to red between the two periods. Results for Northern China (not presented) show similar patterns.

These results fundamentally challenge the consensus in the literature of relative parity between China (or its most advanced regions) and Western Europe at the turn of the century and situates the starting point of China's decline half a century prior to this date.[14]

SOURCES OF MARKET DISINTEGRATION

While empirical studies of the *dynamics* of Chinese market integration are rare (Gu, 2013; Bernhofen, et al, 2017a), a number of scholars have noted the shift from a national integrated market in the mid-18th century to a set of fragmented regional markets a few decades later. Skinner (1977: 211) developed his physiographic macro-regions by arguing for "regional systems [of core and periphery], each only tenuously connected with its neighbours" though this theory is principally located in the 19th century. Pomeranz (2000) supports an explanation put forth by Bin Wong whereby Qing officials faced two rival models of economic expansion: one emphasising multiple self-sufficient cells, another specialisation and interregional trade. Aside from more immediate factors (e.g. a rise in transport cost) Pomeranz (2000: 184, 250) suggests that a strategic choice by Qing officials can explain the shift towards the former model after 1750, citing a need for "less ongoing attention" as the primary motive. While it certainly

[13] We cut off the extreme tails of the distribution to improve illustration: speed of convergence estimates below -0.15 are set to -0.15 (half-life of 4.2 months) and those above -0.01 are set to -0.01 (69 months). In our regression analysis below we do *not* manipulate the underlying 'raw estimates' as just described.

[14] This is in line with the analysis in Gu (2013) for 1736-1911, which reveals a U-shaped pattern for Chinese market integration over time with the low-point around 1810.

dresses these development in a more favourable light, 'less attention' could also be equated with declining state capacity as argued in Sng (2014). Von Glahn (2016: 372) refers to the multiple-cell model as "domestic import substitution" and identifies outmigration from Jiangnan to the Middle Yangtze as the primary 'centrifugal' force: "[a]s the market for Jiangnan textiles in the interior dried up, the flow of rice, timber, and other raw materials down the Yangzi River ebbed" (372). Elsewhere, von Glahn (2016: 335) blames the political and economic crises of the early 19th century for the reversal of interregional integration and an increasingly closer resemblance with Skinner's macro-regions. In the following we argue that unprecedented population growth and internal migration can be viewed as the driving force of the economic, social, political and ecological changes affecting market integration.

POPULATION GROWTH AND POPULATION PRESSURE

The population 'explosion' during the High Qing, "probably the most important single development" of China's 18th century (Elliott, 2009: xi), is widely acknowledged (Mann-Jones and Kuhn, 1978: 108; Pomeranz, 2000: 12; von Glahn, 2016: 363) and historical demographers go so far as to claim that "population processes played a decisive role in both expanding and restraining Chinese economic development" (Lee and Feng, 1999: 19). In this section we discuss the evolution of population (density) growth and its spatial patterns along with its 'direct' consequences for market integration. Our regression analysis provides formal evidence for a relationship between increasing population density and the secular decline in market integration in grain surplus regions, echoing results for a longer time horizon in Gu (2013). We conclude by highlighting the data-related caveats on which our analysis is based.

From Wu's (2012) estimates we can compute a 2% annualised population growth rate for China as a whole between 1724 and 1812 (Online Appendix, Table X-X). This figure hides vast differences across the seven Chinese regions (resembling macro-regions) of Wu's analysis, whereby Northern China with the exception of the Manchu homelands (5.2% pa, albeit from a miniscule base) saw more modest population growth (1.1% in the Northwest and 1% in North China). The Southwest (Sichuan and Yungui) grew at 11% pa, from 3m to 32m,[15] while the region around the mid-Yangtze grew by 4% pa. The Lower Yangtze and Southeastern regions (two-fifths of population in 1724) 'only' grew at the national average, which still translates into a *tripling* of its population over this period. While in 1724 the Chinese population was distributed evenly across North (47%) and South, by 1812 the balance had shifted substantially and two thirds now lived in the South. Given differences in their data employed, the views in the literature regarding the peak of this population explosion vary, but Ho (1959), Naquin and Rawski (1987) and Myers and Wang (2002) all point to the second half of the 18th century.

Population growth exerted severe pressure on natural resources (von Glahn, 2016: 363), namely (a) the availability of arable land (labour aside the main input into agricultural production), and (b) the availability of staple food (one of the main outputs of agricultural production) for consumption and trade.

The Wu (2012) data allow us to compute cultivated acreage per capita (in *mu*) and its evolution, which can highlight the pressure on the land across the empire. Aggregate cultivated land per capita declined from 7.2 *mu* in 1724 to 2.9 *mu* in 1812.[16] The lowest 1812 per capita acreage was in the Southeast (incorporating Lingnan; 1.7 *mu*), followed by the Lower Yangtze (2.2 *mu*). Most striking are the developments in regions with high land availability (in per capita terms) in 1724: the mid-Yangtze (11.7 *mu*) and Southwest regions (13.5 *mu*) declined rapidly and ended up with ratios *below* the national average in 1812 (2.7 *mu* and 2.4 *mu*, respectively). Keeping in mind that "it required 4 *mu* of land to feed one person" (Elliott, 2009: 148) these figures point to a significant increase in pressure on land, both in the Southern economic core

[15] Figures for China's Southwest prior to 1776 are not an accurate representation of the population, with women, non-Han and other folk left out in one or other enumerations (Lee, 1982).
[16] These figures are broadly in line with Elliott's (2009) 3.5 *mu* per person in 1776 and 3.3 *mu* in 1790.

(Lower and Middle Yangtze) and the periphery (Southwest). Ignoring Manchuria the North Chinese region represents the only area which exceeded the 4 *mu* per capita benchmark.

Figure 2 highlights the spatial distribution of population density *growth* at the prefecture level (people per km^2, albeit *not* arable land) based on annualised growth rates (in %) between 1776 and 1820 using data from Cao (2000). The bulk of 18^{th} century population density growth occurred in China's frontier regions to the west and southwest, relatively poor areas on the periphery of Qing China proper (Lee and Feng, 1999: 116; Pomeranz, 2000: 13). This pattern was said to have been driven primarily by government-sponsored migration (Entenmann, 1980; von Glahn, 2016: 312). Figure 2 indicates stylised trajectories of internal migration during the 18^{th} century, highlighting the substantial numbers traversing the internal 'frontier' between developed and developing regions (dashed line, Myers and Wang, 2002). Descriptive analysis at the provincial level (Online Appendix, Table X-X) shows the increase in pressure in the periphery *and* the economic core of Southern China, whereas in the North the low-density periphery grew less than the core. Most median growth rates at the provincial level are higher in the South (16-36% over 45 years, median 20%) than in the North (12-19%, median 15%).

Population pressure on limited cultivated land translates into rising land prices: Chao (1981: 730) shows that Jiangnan land prices more than doubled between the 1740s and 1820s and concludes that "high population pressure seems to be the most crucial factor".

In the following we empirically link population pressure to the dynamics of market integration: results in Table 1 are derived from robust regressions of differences in prefectural half-lives between 1820 and 1776, $\widehat{HL}_{i,1820} - \widehat{HL}_{i,1776}$, on changes in log of population density over the same period, along with a set of province fixed effects which allow for differential trends across locations, and a dummy for prefectures hosting the provincial capital. Estimates in columns (1) and (5) for South and North China, respectively, show only a modest correlation between population density growth and market disintegration, which is statistically insignificant.

However, introduction of an interaction term between population density growth and grain surplus status (time-invariant, from Myers and Wang, 2002)[17] creates diverging results: higher population density growth is associated with *more substantial market disintegration* in grain surplus prefectures, but not in grain deficit and self-sufficient prefectures of South China.[18] Excluding outliers and data for Guizhou (to address data concerns expressed in Lee, 1982) does not alter this correlation. Results for North China, though with the same signs and similar magnitudes for the link between market disintegration and population density growth in grain surplus regions, are estimated much less precisely. Exclusion of outliers and of Zhili province, given its administrative status and the accounts of tribute grain resale in the region (Li, 2000; Cheung, 2008), does not alter this outcome. Our analysis of market integration dynamics thus indicates that differentiating between grain surplus and non-surplus regions delivers strong and statistically significant correlations, but only in the South China sample.

Population data for 18th century China suffers from a number of shortcomings, prime amongst these the systemic under-enumeration prior to the mid-1770s (due to administrative procedure), which can see millions added to the statistics in consecutive years (e.g. Lee, 1982; Elliott, 2009: 146). While our regressions rely on the comparability of Cao's estimates across time and space we note that 1776 is typically regarded as the start of "relatively complete population reporting" (Lee and Feng, 1999: 116). A second concern relates to the endogeneity of population growth, i.e. that migrants streamed into peripheral regions in pursuit of preferable land-labour ratios. Lee's (1982) study on Yungui however suggests that migrants followed *urban* economic opportunities, responding to a rising demand for labour in the periphery.

[17] These data are in turn from Wang and Huang (1989). We found one discrepancy between the two, whereby Shandong is categorised as grain surplus in the latter but as grain deficit in Myers and Wang (2002) – using the surplus instead of the deficit label does not qualitatively change the North China regression results.

[18] Not all prefectures are deemed surplus or deficit areas:19 in our Southern sample self-sufficient in grain provision. Grain surplus prefectures in the South are predominantly in the Upper Yangtze region and in inland provinces of Guangxi, Hunan, Jiangxi and Anhui. In the North surplus prefectures are predominantly in Shaanxi and Henan, with Gansu largely deemed self-sufficient. The latter is a curious

Beyond a 'direct' effect of the population explosion on the availability of land and grain surplus trade there are two major 'indirect' effects which we investigate in the following: first, ecological factors related to hillside erosion, land reclamation, and water management. Second, political economy factors related to the actions of the Qing government and its local agents.

THE ENVIRONMENTAL CONSTRAINTS ON TRADE AND INTEGRATION

Trade costs, in particular transport costs, largely determine possibilities for market integration. Evans (1984: 298) suggests that across China on average a quarter of grain was consumed in the process of shipping it "from where it was grown to where it was eaten." Freight costs however varied substantially across the empire, depending primarily on the mode of transport: water transport was substantially cheaper than land transport (Eastman, 1988; Wang, 1992), especially for bulk cargo with a low value-to-weight ratio such as grains.

Kim (2008: p.235-7) suggests that North China's roads, made from compacted earth not unlike dykes (creating a "major transport problem" during the rainy season) were generally better than those in Europe until the turn of the 19th century, when the former rapidly deteriorated.[19] Southern roads were usually cobbled, even away from major routes (Kim, 2008: 236-7), though easily trumped in efficiency terms by water transport. The Qing government rarely engaged in road maintenance, and the only lasting impact of *private* road improvement schemes were said to have been "stone tablets by the roadsides" left by the 'benefactors' (Eastman, 1988: 105). The 'cost in rice to ship rice' by human porters, the most important mode of land transport, would amount to 6-7% a day (Evans, 1984: 286). Horse-drawn canal barges, junks and sampans in contrast represented a 'model of efficiency:' sea freight was around one third the cost of inland waterway freight, which in turn was between 10 and 60% that of land transport by human porters, wheelbarrow, donkeys or packhorses (Buck, 1937; Evans, 1984; Shiue and

[19] Trees planted alongside elevated roads to counter erosion had disappeared, high volumes of traffic and lack of repair and maintenance were taking their toll.

Keller, 2007). Lack of access to waterways created land transport zones where "[s]elf-sufficiency was of necessity the dominant economic reality" (Evans, 1984: 296).

There were four main waterway trade routes: the Yangtze and its tributaries, the Grand Canal, the West River basin in Lingnan, and the East China Sea (Wang, 1992; Marks, 1998).[20] Although the Yellow River represents a further large waterway system it is only navigable for a few hundred of its 2,800 miles (Evans, 1984: 277) – as the proverb has it, *nan chuan bei ma*: [take] a boat in the South, a horse in the North (Elvin, 1973: 136). Evans (1984: 278) argues that it was the large number of inter-river canals which made a "unified economy underlying the unified political system of Imperial China… possible." He estimates that the Yangtze system alone added up to 30,000 miles of waterways navigable year-round by junk, while the entire empire covered several hundred thousand miles (ibid, 299). Likewise, Pomeranz (2000: 185 and 184) marvels about the "superb system of waterways" which gave "China as a whole a considerable advantage over Europe in water transport."

It is a shortcoming of much of the literature – exceptions include Elvin (2004: 115) and Naquin and Rawski (1987: 161) – to emphasise the vast *expanse* of China's waterways network or the number of boats on the network at a certain time of year, while largely ignoring other hydrological aspects, as well as the original intended purpose of canals and water management more generally. Tvedt's (2010) detailed discussion compares waterways in England and China, highlighting the stark differences in rainfall patterns, height and frequency of rapids, (ground) water levels, peak current speed and silt/sediment levels between East and West, concluding that the "colossal human efforts needed to protect societies against these physical characteristics of the local water system [in China] translated into serious impediments to the

[20] Sea freight by private merchants was subject to repeated bans (*haijin*) under the Qing to control foreign trade and tackle smuggling and piracy (Will, 1990: 216). These measures however do not appear to have worked very well and maritime China under the Qing can be seen as in a 'power vacuum' where the rule of law was weak or entirely absent (Will, 1990: 222, 224f). Cheung (2008) suggests that the prevailing wind patterns implied that sea trade of rice from central China to Fujian via Jiangnan was impossible when demand made this most profitable: junks could only sail south in the autumn, Fujian needed rice in early spring.

development of transport infrastructure" (35). The Yangtze, for instance, is "a violent, silt-laden river, draining 70-80% of China's precipitation" and with differences in water levels of up to 60m between high and low water (Tvedt, 2010: 46 and 36). The Han River, the largest tributary to the Yangtze, varies in the width of its course between four hundred meters and eight kilometres between the dry and wet seasons (Zhang, 2001: 27). These characteristics differ from those of English or French rivers *by several orders of magnitude*. European rivers further flow in all directions, in contrast to the predominantly West-East orientation of Chinese rivers (Vries, 2013: 159). It is also often ignored that Chinese canals were frequently established to act as conduits for excess water (Elvin, 2004: 115; Tvedt, 2010: 36; Dodgen 2001: 16), and that water management has been concerned *first and foremost* with 'taming water,' not goods transportation.

Having laid out the unique characteristics of China's waterway system in some detail, we now turn to the question of the dynamic changes this system witnessed over time and the link between these changes and population pressure. We argue that population growth driving hillside reclamation in upstream and highland regions and similar 'land hunger' in the rice-exporting regions of the Middle Yangtze resulted in heightened hydrological instability. These increasingly precarious *environmental* circumstances were exacerbated by government negligence toward the management of dikes, inadequate financial support for the spiralling cost of hydraulic management, and by the conflict of interest between the state and local people, leading to a mere patchwork in government response to the emerging crisis. This inadequate reaction can be tied to the significant stretch experienced by under-resourced local government officials who were overwhelmed in the face of vast population increase. The deterioration in the waterway network should result in a detrimental effect on river transport and we attempt to capture this in a very simple way: our quantitative analysis investigates market integration between prefectural price pairs, extracting the benefit or penalty accruing from river access at different points in time.

Existing work on 'land hunger' and environmental degradation can be divided into two categories: analysis of (i) the upland settlement and cultivation by 'shack' people as studied in Osborne (1994) for the highland periphery of the Lower Yangtze, and in Wang (2014) for the Han River highlands; and of (ii) the maintenance of dikes and the expansion of *yuan* enclosures in the lowlands of the Middle Yangtze as studied in Perdue (1982, Dongting Lake) and Zhang (2001, Jianghan Plain). Highland reclamation was pursued on marginal soils by outsiders who intensively worked the land with large labour contingents, planting New World crops (maize and sweet potato; Wang, 2014: 24) before abandoning their fields after a short number of years once soils were exhausted. The resultant irreversible land degradation and soil erosion created larger runoffs of rain water and snow melt to the downstream lowlands as well as greater volumes of sediment carried in streams and rivers. Lowland *yuan* enclosures allowed for the reclamation of land with high natural fertility but shrank not only the surface area of lakes (and thus the amount of water preserved for irrigation in the dry season) but also substantially reduced flood diversion areas, "increasing the pressure on the overall dike system and causing more frequent breaks and worse floods" (Zhang, 2001: 37). The maintenance of the 'official' dike system under the control of local officials however had been all but abandoned during the second half of the 18th century (Perdue, 1982: 758, 762; Osborne, 1994: 30) and rabid construction of illegal 'private' dikes constituted a free-for-all beggar-thy-neighbour approach to profitable farming. Social changes also fashioned these developments, as collective responsibility for dike maintenance declined and gave way to landowner's naked myopic self-interest (Perdue, 1982: 751, 756; Zhang, 2001: 47).

Both upland and lowland reclamation created serious conflicts between local/private and national/official interests, with the latter eventually overwhelmed and defeated by the 1750s

(Perdue, 1982: 748, 756, 762; Osborne, 1994: 27, 29; Zhang, 2001: 61): "private interests vested in maximising land reclamation – buoyed by population growth and sharply rising food prices – usually triumphed" (von Glahn 2016: 329).

These case studies aside there are well-known accounts of the challenges experienced by China's river administrations in conducting hydraulic maintenance work in the Eastern lowlands and along the Grand Canal. The classic reference is Hu (1955), whose discussion of the decline in the Yellow River Administration (YRA) is enlivened by accounts of the favouritism, squandering and peculation of the "river officials [who] have become fops and dandies" (510). By the early 19th century "hardly one tenth of the regular and extraordinary appropriations was spent for actual water conservancy" and the YRA had become "a symbol of government immorality" (512 and 510). A revisionist view by Dodgen (2001: 4) emphasises the increasing complexity of hydraulic management: by 1800 "the system was more expensive, technologically sophisticated, fiscally demanding, and administratively challenging than it had been at any earlier time."[21] Dodgen (2001) exalts the literati 'Confucian Engineers,' but his accounts still describe an institutional culture of corruption and graft as portrayed in Hu (1955).

All of the above discussions share a recognition of a "conflict between water and humans" (Zhang, 2001: 8), of a worsening situation over the 18th century (Perdue, 1982: 763; Osborne, 1994: 6; Wang, 2014), and of an explicit link between this development and population pressure (Perdue, 1982: 748; Zhang, 2001: 20; Elvin, 2004: 128, 460; Wang, 2014: 24).

The availability of water transport was a crucial enabler of bulk goods trade in Qing China. The above discussion suggests that the decline in inland waterway navigability already set in decades before the end of the Qianlong era, and our empirical analysis investigates the magnitude and stability of this factor in relation to grain market integration. The impact of any

[21] Elvin (2004: 132) provides some extraordinary numbers for the maintenance of the Grand Canal in the late Ming. In 1606 dredging and diking at the Xuzhou interface required half a million men for five months. The Ming could fulfil these needs through forced labour, but the Qing state had abolished the corvee labour system.

decline would ideally be analysed with time-varying information on river silt-levels, extent and duration of flooding, or such-like. In the absence of systematic data we pursue a cruder strategy of contrasting prefecture pairs *with and without access to the river network* and comparing the evolution of price convergence in these distinct groups using the half-live estimates from pairwise price convergence regressions. For each start year τ of a 20-year period we regress the estimated prefecture pair half-life $\widehat{HL}_{ij\tau}$ on (i) a river network indicator equal to 1 if *both* prefectures are connected to the same river network and zero otherwise (more details below); (ii) province indicators for prefectures *i* and *j*; (iii) indicators for prefecture pairs located in the same province and the same Skinner macro-region, respectively;[22] and (iv) bilateral distance between prefecture pairs. We use robust regression to weigh down the impact of outliers and estimate this equation year by year to allow for variation in the river, distance as well as province and macro-region effects over time.[23] One quarter of Southern prefectures (33 out of 131) are not linked to the river network, in the North this ratio is closer to one half (35 out of 80). We also present results for access to the Yangtze River network for the Southern sample given its importance in the region (connecting 71 out of 131 prefectures).

In Figure 3 we present the estimated coefficients for the ‘river network’ dummy in South and North China, respectively, for each rolling-window from 1740 to 1801. A positive coefficient indicates that river access *increased* the half-life between prefecture pairs, a negative coefficient suggests a *reduced* half-life through river access. The upper panel for Southern China shows that in the full sample (black circles) access to the river network has initially only a modest benefit of less than one month reduced half-life, which increases somewhat towards the 1780s, before a substantial decline in the early part of the 19th century which implies

[22] Note that this can capture the political border effect we study in the following section.

[23] The distance coefficient varies over time and has an *upward* trend in the Southern sample: a bilateral distance of 700km (sample median) *ceteris paribus* adds 2 months to the half-life in the 1740s, 4 months in the early 1760s, and 5-6 months in the early 1790s (always referring to start-years). In the Northern sample the evolution is hump-shaped, with a bilateral distance of 500km (sample median) *ceteris paribus* adding 3 months to the half-life in the 1740s and 1790s, 5-7 months in the 1750s and 1760s, and to 4-5 months in the 1770s and 1780s.

prefecture pairs with river access had *higher* half-lives than those without (between 1.5 and 3 months in the 1800s). At the end of the sample period the river effect is insignificant. Plausible explanations for a river 'penalty' include an increased frequency of water calamities (Osborne, 1994; Zhang, 2001; Elliott, 2009; Wang, 2014) or the breakdown of short(er)-distance grain trade (Cheung, 2008: 11; von Glahn, 2016: 346). Our results clearly pick up the great flood of 1788, which Naquin and Rawski (1987: 167) describe as "the turning point in the hydraulic cycle" of the Middle Yangtze macro-region. The results for prefecture pairs along the Yangtze River (the comparison group here is prefecture pairs without river access or with access to other river systems) follow a similar pattern: in 1770, when the average half-life across all prefecture pairs was 13.6 months, the Yangtze River effect amounted to a 3 months shorter half-life, a 22% reduction; however, from 1789 onwards this benefit disappeared. A number of robustness checks, including sample restriction to prefecture pairs above the median bilateral distance, did not yield any new insights (see Online Appendix). The lower panel shows the river network effect in Northern China, which is largely insignificant with the exception of sporadic beneficial effects in the late 1780s and 1790s, and detrimental effects towards the end of the sample period. Focusing on long-distance prefecture pairs yields no additional insights.

Taken together these findings suggest that there is some evidence that market disintegration was accompanied by a decline in the waterway network of Southern China, especially the Yangtze River network, from the 1760s onwards. Note however that the disappearance of a Southern river network effect *predates* the more dramatic collapse in market integration around the 1780s, highlighted by the unconditional average half-lives reported in Figure 3.

THE POLITICAL ECONOMY OF 18TH CENTURY CHINA

In this section we present political economy aspects, broadly defined, as a transmission channel for population pressure on grain market integration. Our focus is on the vastly increased administrative burden for Qing officials, driven by the Manchu leadership's adherence to minimalist government, in combination with a self-inflicted static fiscal revenue basis and a Qianlong emperor increasingly removed from the economic realities of his subjects. We posit that state officials became more and more exposed to distorted incentives which saw them opting for self-interest, career advancement and outright graft and corruption, resulting in a stifling of trade and economic activity. While the Qing state administration turned inward, increasing population pressure and ecological fragility translated into real economic hardship and alienation for a significant part of society concentrated in the frontier regions of the empire, leading to an increased frequency of uprisings such as the White Lotus Rebellion.

We do not emphasise a supposedly market-friendly 'laissez-faire' interpretation of Qianlong's early stance toward trade and exchange, but instead the deterioration in the state's institutional capability to maintain security and reign in the corruption and self-interest severely affecting trade and economic integration. We empirically investigate one aspect of this development with direct relevance for market integration, the 'grain protectionism' on behalf of self-interested provincial officials, implicit in the dynamic patterns of political border effects.

While China's population exploded, the size of the state bureaucracy stayed roughly the same (1 official per 100,000 inhabitants in the mid-18th century, Elliott, 2009: 152). Since "counties in the core area were consolidated to allow for the creation of new counties on the frontier" (Osborne, 1994: 2), the government's power was stretched in both peripheral *and* core regions, subject to a worsening ratio of resources to population, such that bureaucrats "engaged in a sort of survival politics,… locked in perpetual competition over shrinking state resources" (Wang, 2014: 29). In an environment of intense competition for political advancement resourceful officials resorted to patronage networks and semi-legal or illegal activities (Mann-Jones and Kuhn, 1978), with the result that from the mid-1770s Qianlong "presided over two of the worst decades of official corruption in [Chinese] history" (Elliott, 2009: 165).

Quotas for land tax, the main source of government revenue, had been frozen at the 1711 level thus severely limiting the fiscal capacity of the state (von Glahn, 2016: 315; Sng, 2014: 109). The aging Qianlong emperor however appears to have been unaware that his fiscal base was disappearing fast and, amongst other handouts, magnanimously decreed nationwide land tax amnesties on four occasions, including as late as 1777 and 1790 (Elliott, 2009: 151). All of this translated into the emergence of an even more 'minimalist' form of government than already practiced in the early Qianlong period, a steady decline in the degree of official involvement in local affairs, leading to a "major bottleneck for sustainable politics… during the last two decades of the Qianlong reign" (Wang, 2014: 7). On top of the loss of fiscal capacity, the Qing experienced a serious 'span-of-control' problem (Osborne, 1994: 2; Wang, 2014: 62): the 1788 Lun Shuangwen Rebellion and the White Lotus Rebellion, along with a range of smaller uprisings, form "part of a revelatory conjuncture which showcases the structural limits of the Qing state and its failures of social control during the late Qianlong reign" (Wang, 2014: 7).

The comparative autonomy of provincial government and the short tenure cycle (Elliott, 2009: 152) enticed officials to intervene in the grain trade to maximize *local* food safety and storage as a form of 'grain protectionism:' the political philosophy of 'nourishing the people' was paramount (Will and Wong, 1991), and local rulers needed to guarantee food supply to avoid civil strife (Cheung, 2008: 116, 125; Perkins, 2013: 173). Will (1990: 215) suggests that "[i]n many official's mind, the prohibition of exports (*jindi*) was conceived as a major [local] strategy for keeping prices down." They "deliberately held up departing merchant vessels on the pretext that inspection was required, and the dealt leniently with 'troublemakers' who instigated popular exporter (referring to extra-provincial trade) embargoes" (Dunstan, 2006: 98f). Local gazetteers and handbooks of famine administration are full of accounts of such protectionist behaviour by local officials or the local population (e.g. sources cited in Wong, 1982: 772; Will, 1990: fn 106; Dunstan, 2006: 98f; Cheung, 2008: 130f) and reprimand on behalf of the emperor or other state officials (e.g. Will, 1990: fn 108, 109; Cheung, 2008: 131). Erecting barriers to trade was fairly straightforward, since in particular in the Middle Yangtze region grain trade was concentrated in a small number of cities along the river and could thus easily be disrupted (Will, 1990: 212; Cheung, 2008: 121). Population pressure, more political competition, and more frequent water calamities increasingly motivated officials over the 18th century to engage in protectionist behaviour.

We analyse the effect of political borders on market integration by comparing the half-lives in prefecture pairs which are separated by a provincial border with those that are not, using the estimates from pairwise convergence regressions $\widehat{HL}_{ij\tau}$, where τ is the starting point of a 20-year rolling window. We limit this analysis to prefecture pairs less than 250km apart, though different distance cut-offs yield qualitatively similar results. The boundaries of Qing China's administrative units rarely coincided with those of its physiographic environment, and while Skinner (1977) argued that market integration followed the geomorphological structure, the interference of local Qing officials in the grain trade occurred within the boundaries shaped by the bureaucratic structure. As a placebo test we therefore carry out the same border analysis adopting Skinner macro-region borders instead of political borders: though we do expect a Skinner border effect, we anticipate its dynamic patterns to be qualitatively distinct from those of a political border effect shaped by rising population pressure.

The top panel in Figure 4 shows the evolution of the estimated *physical border* effect for prefectures separated by a Skinner macro-region border in North (red) and South (black) China – here and in the following solid markers indicate years in which this difference is statistically significant. Half-lives are generally higher for pairs where grain transport has to overcome geomorphological boundaries, which is intuitive. In South China, this gap is stable for the first fifty years, then largely disappears when half-lives become large toward the end of our sample.

In North China, the macro-region border effect is larger and more volatile (possibly due to much fewer identifying observations, see fns 24, 25), partially disappearing in the middle period of our sample. The middle panel provides the contrasting evolution of border effects when Southern prefecture pairs are separated by a *political border*.[24] We focus on border effects in four macro-regions: in the Lower Yangtze (in black) the border effect is modest (up to 3 months) in the first thirty years, and as high as 10 months in the final decade of the sample; inbetween we find a period in the 1770s when the border effect is *negative* and on average measures 7 months (dashed black line), when prefecture pairs separated by provincial borders had *lower* half-lives. In Lingnan (in green) substantial border effects in the first half of the sample are followed by significant negative border effects in the 1780s and 90s; in the Southeast (in grey) this pattern is reversed: negative border effects in the 1750s, positive effects in the final decades of the sample. The most striking and arguably economically most significant result is the evolution of the border effect in the Middle Yangtze region (in red) – this region is made up of Hunan and Hubei, in which, according to proverb, “a good year can feed the entire empire” (Zhang, 2001: 77). The political border effect in this core region for imperial rice production *steadily increased* from a low 1-2 months to reach heights in excess of 50 months towards the end of our sample period. This is significant because cutting out the Middle Yangtze region from the grain trade network (see map in von Glahn, 2016: 333) effectively cuts out the lion’s share of Southern inter-regional grain supplies.

[24] A note on sample sizes in the Southern sample: for the physical border effects we have 612 to 746 annual observations, of which 24% are separated by a border. We have the same number of observations for the political border effects, of which 40% are separated by a border. For the political border effects by macro-region these figures are: Lower Yangtze (180/1, 55%), Middle Yangtze (107-190, 30% – the gap arises from the Jiangxi price series dropping out of the sample in the 1790s; the evolution presented is robust to the exclusion of Jiangxi from the sample), Lingnan (82, 24%), Southeast (79, 27% – due to the small sample for distances less than 250km [11 annual prefecture pairs with a border] we use 350km as the cut-off here). We do not analyse the Yungui region since we only have data for Guizhou.

The bottom plot presents the political border effects within the North (in black) and Northwest (in red) macro-regions:[25] in both cases substantial border effects are apparent in the period up to the turn of the 19th century, thereafter the results become highly volatile.[26] The Northwest macro-region includes Gansu province, "a staging ground for [military] campaigns into Central Asia" (Naquin and Rawski, 1978: 185) during most of the 18th century. Kim (2008: 230f) claims that large quantities of grain were only transported over long distances in North China if the state created substantial incentives, e.g. provisioning military garrisons in Gansu.

'Grain protectionism' is merely one aspect of a deteriorating political economy in late-Qianlong China, but our empirical analysis suggests that this phenomenon was highly prevalent in Southern China's 'rice bowl' Middle Yangtze region throughout the Qianlong reign. In Northern China, the effect is particularly pronounced between the 1760s and 1780s, before markets became fragmented in the later period of our sample.

CONCLUDING REMARKS

When did imperial China's divergence begin? The contribution of the revisionist 'California School' has suggested that the answer to this question is firmly located in the 19th century, and econometric analysis, most prominently by Shiue and Keller (2007), has confirmed the 'surprising resemblance' between East and West for the late 18th century in the case of grain market integration. In this paper we collate rich qualitative and quantitative evidence to argue that the decline of Chinese markets set in several decades before the end of the Qianlong

[25] Annual sample sizes and border-subsample shares are as follows: Skinner borders (340-483 observations, 18% with a border – the gap arises from the unavailability of some prefectural price series for Zhili in the early years of our sample); political borders North macro-region (166-304, 45%), Northwest macro-region (96, 46%).

[26] In case of the NW macro-region the post-1787 results suggest a *negative* border effect of magnitudes in excess of dozens of months. However, this is caused by a macro-region average speed of convergence *above* zero (zero is the asymptote, estimates above zero are economically-speaking meaningless), a phenomenon which is driven by the prefecture pairs subject to a political border.

reign,[28] and that unprecedented population growth and internal migration were the ultimate driver of this development. An influx of migrants into the grain-surplus regions of the Middle and Upper Yangtze translated into less availability of grain for interregional trade. Population pressure further transmitted to market disintegration through indirect channels such as ecological decline and local protectionism.

All of these factors were conditioned by the (non-)actions of the Qing state, which despite all the perceived glory of the early Qianlong days was distant, uninformed, minimalist, rigid, underfunded, and unwilling to adjust to the new economic, social and environmental circumstances: (i) the Qing leadership allowed large-scale migration to the West and Southwest to act as "a 'safety valve' for excess population in other provinces" (Entenmann, 1980: 36) without addressing the underlying causes of the 'push' factors for migration; (ii) it did not address an emergent state capacity failure by not revising the fiscal system (in particular the land tax freeze), and by not increasing the number of state officials in line with population growth; (iii) it failed to develop an 'industrial strategy' to explore, encourage, and safeguard structural transformation, primarily the permanent shift of workers out of agriculture, which would have necessitated more active state intervention in the development and diffusion of agricultural technology.

Why did the Qing state not 'implode' during the late Qianlong period or immediately thereafter given the pressures of population growth and environmental decline? We believe that there were multiple reasons, including: (i) the considerable reduction in population growth during the first decades of the 1800s (Perkins, 2013: xiii)[29] along with a decline in internal migration during the White Lotus Rebellion and in its aftermath; (ii), the efforts exerted during the 'Jiaqing Restoration' which succeeded in "[putting] the Qing Empire back on track" (Rowe,

[28] Note that in a recent entry on the NEP-HIS blog, June 6 2017, Kenneth Pomeranz suggests parity between East and West was likely around 1750 rather than the 1800 as previously argued.

[29] Perkins (2013) draws on the example of Sichuan to suggest that while official population reports were relatively reliable around 1800, in the 1850s they imply population growth which is unlikely to have occurred.

2011: 78) by exchanging provincial leaders, cracking down on corruption, reinstituting capital appeals, and showing concern for economic grievances and official oppression as a cause for widespread rebellion; (iii), pure luck: although we have painted an almost deterministic picture of the high Qing economic fortunes as a function of state (non)intervention and population pressure, success or failure in an agrarian economy are still driven to a very significant extent by the weather. During the final Qianlong and early Jiaqing years the share of prefectures experiencing serious floods or droughts was substantially below the long-term median of 17%, thus offering the administration some breathing space after the disastrous floods of the 1780s.[30]

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[30] The historical weather data for 1470-1979 used in Jia (2014) reports a dryness indicator from which we compute the share of prefectures with exceptional floods or droughts in any one year. Figure X-X in the Online Appendix shows the 5-year and 11-year (backward-looking) moving average prefecture share.

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Tables and Figures

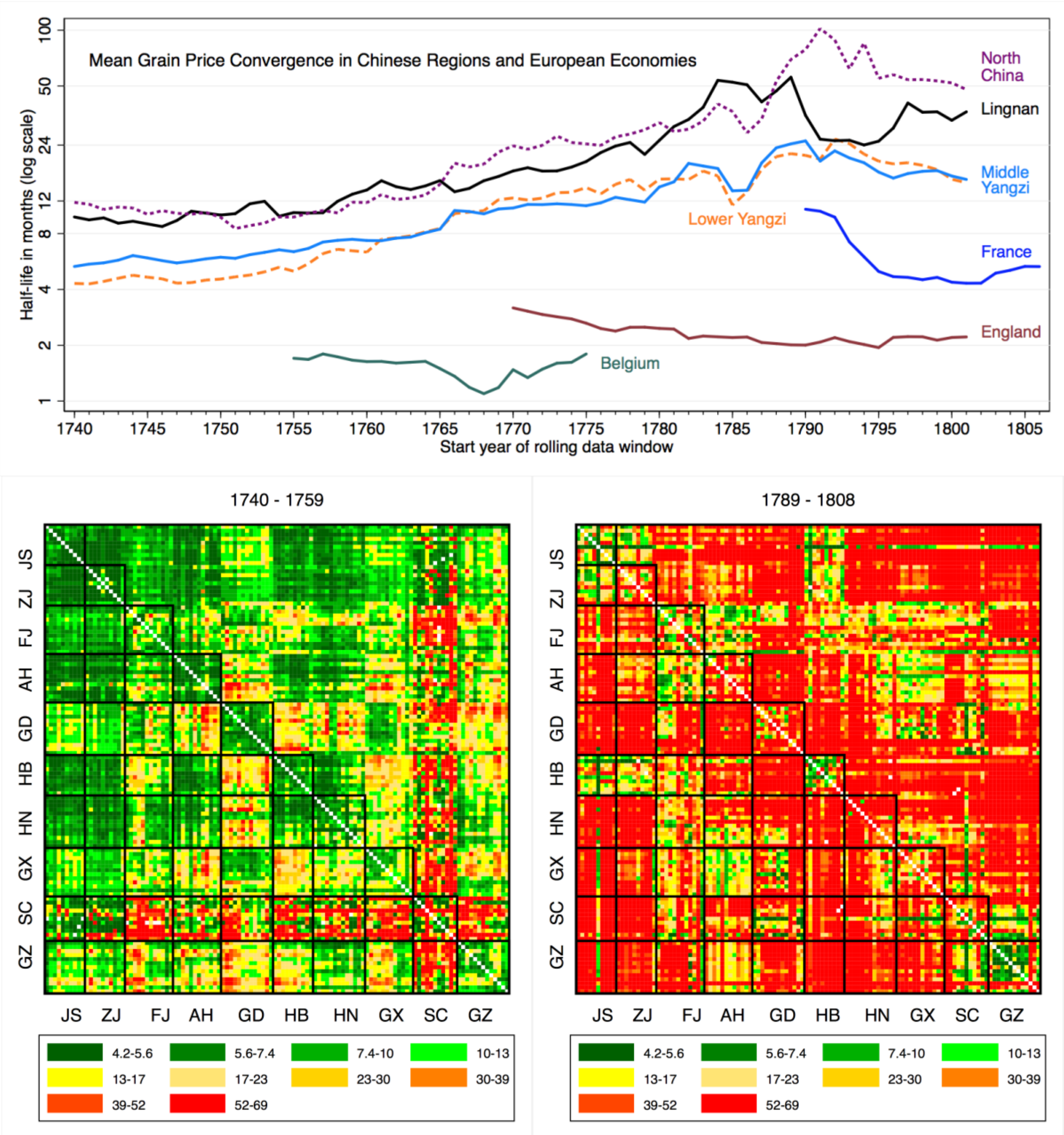
Table 1: Population Density Growth and Market Disintegration

Dependent Variable	Difference in prefectural half-lives: $\widehat{HL}_{1820} - \widehat{HL}_{1776}$			
(A): South China Excluded from the sample	(1) -	(2) -	(3) Outliers	(4) Outliers + GZ
Δ ln(Population Density)	0.407 (0.342)	-0.044 (0.381)	-0.044 (0.379)	-0.44 (0.452)
Δ ln(Population Density) × Grain Surplus		2.394 (0.706)***	2.395 (0.794)***	2.312 (0.799)***
Prefectures in the sample	117	117	116	103
of which Grain Surplus	49	49	48	48
Province FE (*p*-value)	0.00	0.00	0.00	0.00
(B): North China Excluded from the sample	(5) -	(6) -	(7) Outliers	(8) Outliers + ZL
Δ ln(Population Density)	0.202 (0.176)	-2.392 (1.841)	-2.431 (1.778)	-3.053 (2.426)
Δ ln(Population Density) × Grain Surplus		2.617 (1.849)	2.649 (1.786)	3.300 (2.435)
Prefectures in the sample	78	78	76	63
of which Grain Surplus	25	25	23	23
Province FE (*p*-value)	0.00	0.00	0.00	0.00

Notes: ***, ** and * denote 1%, 5% and 10% significance level, respectively. We regress the difference in the prefecture-specific estimated half-life (in months) between the early (20-year window ending in 1776) and late periods (20-year window ending in 1820) of our sample on the growth rate of prefectural population density, a dummy for grain surplus prefectures (estimates not reported), a dummy for the provincial capital (not reported), an interaction term between population density and grain surplus (in all but [1] and [5]), and province dummies (not reported). The omitted category contains grain-deficit or self-sufficient prefectures. The Southern sample excludes estimates for Jiangxi since price series for prefectures in this province end in the 1790s. We indicate the *p*-value of a test of joint insignificance for the province fixed effects. Outlier detection is conducted using the *dfits* statistics in standard OLS regressions. Models (4) and (8) exclude prefectures in Guizhou (GZ) and Zhili (ZL) provinces, respectively, for reasons discussed in the text. All estimation results are obtained using robust regressions (Hamilton, 1992), with absolute standard errors in parentheses.

Sources: The population density data for 1776 and 1820 (people per square kilometer) are taken from Cao (2000), the (time-invariant) provincial grain surplus classification from Myers and Wang (2002, Map 12). The dependent variable $\widehat{HL}_{1820} - \widehat{HL}_{1776}$ is derived from estimates in Bernhofen, et al (2016).

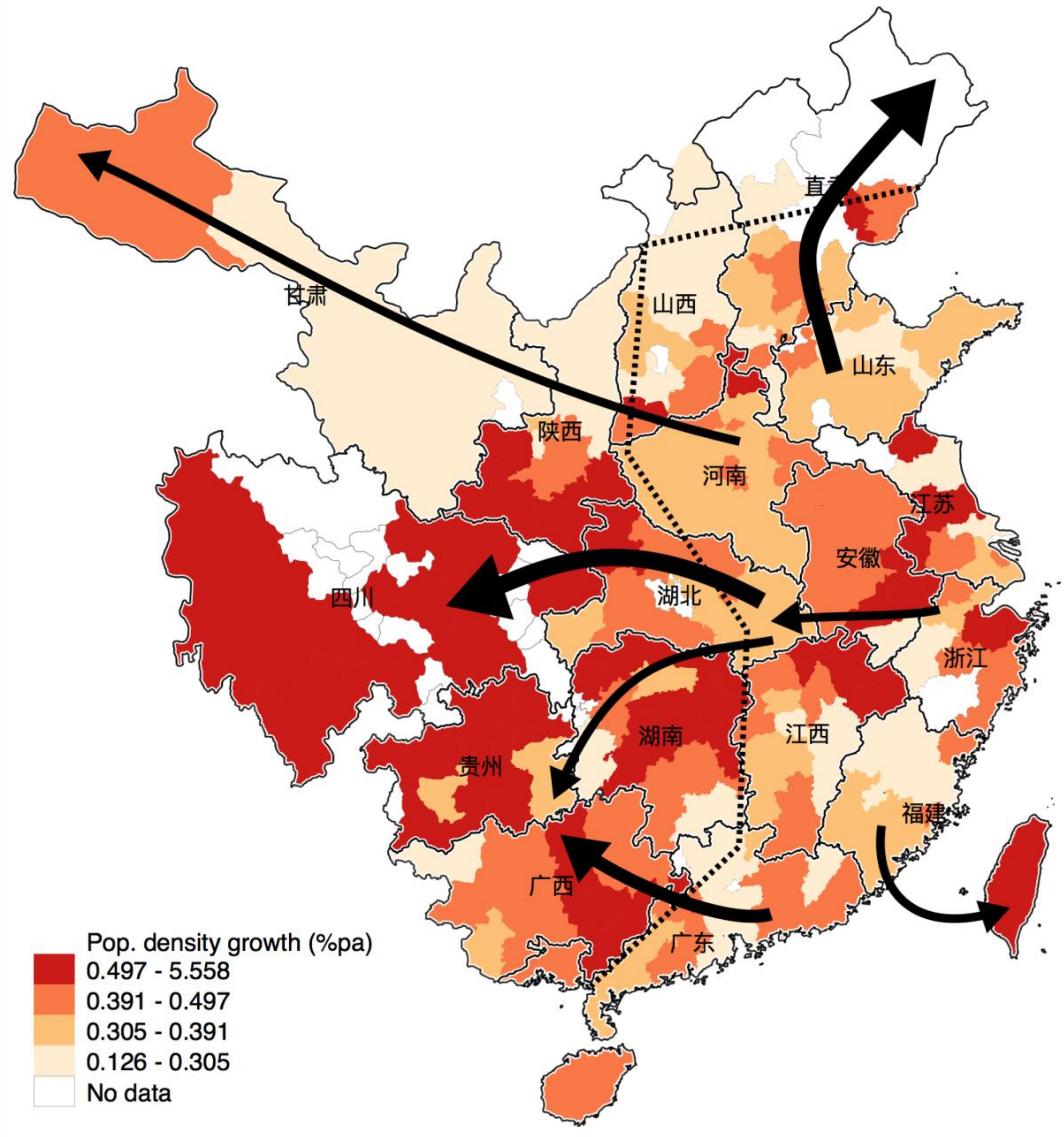
Figure 1: Market (Dis)integration in Early Modern China and Western Europe



Notes: In the upper panel we compare estimated half-lives (in months) for Chinese macro-regions and European economies from rolling window panel convergence regressions (window length 20 years for China and England, 10 years for Belgium and France). In the bottom panel we plot the estimated half-life for each prefecture pair for two 20-year windows in the Southern Chinese sample. Provinces and prefectures are ordered from East to West on each axis, colours indicate the magnitude of the half-life (in months); ranges reflect a logarithmic scale. Purely for visual purposes the results in each lower triangle are repeated in mirror image in the upper triangle. See text for data adjustment applied in this visualisation.

Sources: Bernhofen, et al (2016, 2017b) for top and bottom panels. Skinner region from CHGIS version 4.

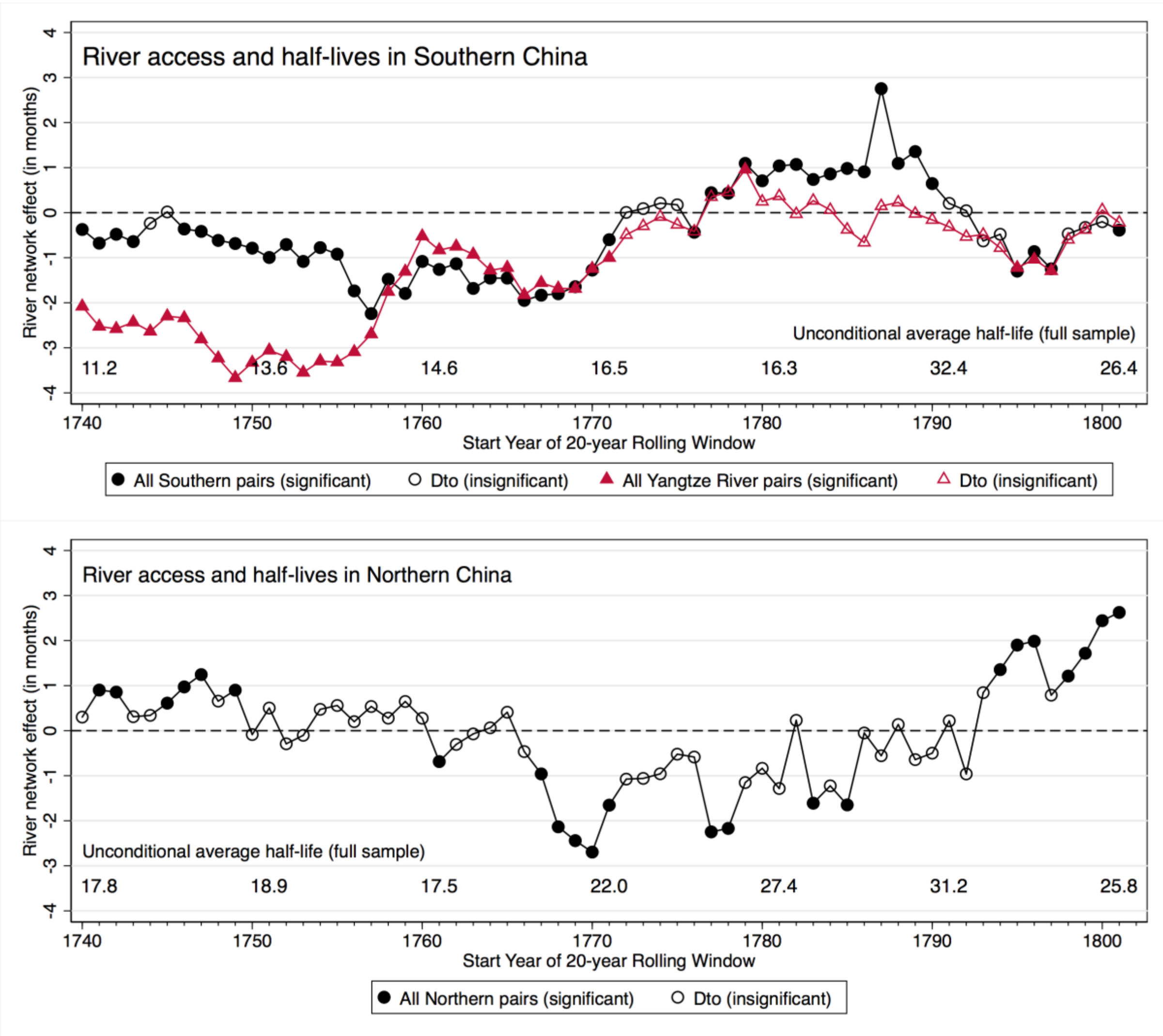
Figure 2: Population Density Growth and Internal Migration



Notes: We plot the annualised population density *growth rates* (in percent) between 1776 and 1820 for 211 prefectures. Black solid lines indicate provincial borders. The dashed line marks the early 18th century 'frontier' between developed and developing areas of Qing China (Myers and Wang, 2002). Arrows indicate major internal migration flows (stylised representation) during the 18th century. The two Northern migration strands actually extend beyond Qing China proper into Xinjiang and Manchuria.

Sources: Population density data are taken from Cao (2000), information on 18th century migration flows from Eliott (2009: 147), Entenmann (1980: 41f), Ho (1959: 139ff), Lee and Feng (1999: 118), Mann-Jones and Kuhn (1978: 109f, 132), Myers and Wang (2002: Map 9), shapefiles from CHGIS version 6 (2016).

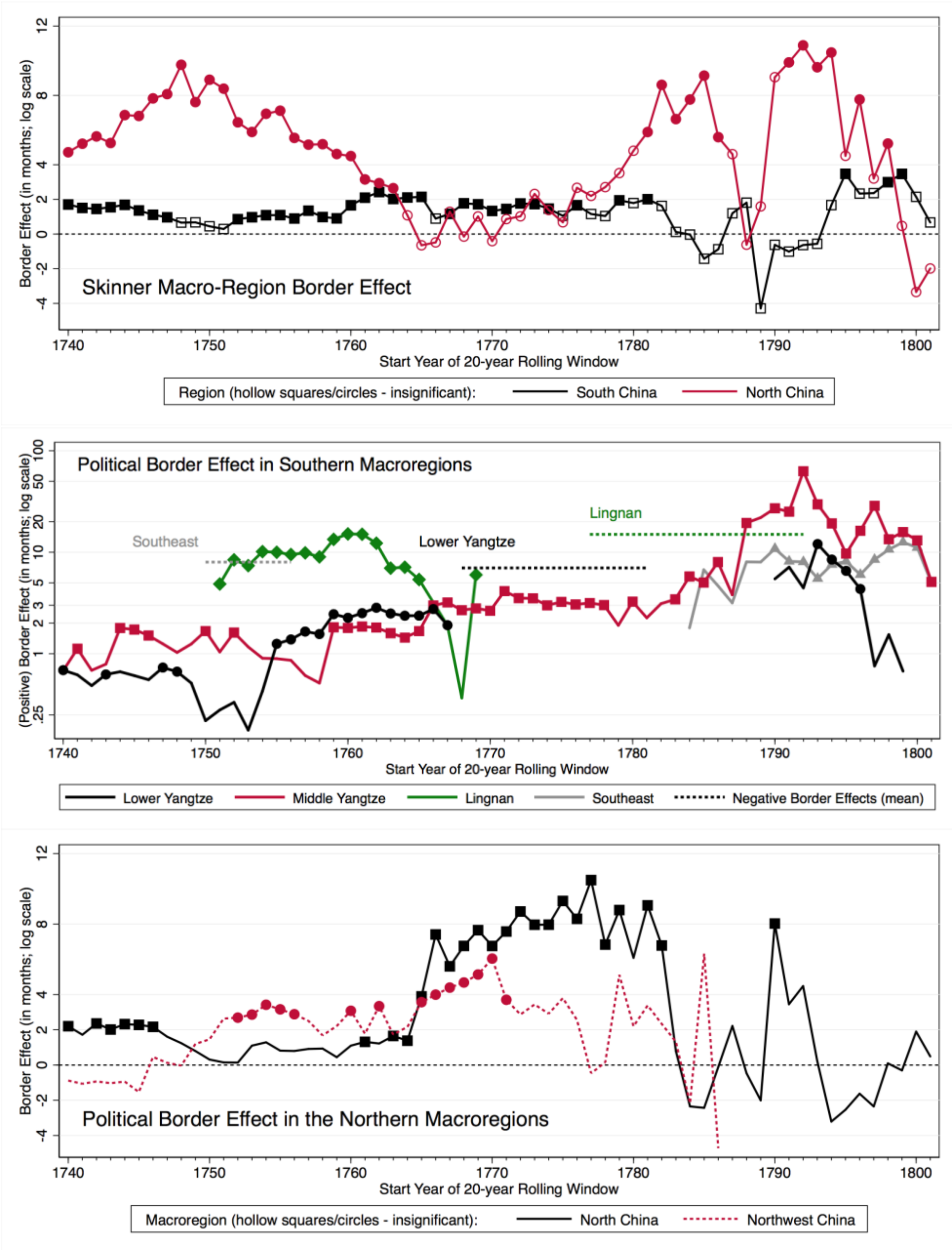
Figure 3: River Access and Grain Price Convergence



Notes: We regress the estimated prefecture pair half-lives (in months; taken from 20-year rolling window prefecture pair convergence regressions) on a (Yangtze) river network dummy, which is equal to one if *both* prefectures are part of the (Yangtze) river network – this is the case in around 55% of annual observations (30% for the Yangtze River). This robust regression further controls for (i) bilateral distance, (ii) common province, and (iii) common Skinner region, as well as (iv) province fixed effects for either or both prefecture(s), if applicable. In both plots statistically (in)significant river dummy estimates are represented by filled (hollow) markers. For ease of interpretation we also report unconditional robust means for the estimated half-lives (in months; smoother over 5 years) at a few points in time. Thus for instance in the early 1750s the average half-life for all Southern prefectures was around 13.6, while a prefecture pair on the Yangtze River had a half-life roughly 3 months shorter.

Sources: Half-lives derived from results in Bernhofen, et al (2017b), for other data see text.

Figure 4: Geographical and Political Border Effects



Notes: In a sample of prefectures less than 250km apart (Southeast macro-region: 350km) we regress the pairwise half-life for each 20-year period on an intercept, a Skinner/province border dummy and (in the political border regressions) a dummy for the governor-general. In the top panel we plot coefficients for Skinner macroregion (physical) borders in South and North China. In the bottom two panels we plot political border dummy coefficients for macro-regional subsamples; we highlight periods and average absolute magnitudes of statistically significant 'negative border effects' for South China. Results for the Northwest are omitted for the last 20 years – see text. Statistically significant effects (5% level) are indicated with full markers in all panels.

Sources: Half-lives derived from results in Bernhofen, et al (2017b), for other data see text.